THE APPLICATION OF EXISTING DIGITALLY-CONTROLLED FLAT-BED WEFT KNITTING TO FASHION KNITWEAR FOR THE INDIVIDUAL BODY SHAPE OF WOMEN, PARTICULARLY THOSE ABOVE UK STANDARD SIZES

Vikki Haffenden

A thesis submitted in partial fulfilment of the requirements of the University of Brighton for the degree of Doctor of Philosophy

September 2012

The University of Brighton
Abstract

The Application of Existing Digitally Controlled Flat-Bed Weft Knitting to Fashion Knitwear for the Individual Body Shape of Women, Particularly Those Above UK Standard Sizes

The primary aim of this practice based research was to develop, for the first time, a new combination of knitting methods which created knitted garments for larger size women that uniquely did not rely on stretch to fit their body shape. Through working with real women, an innovative capsule collection of custom-fitted knitwear toiles incorporating 3D knitted shape was produced which positively demonstrated the originality, effectiveness and significance of the outcomes.

This research therefore focused on developing knitwear with an improved fit for the individual body shapes of a cohort of women over a UK size 16.

In 2004, publicly available information from SizeUK indicated that the average women’s size in the UK was a size 16. However following a literature search, and in conjunction with primary data from this research, it became evident that women over a size 16 were experiencing dissatisfaction with clothing fit. This disjunction formed an early driver for the research idea and helped to form the research framework that spanned three main areas: clothing fit, larger female body shape and mass knitwear manufacture.

The research has been necessarily set in the wider context of debates on larger women’s self–image and their relationship with fashion. Interviews and an online survey provided primary data on clothing fit, clothing choices, shopping experience, body image, body cathexis and self perception in relation to clothing.

A case study research method was developed that resolved ethical issues which arose when working with participants.

Prior to knit sampling, a hierarchy of desirable technical and aesthetic knit qualities was established, and a design process comparable to that in industry adopted in order to place this research in a ‘real’ commercial context.

The knitwear was developed from manually acquired measurements and 3D body scanned data, using specific measurement protocols developed by the research for measuring larger size. Objective and subjective evaluation of the knitwear employing wrinkle-analysis, fit and comfort tests informed a final design development process that ran parallel to commercial examples.

Amongst the final outcomes of this research is a library of visual digital templates derived from the knit programming, which offers a transferable new resource for future industrial developments of this process. Their particular and unique value is to contribute information to the emerging field of mass-customisation of knitwear and larger sized clothing as recommended for EU development by the SERVIVE report of 2010.

This research concluded, as a significant contribution to new knowledge in the field of larger sized fashion knitwear, that improving the fit of knitwear for larger women by removing the fit-by-stretch factor (a major style and psychological drawback for these consumers), enhanced wearing experience and enthused the wearer towards the garment.
Papers and presentations extracted from this research have been presented at the following conferences and exhibitions:


# TABLE OF CONTENTS

## Acknowledgements

INTRODUCTION

1 RATIONALE FOR THE RESEARCH IDEA, RELATED LITERATURE REVIEW, AND AIMS AND OBJECTIVES

1.1 Introduction

1.2 Knitwear for large sizes
  1.2.1 The problematic consequences of stretch-to-fit in larger sizes

1.3 The needs of an increasingly larger sized and older population

1.4 Rationale for the research idea: research interviews and survey responses
  1.4.1 Interview with participant: Desdemona
  1.4.2 Interview with participant: Portia
  1.4.3 Background anecdotal information from the online research survey

1.5 Literature review of the rationale for the research idea
  1.5.1 Sizing, fit, and availability of larger sized clothing and knitwear
  1.5.1.1 Sizing in knitwear manufacture
  1.5.2 Larger size: its effect on clothing satisfaction, perceptions of self and femininity
  1.5.3 Larger women and fashion
  1.5.4 Larger sized women’s experience of shopping
  1.5.5 Knitwear as fashion
  1.5.6 Historical knitting capabilities
  1.5.7 Digital knitting technology and its relevance to the research rationale

1.6 Aims and objectives of this research

1.7 Conclusion

2 RESEARCH THEMES, RESEARCH METHODS AND ACTIVITIES, AND RELATED LITERATURE REVIEW

2.1 Introduction

2.2 Research themes
  2.2.1 Larger body shape and size

2.3 Literature review of the research themes and methods
  2.3.1 Body shape in relation to clothing size and fit
  2.3.2 Participant involvement
  2.3.3 Gathering background and supporting data
  2.3.4 Clothing fit and ease
  2.3.5 Commercial customisation of knitwear
  2.3.6 Measuring body size and shape
  2.3.7 Evaluation of clothing fit
  2.3.8 Design process
  2.3.9 Stretch in knitting
2.3.10 Knitting methods

2.4 Research activities
2.4.1 Survey design
   2.4.1.1 Target age range of the survey
   2.4.1.2 Purpose of the survey
   2.4.1.3 Formulating the questions
   2.4.1.4 Format of the survey
   2.4.1.5 Survey deployment
   2.4.1.6 Survey analysis methods
2.4.2 Case study
   2.4.2.1 Participant recruitment for the pilot and main studies
2.4.3 Diaries
2.4.4 Measuring larger body shape
   2.4.4.1 Clones
   2.4.4.2 3D Body scanning
2.4.5 Selection of machinery
2.4.6 Selection of suitable yarn and establishing a base knit structure
   2.4.6.1 Yarn selection
   2.4.6.2 Establishing a base knit structure
   2.4.6.3 The embedded topological evaluation grid developed for this research
2.4.7 Template development
   2.4.7.1 How this led to garment shaping – knitting methods
   2.4.7.2 The developmental route: from body shape to template to garment
2.4.8 Garments - participant and objective evaluations

2.5 Conclusion

3 THE DEVELOPMENT OF A PRACTISE BASED RESEARCH FRAMEWORK FOR BODY MEASUREMENT AND 3D KNIT SHAPING FOR LARGER FEMALE BODY SHAPES

3.1 Introduction

3.2 The challenges in terms of measurement issues
   3.2.1 Methods for capturing body shape and dimensions
   3.2.2 Landmarks and dimensions for larger body size
   3.2.3 Measuring session protocol
   3.2.4 Establishing lower torso landmarks
   3.2.5 Defining the waist in manual measuring and 3D body scanning
      3.2.5.1 Locating the natural waist, landmarked as E2, in both manual and body scanning
   3.2.6 Landmarks and measurements affected by waist position in manual and 3D body scanning of larger body shapes for knitwear
   3.2.7 Establishing upper torso landmarks
   3.2.8 Cloning body shape to aid the design process

3.3 Increments and tolerances

3.4 The practical application of the measurement system developed for larger body size: measuring Juliet for the pilot study

3.5 3D knitting methods
   3.5.1 3D shaping in mass produced knitwear
   3.5.2 Knitting 3D shape with flechage
   3.5.3 Fitting knitting to 3D larger body shape
3.6 Fabric development

3.6.1 Developing a knitted fabric with potential for evaluating stretch on the body 195
3.6.2 Developing a knitted structure with an embedded grid to evaluate stretch 196
3.6.3 Fabric design, technical and aesthetic considerations 200
3.6.4 Rationale for final structure selection 201
3.6.5 Incorporating a visual evaluation tool 203

3.7 Conclusion 203

4 APPLICATION OF THE PRACTICE BASED RESEARCH FRAMEWORK TO DEVELOPING INNOVATIVE 3D SHAPED KNITWEAR FOR LARGER BODY SHAPES 206

4.1 Introduction 206

4.2 Technical design processes developed to enable knitting 3D garment shape for larger body shape 208

4.3 Developing knitting templates for larger body shape on the Shima Seiki SDS®-ONE system 209

4.4 Shaping the shoulder and body 218

4.5 Shaping the bust with flèchage 223

4.6 Fitting the garment to the lower torso 227

4.7 Shaping the armhole and fitting the sleevehead 231

4.8 An example of the research design development process: re–designing the Desdemona 2 garment as Desdemona 3a 231

4.8.1 Design process 233

4.9 Conclusion 247

5 EVALUATION OF FIT OF KNITWEAR DESIGNED FOR LARGER FEMALE BODY SHAPES THROUGH THE INNOVATIVE APPLICATION OF 3D SHAPING 250

5.1 Introduction 250

5.2 Evaluation of the research garments 250

5.2.1 Drape characteristics are influenced by complex interactions 250

5.2.2 Juliet – the pilot study 251

5.2.2.1 Evaluation of Juliet 2 254

5.2.2.2 Evaluation of Juliet 3 259

5.2.2.3 Evaluation of Juliet 4 260

5.2.3 Desdemona 261

5.2.3.1 Evaluation of Desdemona 2 261

5.2.3.2 Evaluation of Desdemona 3 262

5.2.4 Portia 266

5.2.4.1 Uneven shoulders 266

5.2.4.2 Portia 4a; a refined development process 269

5.2.4.3 Evaluation of Portia 4a 271

5.3 Portia 5 – the proof of concept garment 282
5.4 Conclusions about knitting for larger body shape based on the research knitwear toiles 287

5.5 Transferable methods 290

5.6 Outcomes that may lead to future developments 293

5.6.1 Differences between garments developed from manual measurements and those from 3D body scan measurements. 293

5.7 Conclusion 294

6 FINDINGS, OUTCOMES AND CONCLUSIONS OF THE RESEARCH INTO IMPROVING THE FIT OF KNITWEAR FOR LARGER FEMALE BODY SHAPE PRODUCED THROUGH THE INNOVATIVE APPLICATION OF 3D SHAPING 297

6.1 Overview of findings 297

6.2 Findings 298

6.3 Discussion on findings 301

6.3.1 Challenging stretch to fit in knitwear for larger sized body shape 301

6.3.1.1 3D shaping and its relationships to larger body shape 302

6.3.2 Combining 3D body scanning with digital knitting technology to produce knitwear with an improved fit for larger body shape 304

6.3.3 The research template library

6.3.3.1 The transferable knitting templates can be exploited commercially for future development 306

6.3.4 Issues of the visual evaluation of stretch in knitwear for larger sized body shapes 307

6.3.4.1 Evaluation methods developed for knitwear for larger body shape 308

6.3.5 Measuring larger sized 3D body shape specifically for knitwear 309

6.3.6 Improved fit in knitwear for larger sizes can be achieved with widely available knitting technology 310

6.4 Future potential of the findings and outcomes 310

6.5 Overall conclusions drawn from the research 313

GLOSSARY OF TERMS 321

BIBLIOGRAPHY 327

APPENDICES 354

Appendix A Manual measuring and development of a specific measuring system for larger body shape and size. 355

A 1 Supporting documentation

1.1 Pilot Study Landmarks 356

1.2 Page from research diary – preparation for Pilot Study measuring (2 pages) 357

1.3 Pilot study measurement table (2 pages) 359

1.4 Measurement table revised for the main study (3 pages) 361

1.5 Participant consent and information sheets 365

Consent Form 365

A 2 Manual measuring 369
2.1 Measuring Desdemona 29th June 2006
2.2 Measuring Portia 19th July 2006

Appendix B Initial yarn selection, development of fabric, knitting techniques and early prototypes. 378

B 1 Supporting documentation 379
1.1 Knitting data sheet designed for the research 379

B 2 Research diary pages 380
2.1 Initial knitting and shaping sample development. 25th February 2004 380
2.2 Reflections on working methods, yarn selection and knitting structures. 1st April 2004. 381
2.3 Record of yarn test of Baruffa 2/30s Cashwool. 3rd October 2004. 382
2.4 Development of first grid designs. 14th October 2004 383
2.5 Definition of the original grid for evaluation of garment and fabric behaviour on the body. 5th January 2005. 384
2.6 Original flèchage method for Juliet. A larger bra cup was causing problems with missed stitches and gathering. 385
2.7 New flèchage method for bust darts, developed with the help of Phil Baines, Shima Seiki Europe Ltd. 29th September 2005. 386

B 3 Knitting samples and developments 387
3.1 Schema of conf9_darts.dat, early developments of vertical darting methods. 387
3.2 Conference poster presented at Knitting: Global Challenges conference, Manchester, 2005. 388
3.3 Method for drawing schemata for larger size 389
3.4 Schema of bil2dev22asstrp12.dat, incorporating the ‘new’ flèchage method at the bust. 392
3.5 Striping and finishing samples for the ‘Australia’ garment based on bil22a (pilot study) series of samples. 393
3.6 Spiral A and B flèchage experiments. 394
3.7 Early samples for Juliet 1. 395

Appendix C Development of 3D body scan data into knitting processes. 396

C 1 Supporting documentation 397
1.1 Definitions of 3D body scan measurements from sample scan –LCF mep file. 397
1.2 Body scan measurement of Desdemona using LCF mep file 399
1.3 Body scan measurement of Portia using LCF mep file 401
1.4 Portia measurements from Vikkiknit1.mep file – related to manual landmarks 403

C 2 3D knitwear programming method 406
2.1 Method for generating knitwear with 3D shaping for larger body shape using the SDS-ONE® SPaint programme 406

C 3 Proof of concept garment 416

C 4 Communications regarding 3D body scanning 424

Appendix D Final design developments - evaluation on participants 426

D 1 Juliet 2-4 evaluations 427
1.1 Juliet 2 427
1.2 Juliet 3 429
1.3 Juliet 4 435

D 2 Desdemona 2-4 439
2.1 Desdemona 2 – on clone 439
2.2 Desdemona 2 on participant 443
2.3 Diary page on re-working Desdemona 2 bust darts 445
2.4 Desdemona 3 on clone and then on participant 446
2.5 Desdemona 4 – on clone 450

D 3 Portia 4a 452
3.1 Example of the participant garment evaluation form – Portia 4 455
3.2 Portia 5 – on clone 457

Appendix E Supporting documentation- interviews and survey data. 459

E 1 Interviews with participants 460
1.1 Portia 460
1.2 Desdemona 462
1.3 Portia second interview 476

E 2 Interviews with designers and industry 478
2.1 E mail interview with Anna Koski, American Eagle. 11 April 2011 478
2.2 E mail interview with Frances Tobin ex buyer and designer – 13th June 2011 480
2.3 Excerpts from an interview with Sales Director of Shima Seiki Europe Ltd. 481

E 3 Survey 487
3.1 Definitions of larger figure types used in the online survey 487
3.2 Survey questionnaire 489
3.3 Survey data 491
3.4 Selected survey responses 496

Appendix F Knitwear as fashion. 498

F 1 The emergence of knitwear as fashion 499
1.1 Analysis of knitted items, knitwear and catalogues in the Hodson Shop collection at Walsall Museum. 503

F 2 Examples of sizing variations in contemporary plus size, high street fashion knitwear (2007). 515
LIST OF FIGURES AND TABLES

CHAPTER ONE
FIGURE 1. SCREENSHOTS FROM SIMPLY BE AND BODEN’S ONLINE STORES 35
TABLE 1. CHARTS COMPARING THE FINDINGS FROM SIZEUK WITH WOMEN’S CLOTHING SIZES DEFINED BY MAJOR UK RETAILERS. 53
FIGURE 2. THREE DRESSES FROM MARK FAST’S 2010 READY-TO-WEAR COLLECTIONS. 56
FIGURE 3. MANUAL INTARSIA BEING CARRIED OUT IN THE PRINGLE FACTORY, HAWICK. 61
FIGURE 4. KNITWEAR BY DESIGNERS WHO HAVE STIMULATED ITS DESIGN SINCE THE 1990S. 62
FIGURE 5. BLACK HAND-KNITTED SWEATER, ASYMMETRICAL AND HOLED. 67
FIGURE 6. TIMELINE SHOWING THE PIVOTAL DEVELOPMENTAL STAGES OF INDUSTRIAL MACHINE KNITTING AND KNITTED CLOTHING 1589-2011. 72

CHAPTER TWO
FIGURE 1. TWO 3D BODY SCAN IMAGES OF PORTIA. 99
FIGURE 2. THREE PHOTOGRAPHS OF THE RESEARCH KNITTING WITH EMBEDDED GRID. 109
TABLE 1. CHART SHOWING LOWER BODY SIZE BY % GROUPINGS OF TOTAL RESPONSES TO SURVEY.118
TABLE 2. CHART SHOWING UPPER BODY SIZE BY % GROUPINGS OF TOTAL RESPONSES TO SURVEY. 118
TABLE 3. COMPARATIVE GRAPH OF THE INCIDENCE OF UPPER AND LOWER BODY SIZE AMONGST THE 55-70 YEAR OLD RESPONDENTS, 119
TABLE 4. TYPE A BODY SHAPE AND BODY SIZE DATA FROM THE RESEARCH SURVEY. 120
TABLE 5. TYPE D BODY SHAPE AND BODY SIZE DATA FROM THE RESEARCH SURVEY. 120
TABLE 6. TYPE E BODY SHAPE AND BODY SIZE DATA FROM THE RESEARCH SURVEY. 121
TABLE 7. CHART SHOWING PERCENTAGE OF 16-20 YEAR OLD FEMALE RESPONDENTS (13 OF 294) TO THE ONLINE SURVEY WHO WEAR DRESS SIZES 8-24+. 122
TABLE 8. CHART SHOWING PERCENTAGE OF 20-35 YEAR OLD FEMALE RESPONDENTS TO THE ONLINE SURVEY WHO WEAR DRESS SIZES 8-24+. 122
TABLE 9. CHART SHOWING PERCENTAGE OF 35-55 YEAR OLD FEMALE RESPONDENTS TO THE ONLINE SURVEY WHO WEAR DRESS SIZES 8-24+. 123
TABLE 10. CHART SHOWING PERCENTAGE OF 55-70 YEAR OLD FEMALE RESPONDENTS TO THE ONLINE SURVEY WHO WEAR DRESS SIZES 8-24+. 123
FIGURE 3. CONVERGENCE OF EVIDENCE RECOGNISED AS A BASIS FOR THIS RESEARCH. 125
TABLE 11. CHART OF FRONT BODY SHAPES BY TYPE AS A PERCENTAGE OF TOTAL RESPONSES TO THE ONLINE RESEARCH SURVEY. 127
TABLE 12. TABLE OF THE THREE PARTICIPANTS’ BODY SHAPE AND POSTURE RELATED TO THE DESCRIPTIONS AND IMAGES DEFINED FOR THE ONLINE RESEARCH SURVEY. 129
FIGURE 4. EXAMPLES OF MERINO WOOL GARMENTS ON SALE BETWEEN AUTUMN/WINTER 2010 AND JUNE 2011. 138

CHAPTER THREE
FIGURE 1. DIAGRAM OF THE PRINCIPLE ANTHROPOMETRIC PLANES AND TERMS OF ORIENTATION. 156
FIGURE 2. DIAGRAM OF BODY LANDMARKS FOR LARGER SIZED FEMALE BODY SHAPE 163
FIGURE 3. WAIST AND HIP Girth BODY SLICES EXTRACTED FROM PORTIA’S BODYSNAP. 164
FIGURE 4. FIVE VARIATIONS IN WAIST PLACEMENT ON PORTIA. 167
FIGURE 5. MEASUREMENT LINES FOR LARGER SIZED FEMALE BODIES SHOWING RELATIONSHIPS TO LANDMARKS. 170
FIGURE 6. MEASUREMENT NETWORK FOR LARGER SIZED FEMALE BODIES, SHOWING RELATIONSHIPS TO LANDMARKS - FRONTAL VIEW. 172
FIGURE 7. MEASUREMENT NETWORK FOR LARGER SIZED FEMALE BODIES, SHOWING RELATIONSHIPS TO LANDMARKS - ANTERIOR VIEW. 173
FIGURE 8. CLONE BUILDING. 176
FIGURE 9. A SERIES OF IMAGES SHOWING THE CLONE BUILDING PROCESS FOR DESDEMONA. 177
FIGURE 10. JULIET FULL SIZE BODY CLONE. 178
FIGURE 11. EQUIPMENT USED WHEN MEASURING JULIET. 180
FIGURE 12. MEASURING JULIET, TWO VIEWS. 182
FIGURE 13. MEASURING JULIET, TWO SIDE VIEWS. 183
CHAPTER FOUR
FIGURE 1. PHOTOGRAPHS OF THE THREE PARTICIPANTS. 207
FIGURE 2. PROCESS MAP DESIGNED THROUGH DEVELOPING THE PILOT STUDY RESEARCH GARMENTS. 2005-2006. 210
FIGURE 3. THE TEMPLATE FOR THE BIL2A DEVELOPMENT OF THE EARLY PROTOTYPE GARMENTS. 213
FIGURE 4. VISUAL REPRESENTATION OF THE SYSTEM DESIGNED IN THIS RESEARCH SO THAT DIMENSIONS OF LARGER BODY SIZE ARE CORRECTLY INPUT INTO THE SPAINT GARMENT DEVELOPMENT TABLE. 215
TABLE 1. COMPARISON OF DESDEMONA’S MEASUREMENTS TO THOSE OF A STANDARD SIZE 20. 219
FIGURE 5. PHOTOGRAPH OF DESDEMONA DURING MEASURING. 221
FIGURE 6. WORKING ON MINI9PHIL2.DAT SCHEMATIC. 224
FIGURE 7. DIAGRAM OF THE SHORT ROWS INVOLVED IN KNITTING THE THREE DIFFERENT FLÈCHAGE DARTS. 226
FIGURE 8. SPIRAL A AND B BUST DART FLÈCHAGE SAMPLES. 228
FIGURE 9. GRAPHICAL REPRESENTATION DEMONSTRATING THE EFFECT OF SPIRAL A FLÈCHAGE. 229
FIGURE 10. THE REVISED RIGHT HAND SLEEVE TEMPLATE SCHEMATA FOR DESDEMONA 3. 232
TABLE 2. TABLE OF THE KNITTED PIECES FOR THE DESDEMONA 2 GARMENT. 233
FIGURE 11. THE FOUR TEMPLATE SCHEMATA OF THE DESDEMONA 2 PIECES. 234
FIGURE 12. EVALUATION PHOTOGRAPHS OF DESDEMONA 2 ON THE CLONE AND DESDEMONA. 237
FIGURE 13. EVALUATION PHOTOGRAPH OF THE FRONTAL VIEWS OF DESDEMONA 2 ON THE CLONE AND ON DESDEMONA. 238
FIGURE 14. EVALUATION PHOTOGRAPH OF DESDEMONA 2 ON THE CLONE. 240
FIGURE 15. EVALUATION PHOTOGRAPH OF THE RIGHT BUST DART ON DESDEMONA 2. 241
FIGURE 16. EVALUATION PHOTOGRAPHS OF DESDEMONA 2 ON DESDEMONA. 242
FIGURE 17. EVALUATION PHOTOGRAPH OF DESDEMONA 2 WORN BY THE PARTICIPANT. 244
FIGURE 18. EVALUATION PHOTOGRAPH OF THE LEFT SLEEVE OF DESDEMONA 2. 245

CHAPTER FIVE
FIGURE 1. PHOTOGRAPHS OF EARLY EVALUATIONS LEADING TO JULIET 1 GARMENT. 253
FIGURE 2. THE EVALUATION OF JULIET 2. 255
FIGURE 3. STRIPED FULLY FASHIONED GARMENT THAT DOES NOT RELY ON STRETCH TO FIT. 258
FIGURE 4. DESDEMONA 3 SLEEVEHEAD EVALUATION. 264
TABLE 1. TABLE OF SHOULDER RELATED MEASUREMENTS GENERATED WITH THE RESEARCH MEP FILE FROM PORTIA’S BODY SCAN. 266
FIGURE 5. THE THREE PARTICIPANTS: PORTIA, DESDEMONA AND JULIET. 267
FIGURE 6. FRONTAL PLANE ‘SKINNED’ IMAGE OF THE DATA GENERATED FROM PORTIA’S 3D BODY SCAN. 268
FIGURE 7. SCREENSHOT OF THE BASE PATTERN, PORTIA 4A GARMENT. 270
FIGURE 8. PORTIA 4A. 272
FIGURE 9. STILL IMAGE FROM PORTIA 4A EVALUATION. 274
FIGURE 10. PORTIA 4A, BACK VIEW. 277
FIGURE 11. STILL PHOTOGRAPHS EXTRACTED FROM THE EVALUATION VIDEO. 278
FIGURE 12. STILL IMAGES FROM PORTIA 4A EVALUATION. 280
FIGURE 13. STILL IMAGE FROM THE EVALUATION VIDEO OF PORTIA 4A. 281
FIGURE 14. STILL IMAGES FROM THE EVALUATION VIDEO OF PORTIA 4A. 283
FIGURE 15. THE PORTIA 5 PROOF-OF-CONCEPT GARMENT KNITTED BY SHIMA SEIKI EUROPE LTD. 285
FIGURE 16. THE PROOF-OF-CONCEPT GARMENT KNITTED BY SHIMA SEIKI EUROPE LTD. 286
FIGURE 17. MARKS & SPENCER CLASSIC, ROUND NECK, SET-IN SLEEVE JUMPER IN A SIZE 20. 288
APPENDICES

FIGURE 1. PATOU SWEATER. C.1925-30. 500
FIGURE 2. CHANEL-INSPIRED JERSEY JACKET IN DARK SALMON COLOURED, C.1929-1930. 501
FIGURE 3. ST MARGARET'S, BLUE AND PEACH PLATED WOOL AND RAYON JUMPER SUIT, 1927. 504
FIGURE 4. APPLE GREEN FINE GAUGE SINGLE BED KNITTING JUMPER SUIT WOOL, C.1930. 505
FIGURE 5. JUMPER FROM A GREEN KNITTED SUIT AND PAGE FROM WILKINSON AND RIDDEL CATALOGUE, 1930. 506
FIGURE 6. ST MARGARET'S BRAND CUT AND SEWN JUMPER, 1920S. 507
FIGURE 7. RED ARTIFICIAL SILK JUMPER C.1926. 508
FIGURE 8. FULLY FASHIONED RED WOOL CARDIGAN IN SINGLE BED, 1950S. 510
FIGURE 9. FULLY FASHIONED TURQUOISE WOOL CARDIGAN, 1950S. 511
FIGURE 10. PAGE FROM BELL & NICHOLSON'S CATALOGUE, 1959. 512
TABLE 1. TABLE OF LARGER Sized KNITWEAR FROM THE HODSON SHOP COLLECTION. 514
FIGURE 11. COMPARISON OF TWO 'FASHION' CARDIGANS IN SAME STYLE. 516
FIGURE 12. COMPARISON OF TWO FULLY FASHIONED GARMENTS, BOTH LABELLED SIZE 18. 2007. 518
Acknowledgements

Without the belief and commitment of the participants, this project would not have been possible. I would therefore like to give special acknowledgement and thanks to the women who gave their time so generously and their opinions so honestly.

I particularly wish to thank the following individuals and companies for the helpful advice and generous support they have provided throughout my research:

Dr David Bruner of the Textile Clothing Technology Corporation, Cary, North Carolina.
Dr Jerome Leary of the Faculty of Science and Engineering, University of Brighton.
Jeni Bougourd.
Nick Young of the Faculty of Science and Engineering, University of Brighton.
Nina Shephard, Marketing and Design Management Specialist.
Shima Seiki Europe Ltd.
Woodhead Publishing.
Wykes International.

I am deeply indebted to Professor Lou Taylor for her supervision throughout this project.

I would also like to acknowledge the support received from the Research Student Fund through the Faculty of Arts’ Centre for Research Development at the University of Brighton, which has provided funding for materials and travel in support of this research.

For keeping me focused, I owe heartfelt thanks and friendship to Gail Kennington.

Finally, words fail me when I try to express my enduring gratitude to my family for their continuing faith and patience whilst I pursued my passion, and in the process robbed them of the attention they deserved.
Declaration

I declare that the research contained in this thesis, unless otherwise formally indicated within the text, is the original work of the author. The thesis has not been previously submitted to this or any other university for a degree, and does not incorporate any material already submitted for a degree.

Signed

Dated
Introduction

When designing this research, it became clear from initial reading and anecdotal evidence and experience that women over a UK size 16 were having difficulty buying fashionable clothing that fitted their body shape. Knitwear seemed to present a particular problem because of the way knitting clings to both desirable and undesirable curves.

Through exploratory reading of feminist literature related to issues of body shape and size, including Bordo, Orbach, Seid and Millman, it became obvious that women’s negative experiences with the fit and availability of clothing were associated with those of their body image, self esteem and body cathexis. Therefore the practical problems of satisfactory knitwear purchase and fit, coupled with the social and cultural issues of large sized women’s body image and self esteem in the context of their clothing, suggested that improving the fit knitwear for larger sized women was an area with considerable potential for practice based research.

In order to achieve physical outcomes, a fresh understanding of larger female 3D body shape specific to knitwear, was required. Once having achieved this new, contextual understanding of larger 3D body shape, the intention was to develop the use of strategically placed 3D knitting methods to created garments that improved the fit preferences of real women and offered an enhanced fit for larger body shape types. The research was developed through the creation of a case study collection of prototype knitwear toiles, designed to exemplify techniques, not as a final, styled fashion collection. Furthermore by developing the knitwear on V-bed electronic knitting machinery of a type that was widely available within the knitting industry, outcomes would be accessible and transferable, thereby offering commercial
opportunities for exploitation of the research findings on a wider, industrial scale.

During the development of the research idea and through the chronological progress of the research, it became apparent that the study crossed a number of disciplines. The demanding technical skill level and multi-disciplinary nature of the study became increasingly apparent, providing possible insight as to why this field of research has, until now, remained largely unexploited. In response to this, innovative methods and processes had to be developed and incorporated into the research methodology where appropriate.

This was therefore not a purely technological investigation, neither was it based exclusively in knitwear design, the fit of knitwear or the physiology or psychology of larger size. It was instead a cross-disciplinary enquiry, exploiting existing experience in all these fields, and developing new skills which have been used to create an original set of knitwear matched with fresh research methodology, research methods, and outcomes.

This research has, as will be shown, developed knitting methods which enable an improved fit in knitwear for larger body shapes. It is important to stress that the prototype garments which were the outcome of this research are not finished fashion garments, but toiles from which future knitwear based on the research idea can be styled to meet fashion needs. Other stitch structures, colour patterns, and design or styling details may be substituted, providing they do not compromise the underlying knitting methods.

In order that the background to the research idea may be clearly differentiated from both proposed and realised practice based activities, the literature reviews for these have been included in the relevant separate chapters. The theoretical background,
research activities and practice based research are chronologically charted in this text and are outlined here.

Chapter One introduces and explains the background to the research idea and rationale, discusses the relevant literature and establishes the aims and objectives of the practice based research. Chapter Two describes the research themes, methodologies and processes which were designed for this project, and discusses the literature relevant to these. Following this, Chapter Three charts and exemplifies the development of a research framework for working with larger sized 3D body shape and knitwear. Chapter Four describes the application of the practice based research framework, the practical challenges encountered in developing methods for applying 3D knitting to larger body shape, and solutions developed in response to these. It also includes a detailed example of the application of the research design process. Chapter Five contains the detailed evaluations, by both researcher and participants, of the resultant knitwear. In Chapter Six the findings of the research practice are consolidated, conclusions are drawn from the practice based research and future possibilities are discussed.

It was recognised from the start that pre-existing projects influenced early developments of the research idea, SizeUK (the first national sizing survey since the 1950s carried out between 2000-2001, the results of which were publically published in 2004), and the 1999-2002 E-TAILOR project into e-commerce and the mass customisation of clothing were both formative to the research idea. Meanwhile the Swedish Knit on Demand project, which is discussed in Chapter Two, section, 2.3.5, confirmed the need for further development in the field of customised knitwear design beyond that which had actually been achieved. It should also be noted that the original idea for this research, which began in 2005, preceded others with similar interests that
have occurred since. These include that of Brownbridge at Manchester Metropolitan University, started in 2006, which has identified the need for new thinking in the sizing of knitwear, and Black’s project at the London College of Fashion (2008-2009). It likewise pre-dated the report from the EU SERVIVE project, published in August 2011, which highlighted women’s knitwear and larger sizes as areas ripe for development towards mass-customisation. Such a proposal from an eminent, international, EU funded project did however confirm that this PhD research was at the forefront of fresh thinking about large size knitwear fit and satisfaction, and that its findings have contributed new knowledge in the highly specialised field of knitwear for larger sizes, and to the still evolving concepts and processes of mass-customised clothing for larger sized women.

1 Kathryn Brownbridge, Hollings Faculty, Manchester Metropolitan University, http://www.hollings.mmu.ac.uk/index.php?option=com_content&task=view&id=250&Itemid=45. n.pag.7.7.2012. {, #543@n.pg}

2 {, 2011 #1089 @18 and 55}
1 Rationale for the research idea, related literature review, and aims and objectives

1.1 Introduction

It is a premise of this research that large women’s shapes vary in height, girth and posture to a degree that causes difficulties for them when trying to purchase pleasing clothing, especially fashion knitwear with its stretch problems, available from amongst the racks of products available in the majority of fashion retailers.

A number of national sizing surveys have been conducted in the last ten years indicating a growing awareness that there has been a change in the body size of the population. These started with SizeUK in 2000-2001, which has been followed amongst others by those in America (SizeUSA), France (‘Campagne National de Mensuration’), Spain, Brazil, and Thailand. SizeUK, SizeUSA and both Spanish and French surveys confirmed some change in their population’s average body size.3 Meanwhile recent studies have predicted that 36% of the female population in the UK will be classified as obese by 2020.4 If this prediction is correct, a significant amount of the female population will fall into what is commonly termed the ‘plus’ or ‘out’ size clothing market. Despite this trend, and the huge potential consumer market that clearly exists, much research has concluded that larger women experience


dissatisfaction with clothing fit.\(^5\)

### 1.2 Knitwear for large sizes

It will aid clarity if the difference between knitwear and knitted garments, as discussed in this text, are defined from the beginning. Either of these generic terms can cover a cut-and-sewn or a shaped garment. For this research however, knitwear was taken to mean a garment that was predominantly knitted to shape, with an integrally knitted hem rib or welt, whilst a knitted garment was taken to mean one that was completely cut and sewn from knitted fabric.

It had been acknowledged by Brackenbury in 1992, that historically, commercial knitwear relied on its inherent elasticity to follow the body’s contours, thereby accommodating dimensional differences that fell outside standard sizes and reached some kind of ‘fit’.\(^6\) When developing the rationale for this research, it was noted by the researcher that stretch in knitwear was still being used on the high street to achieve fit over wide extremes in body shape. The size designators ‘S’, ‘M’, ‘L’, a bust measurement alone, or even occasionally ‘one size fits all’, left the consumer with little or no information about a garment’s real dimensions or, particularly important for a fashion item, intended fit. This formed a fundamental corner stone to the research idea.

Current knitting technology enables side seam shaping and darting to fit the body as is commonly employed when working with woven fabrics, and yet the researcher observed ,during store research in 2005 and 2007, that although side seam shaping

---


was seen in modern commercial knitwear, darting was rarely used. It was also evident
that side seam waist shaping was placed at standard levels, not necessarily where
larger body shape would require it. The result of this could be seen in knitted garments
in high street stores that clung over parts of the body when worn on larger body
shapes, even if they fitted elsewhere. Responses to this research, as will be shown in
section 1.4, indicated that larger women can find this uncomfortable and unflattering,
and therefore may eschew knitwear as an apparel choice. (See Online Survey
Responses, respondents 18, 39, 52, 78, 211, 259, 260 in Appendix E) The central
issue of stretch in knitwear was thus identified as key to this research.

1.2.1 The problematic consequences of stretch-to-fit in larger sizes

A technical explanation of stretch in knitting is included in Chapter Two section
2.3.9., but for this research, stretch was seen to occur in the following way. When the
fabric was relaxed, within a measured square of fabric there were a particular number
of stitches and rows and the fabric looked as it was intended by the designer. When
the fabric was stretched, the area covered by the same number of stitches increased, or
to put in another way, the number of stitches and courses per centimetre of fabric was
reduced. The first effect was to distort the fabric, depending on the direction of stretch
this would narrow or widen the stitches as they extend. A secondary and undesirable
visual effect of extension was to increase transparency, thereby highlighting
prominent areas of the body by colour shading and show-through of skin or
undergarments.

These two direct effects of stretch; moulding to the 3D body shape and reduced
opacity over bodily prominences, have been proven in this research to be generally
undesirable to larger women. This was established, through participant interviews and
anecdotal data which will be discussed in section 1.4. of this chapter, to be why
commercial knitwear is often avoided by larger women. (See Appendix E for interview transcripts and survey responses)

1.3 The needs of an increasingly larger sized and older population

Attendant to the issue of larger body shape was that of an ageing population, as certain features of body shape were shown to be shared by both larger sized women and the ageing body shape. Meanwhile an increase in longevity and reduced birth rates has created a proportionally larger older population throughout the Western world. In 2006, Mintel predicted that, based on consumer numbers and sales values, clothing sales to the 45+ age group could soon outstrip the overall clothing market. Twigg further reported in 2010 that £12.2 billion had been spent by the over 45 age group on clothing in 2006.

Therefore for the first time ever there is potentially a bigger market (with proven significant buying power) for fashionable clothing to fit older body shape than there is for that of younger people. The similarities indentified between larger body shape and ageing body shape were important to the development of the research idea, and were considered to offer potential for wider commercial impact of the outcomes.

1.4 Rationale for the research idea: research interviews and survey responses

Background information for the research was gathered through interviews with the research participants whose involvement and recruitment is discussed in Chapter Two section 2.4.2.1., and via online survey which will be discussed in detail in Chapter Two section 2.4.1.

---

Whilst conducting interviews with the participants in this research, they all expressed frustration with the sizing and availability of their size in desirable clothing on the high street. Desdemona, (first participant in the main study) and Portia (the second participant in the main study), both found shopping in mainland Europe far more satisfying in this respect, having found both Germany and France to offer superior ranges and choices in larger sized clothing.

1.4.1 Interview with participant: Desdemona

Desdemona’s description of a recent European shopping experience was,

"I had a wonderful shopping trip [in Germany]. Its not like here. Here you have to look so hard to find something you like, and then it’s not in your size. In Germany it’s all on the rail, sitting here, -on the rail - for you to choose from."

She continued by asking,

"Why can't British shops be like that? More mature women want to look nice, we want to buy what suits us, what we've learned we look good in, not these [gesture to midriff] up here, girly things".

In a later interview her comparison of the two shopping experiences concluded with,

“...here [in England] I couldn’t find anything fashionable or nice. So in Germany you could buy fashionable, clothes you wanted to buy, not just because they fitted. They were the right size, but they’d fit better as well.”

In addition she commented on the affordable prices of well fitting larger sizes in Europe,

"But it’s not expensive [in Germany]. I bought lots of tops, and trousers, really well fitting, lots of well fitting trousers. But nothing was expensive. Tops, tops were nothing over £20. This blouse was one of them, really nice things for £20, and in my size, on the rail."

Desdemona’s emphatic re-iterations of ‘on the rail’, ‘in my size’ and, ‘in your size’ reflected her positive response to unexpected experience.

---

9 Desdemona (Participant 2), (2008), Interview 2 - after weight loss, 9th January: 2.
10 Desdemona (Participant 2), (2006), Interview 1 - about purchasing clothing and body type, 19th September: 1.
In contrast, Desdemona reported that after her weight loss of sixteen kilos later on in the research, the consequences of which are discussed in Chapter Five, she found it easier, and a completely different experience, when shopping for attractive clothing. During a post-weight loss interview, her enhanced body image and her own more positive self image reflected similar behaviour as described and discussed by Rudd and Lennon, who linked body image to self esteem.\(^1\) This was clearly evidenced in her report that she now wore waisted clothing and her positive description of wearing a broad belt, “...it looked lovely”, which was the opposite of previous clothing choices and self-descriptions of her former size and shape. Desdemona also retrospectively reported a preference, as identified by Chattaraman and Rudd, for disguising her former, larger self by wearing,

“... loose shirts, loose jumper, with a nice little tee shirt under, so you know, it looked flowy, whereas now I can wear tight.”\(^2\)

When questioned about the shops she preferred when larger sized, she replied,

“It got really a bit difficult and it ended up with *Marks & Spencer* because they always have quite generous cuts. But you see I could compare because I used [to] go to traditional shops, *Laura Ashley*...you know on the bigger sizes but they used to look OK on me and I couldn’t find clothes in *Laura Ashley* anymore.

*[Kaliko is]*, expensive and they’ve got a very small range but its really lovely and I couldn’t fit into any of their stuff anymore. But *Next* you could forget about. I couldn’t, couldn’t fit into any of their stuff. But I’m terribly disillusioned with most of the clothing in this country anyway ... I’ve never found it easy, I prefer small boutiques or small places, not the sort of trendy ones. I’ve never found stuff I wanted in there. But I had to give all that up and that’s why I ended up in *Marks & Spencer* and *Debenhams* and you know. Oh, the other one I ended up in, oh my goodness, whats it called, with E?

*[Evans?]*

Oh yeah, I did! [laughing] and it was so sad. It’s so depressing, because the quality is so poor.

But that’s where I ended up - where anything fitted. I couldn’t find anything anywhere else, and that’s why I ended up, especially the last few years’ buying stuff in Germany because they have cheaper shops like Evans, (It’s not expensive), umm but the quality is better and the variety is better”.13

This reflective monologue has been included in the text because it so clearly illustrates Desdemona’s negative shopping experience in the UK high street, along with her responses to the clothing that she found in her size (which was an 18-20 at this time).

Another significant passage in the interview was regarding her clothing preferences as a size 18-20 woman. In response to this she stated that she had, when larger, bought what was available rather than what she desired, saying,

“Yes, I was totally limited, even in Germany. It was about looking through and anything that was reasonably nice and fitted me, I would buy. And now [after weight loss] I would look at it and think ‘not really’. So it [being a smaller size and shape] has actually changed the way I dress, because it wasn’t what took my fancy or that I really liked... it was really about what was available...in my size.”14

Desdemona demonstrated a clear recognition of the importance of not just size but shape, in the fit of garments when she observed,

“... when you go to Evans. There is something about the way these big clothes are tailored. They don’t fit properly... [On television] you see really big women dressed flamboyantly and I think it all has to do with a good cut. I noticed sometimes, when I was a big size, that in a really, really expensive outfit I could look a different person, I could look a million dollars. But I couldn’t go out and buy them.” 15

Overall Desdemona’s displayed a preference, whatever her size, for small chain stores or boutiques that offered well fitting individual clothing in the mid range price.

Generally price was a factor in her clothing purchases. However Desdemona reported

13 Desdemona (Participant 2), Interview 2: 7.
14 Desdemona (Participant 2), Interview 2: 9 and 10.
15 Desdemona (Participant 2), Interview 1: 9.
that she would pay considerably more for particularly attractive, well fitting, special occasion apparel, and that she tended, “...to spend a fortune if I do see something, you know, if I see something that’s really stunning.”\(^\text{16}\)

Her former style preference when larger had been for looser fitting, ‘disguising’ clothing, but she asserted this to have been rooted in the inadequacies of the shape of the tailored and classic larger sized clothing available in her price range, rather than personal choice. Her opinions were based on personal experience of high street shopping in the UK, and confirmed that she displayed sophisticated understanding of fit and well developed self awareness in her clothing preferences, something which was mirrored in many survey responses. Her attitude to the larger sized clothing available in the UK high street in comparison to that in Europe was in line with that expressed by Portia, whose shopping experience and preferences will be discussed next.

### 1.4.2 Interview with participant: Portia

Portia had originally been recruited as representative of one of the most common female body shapes. She too became more toned during the period in which she was involved in the research, due to taking up sports. Overall, she reported that she had found purchasing well fitting lower garments, particularly trousers, to be difficult at any size, and preferred ‘A’ line to pencil or pleated skirts as the latter emphasised her hips and thighs.

When a size 18, the size and shape at which she was recruited, manually measured and digitally 3D body scanned, she had consistently experienced clothing shopping as, ‘difficult and depressing’, and found it easier to shop from catalogues and internet sites which offered larger sizes in styles she knew from experience would fit her. She

\(^{16}\) Desdemona (Participant 2), Interview 2: 9.
described herself at this size and shape as wearing, ‘a strange mixture of internet clothes.’

Portia explained how her knitwear preferences had changed from when she was both younger and a size 10 saying,

‘I used to like jumpers, particularly patterned jumpers, but I realised...a few years ago, that perhaps that wasn’t such a good idea any longer’. She observed however that, ‘I do like jumpers - I like to wear a V-necked black sweater. What I find there is that very often they’re a bit short... I like something a bit longer, and that’s quite hard to find.’

Her rationale for this choice was that, ‘I like [jumpers] longer. I suppose just below the stomach, because that’s the bit that sticks out ... what happens with those shorter ones is that they ride up ... and its just not very attractive.’ In response to being asked what sort of jumpers she now liked, she expressed clear choices, stipulating that they should be, ‘ ... fine wool and reasonably close fitting.’ She explained that she didn’t like things too loose because, ‘ ... when you get a bit bigger the temptation is to wear a tent - and that isn’t always the best answer.’ She continued,

‘But to find something that sort of skims the body and is flattering without sort of sticking to you and showing up every wrinkle of flesh is quite difficult.’

After weight loss, she found she could be more experimental in her clothing purchases and, in contrast to Desdemona, would now spend more on an item, being confident that it would be the right size, (although she observed that this may have been influenced by a positive change in her financial circumstances). For example, in 2006 Portia would not have considered purchasing a cashmere jumper, especially if it required hand washing which she was not prepared to do. Now she would consider spending up to £100 on a well fitting pair of trousers, whilst her habit of buying from

---

17 Portia (Participant 3), (2009), Interview 2 about clothing purchasing and body size, 27th February: 3. Portia (Participant 3), (2006), Interview 1 about clothing purchasing and body size, 19th July: 1.
18 Portia (Participant 3), Interview 1: 1.
19 Portia (Participant 3), Interview 1: 1 and 2.
charity shops has diminished commensurately.

When larger, she had chosen dull, ‘disguising’ colours and avoided dresses and skirts, even though she found buying well fitting trousers difficult. She reported having more self confidence once she no longer considered herself large, but more ‘normal’ sized. A clear parallel can be drawn with the raised self-esteem and body image encountered in Desdemona once she considered herself a to be of a size and shape to be able to purchase more widely available styles in sizes that would fit her. This elevated self esteem was also reported by a survey respondent, who reported losing weight to become a ‘standard’ size and subsequently feeling, “…more like a woman”, and that,

“One dress size makes a lot of difference in what I wear and how I feel about myself. No longer do I feel limited to the basic black that are sold for women of size”. (Respondent 64)

It should be noted however that this reference to black did not hold true during the shop survey conducted in 2007, during which a number of designers for larger sizes, including the UK plus size designer Anna Scholz, were found to offer extremely bright clothing for larger sizes. Therefore this might have been a reflection of this respondent’s need to disguise her body shape in the same manner as that described by Portia. Overall when a size 18, Portia’s shopping preference was to buy neutral coloured clothing from Marks & Spencer, mail order catalogues such as Boden and European retailers. Once she was ‘normal sized’ (although the same shape), Portia preferred small boutiques that cater for the ‘more mature’ woman, buying individual styles including skirts and dresses in bright colours where possible. She spent more in total on clothing and on individual items, as mistakes were less likely due to clothing being increasingly likely to fit her, and although she still used Marks & Spencer and

20 Portia (Participant 3), Interview: 3.
Boden it was now through choice not necessity. She considered her clothing selection to have become more experimental, and observed that she now sent her mistakes to charity shops, rather than herself buying other people’s mistakes (once again this may have been partly affected by personal economic changes).

The analysis of these two responses confirmed that larger sized women lacked choice in clothing on the UK high street, being relegated to major retailers such as Marks & Spencer which are more likely to cater for their size. The specialist large size clothing multiple stores such as Evans and Ann Harvey were found to be perceived by many larger sized women as offering badly fitting, unfashionable clothing and other anecdotal evidence, as discussed next, was found to further endorse this view.

1.4.3 Background anecdotal information from the online research survey

Anecdotal responses supplied through a free text area provided in the online research survey were enlightening, and provided rich evidence about shopping experiences and clothing choices amongst larger sized women.21 In line with Desdemona and Portia’s anecdotal interviews, UK respondents found the choice limited and unexciting, one wrote,

“Because shops are at the mercy of ‘fashion’, for the past few years it has become impossible to buy loose-fitting tops. I have spent many fruitless hours wandering round the main clothing stores - e.g. M&S. Debenhams, House of Frazer unable to buy anything that looks half decent.” (Respondent 10)

Whilst the experience described here was not exclusive to larger size, the reference to the unsuitability of many fashionable styles for larger sizes was echoed by Desdemona who said, “…if you look at the catwalks stuff, most of that stuff couldn’t be carried off by normal people, could it?”22

---

21 Vikki Haffenden, Knittofit website, <http:\www.knittofit.co.uk>.
22 Desdemona (Participant 2), Interview 2: 9.
Another feature of fashionable and, often but not exclusively, lower priced clothing was highlighted by respondent eleven who replied that she found it, “Extremely difficult to find stylish affordable clothes in my size. Fabrics are often man-made”. In this observation she was exhibiting the preference for natural fibres often found amongst larger sized women, (because they tend to overheat and find synthetics less comfortable when perspiring), that was noted by Deckert in *Sewing for Plus Sizes.*

The practice of assuming that women who have larger girths are equally tall is criticised by a number of respondents who recognised and bemoaned the lack of correctly proportioned sizing in plus sized garments. Respondent 13 wrote,

> “Clothing manufactures do no not take into account that because you are overweight on most of the body your shoulders may not be wide. Therefore set-in sleeves look more like drop shoulders and the whole look is out of proportion.” (Respondent 13)

This respondent displayed the quite sophisticated knowledge of clothing styles and garment cutting that is echoed in other replies by adding, “This anomaly could be overcome by the use of raglan sleeves on large sizes. But this cut is very hard to come by”. In a similar vein respondent twenty one wrote,

> “I would like to know why if you have a big bust, manufacturers think you have shoulders the size of football player.’ (Respondent 21)

Yet another wrote about finding garments with,

> “Armholes that are lower than your bra, neck holes that are wider than your bra straps”. (Respondent 14)

This comment quite clearly highlights another result of the aforementioned designer and manufacturers' misunderstanding of larger body shape which was a common theme the majority of survey responses. (Appendix E)

The issue of disparity between upper and lower body size and its attendant

---

problems for clothing purchasing, was raised by many respondents. Respondent eighteen wrote, “I haven't been able to buy a one piece dress in fifteen years - can't fit both the top and the bottom”. The difficulties of buying clothing that fits the larger ‘pear’ shape with a bigger lower than upper body size were described in this message, “It seems to me that sizing standards for the highest sizes need to recognize that the hips are usually 8+ inches larger than busts and make clothing to fit that standard. Also, most plus-size folks I've measured have relatively small necks & shoulders” (Respondent 28)

A different fitting problem, as highlighted by respondent Thirty Nine, is that she found sleeves on fitted garments to be too tight on the upper arm because she had a larger bicep measurement than was allowed for in the garments she tried on. Both these issues became focuses for the research and the effect of larger bicep size on the knitwear development is discussed in Chapter Three section 1.7.

The problem of the availability of larger sized clothing was reflected in the survey by one respondent. When discussing finding suitable clothing in her size, she wrote, “I live in a 'clone' town where there are no individual shops. For those I have to travel to Bath, Bristol or Cheltenham which adds cost to an already expensive outing. Clothing for my size (and age) is either extremely expensive or non-existent.” (Respondent 10: 55-65 years old, size 16)

Thus it was clear from these responses that the issues which larger women had with achieving clothing satisfaction centred primarily on the sizing of clothing. Amongst other things, it was found that dissatisfaction with fit was caused by unsatisfactory sizing of clothing. These issues were then shown to have been compounded by a lack of availability of clothing in styles that larger sized women wished to purchase.

1.5 Literature review of the rationale for the research idea

1.5.1 Sizing, fit, and availability of larger sized clothing and knitwear

In order to understand the very real consequences and significances of large size women’s body anxieties, this research has been placed in the context of established
cultural attitudes to larger sized women and their clothing needs through a literature review of the Twentieth and early Twenty First century.

Although outsize knitwear was not found to have been documented as a separate historical study, it had been possible to gauge social attitudes to larger sizes within the commercial clothing industry in the UK in the 1930s. One example was that given by Eric Pasold (founder of the Ladybird clothing label) who remembered a clothing wholesaler’s explanation for not re-ordering Pasold’s knitted Directoire knickers. His reason was that women now wanted light-weight underwear, and only ‘the very big ones’ still bought the fleecy Directoires offered by Pasold, as there was no alternative. In his words, ‘Manufacturers of up-to-date garments don’t cater for them [larger women].’ Segregation, or omission, of larger sizes in the pre-Second World War period was found to be common. In a disarmingly frank article in Silk Journal and Rayon World of November 1929, the larger (and older) models in a mannequin parade are reported as, ‘built on generous lines ...’ but ‘extraordinarily handsome ...’ and that, ‘smiling above their double chins, [they] walked heavily down the dais...’ The clothes were described as ‘correct wear for the large woman’, implying at least a commercial recognition in 1929 of this market, but also reflecting a stigma to large size. Both reports marginalised larger women and indicated that the larger woman’s desire for fashionable and comfortable clothing was considered to be less important than that of other women.

During the analysis of a large collection of surviving wholesale clothing catalogues from the 1920-50s in the Hodson Shop archive conducted for this research, there was very little evidence of items classified as OS (outsize), or XOS (extra outsize).

These catalogues originally came from a small private dress shop in Willenhall near Walsall, and form part of the main Hodson Shop collection held at Walsall Museum. Similarly, during a search of London newspaper fashion advertisements of the 1930s, very few examples of large sized knitwear were found.

However, interestingly, in 1939 a sizing trial for the ready-to-wear clothing trade was held by the Fashion Group of Great Britain at the Dorchester Hotel. Alison Settle, the well known English fashion journalist and editor of *Vogue* from 1926-36, writing just afterwards, observed that this had been, ‘... most important for its repercussions not seasonal but permanent’, and was, ‘Of such national importance that reactions will come in, if slowly, yet with increasing weight.’ She continued by reporting that the *Daily Express* followed up with a, ‘... campaign to women readers asking are they able to get clothes that fit correctly and if not, what sizes were desirable?’ Settle observed that the trade papers had also taken up this issue, which had resulted in some important national clothing manufacturers altering both sizes and proportional measurements of clothing. 26 Within the scope of this research, this information may offer some insight into why, as established during this study, sizing began to be more obviously applied to knitwear after 1939. Although on a broader subject than knitwear, the existence of this sizing trial offers opportunities for future research, as little information seems immediately available about its impact, either in wartime production or thereafter.

It was not however, until the 1950s that sizing in the UK finally became partly standardised. This was largely the result of a national survey of women’s measurements and sizes that Kemsley carried out in 1957 for the British Joint

---

26 Alison Settle, 'Repercussions', 1939, unpublished manuscript. Alison Settle Archive, Design Archive, University of Brighton Box 3 FGS. 1. Print.
Clothing Council.\textsuperscript{27} From this point Kemsley’s data formed a basis for women’s clothing sizes until the 2003 SizeUK survey established modern body dimensions of the population.\textsuperscript{28}

As this research progressed from 2005, repeated high street searches indicated that from this point onwards, larger sized knitwear was becoming more common on the high street. Alongside the existing Arcadia group’s plus-size specialist $\text{Evans}$ stores (sizes 14-32) and Alexon’s $\text{Ann Harvey}$ outlets (sizes 16-32), $\text{Primark}$ supplied up to a size 22, Mackays brand $\text{M&Co}$ up to a size 28 and New Look up to a size 26 in their $\text{Inspire}$ range.\textsuperscript{29} In-store concession ranges such as $\text{Elvi}$, and own brand plus size ranges in Marks and Spencer, $\text{George}$ at Asda, $\text{H&M}$ and $\text{Wallis}$ offered additional choice for the size 16 plus woman.

Meanwhile a proliferation of increased size ranges and larger sized outlets had occurred online. Traditional mail order company J.D. Williams had developed online plus size ranges $\text{Marisota}$ and $\text{SimplyBe}$, Redcats Group owned both $\text{la Redoute}$ and the $\text{Taillissime}$ brand, offering up to sizes 32 and 36 respectively, and non-specialist companies such as $\text{Boden}$ catered up to a UK size 22 and $\text{Lands' End}$ up to a UK size 30 across some of their range.\textsuperscript{30} (Figure 1) Yet, despite all this apparent choice on the high street and online, larger sized women were still experiencing difficulty finding well fitting knitwear in styles that they wished to wear.

Of course whatever size or shape the purchaser, online shopping means that trying-

\textsuperscript{28} Allen, et al.: 1.
Figure 1. Screenshots from Simply Be and Boden's online stores, illustrating the knitwear sizes offered by specialist plus-size and non-specialist retailers. http://www.simplybe.co.uk/ and http://www.boden.co.uk. Accessed 29/7/2010. (ORIGINAL IN COLOUR)
on at point of sale is impossible. This shortcoming was reflected in Otieno’s conclusion from her 2007 study of online shopping behaviours that consumers prefer to limit online clothing purchases to obtaining the correct size or colour of an item they have already seen in a shop.\(^{31}\) An alternative to this was the online consumer practice of purchasing items, sometimes in multiple sizes, and returning unsuitable items after trying them on. As reported in *Drapers Record* of 2003, this practice caused stock control problems for online retailers, and as was partly addressed by *Lands’ End USA* in 2001 with their custom-fit trouser initiative.\(^{32}\)

Alongside the multiples and online suppliers as just described, there were found to be independent specialists, such as *Box 2* and *Curvety*, offering American and European knitwear amongst their selection. Customer interviews at one such outlet showed that the shop attracted customers from another city forty miles away as there was, in their opinion, nothing similar locally apart from multiple specialist large size retailers *Ann Harvey* and *Evans* from which they did not wish to purchase.\(^{33}\)

Customers of the same independent plus size retailer expressed dissatisfaction with online purchasing, even from ranges they knew, because they understood that even if a garment was the correct size, their body shape would look better in certain styles and that, as personal fit preferences governed their choices, they needed to try garments on.\(^{34}\) Customer’s self awareness and understanding of their body shape, as already noted, was recognised by Anna Scholz, a UK designer who specialises in larger sizes. Scholz explained during an interview that she catered for this in her plus size clothing range, by providing at least three styles in each fabric design; an empire line for ‘pear’

\(^{34}\) Brighton: 1.
shapes, a waisted look for hourglass and a straighter, longer tunic style for more rectangular body shapes.\textsuperscript{35}

The shopping experience for larger women on the high street was summed up by two respondents to the online research survey writing about their experiences of being a larger sized. The first respondent was referring to high street retail’s unchanged view of what, despite SizeUK’s findings to the contrary, was considered a ‘plus size’,

“\textit{Topshop} recently told me that they didn’t have any size 16’s left, as their policy was only to order two ‘specialist’ sizes in each range !!!!!!!!”. (Respondent 260)

The second observation referred to the limited choices available in larger sized clothing, about which respondent Fifty Six wrote,

“I hate the lack of choice on the high street. It means that whenever \textit{Evans/Ann Harvey} have anything nice, every large woman rushes to buy it and I see my clothes worn by other women.” (Respondent 56)

As previously stated, the fundamental premise for this research was that body shape is not standard, and furthermore that knitwear can be successfully fitted to individual body shapes that do not conform to standard sizes. This first premise was supported by existing research into larger sized apparel and clothing satisfaction. For example in 1988, Chowdhary and Beale studied plus size women’s clothing interest and found that 55% were not satisfied with what was available.\textsuperscript{36} This was reflected by Kind and Hathcote’s study of ‘speciality’ sized college women in 2000.\textsuperscript{37}

Even for non-plus sized women, finding well fitting clothing was obviously a problem. In 2010, a public survey into retail clothing size carried out by \textit{Which?} reported that 91% of women questioned did not trust retailers' sizing but needed to try on clothing to get the right fit. The same \textit{Which?} survey also reported variations in

\textsuperscript{35} Anna Scholz, (2011), Interview about the design process for larger sizes, 17th May: n.pag.
\textsuperscript{36} Chowdhary and Beale:783
\textsuperscript{37} Kind and Hathcote:315
sizing between retailers and even between same-brand ranges (Marks & Spencer Per Una range waist was reported as being 1cm smaller than their standard range waist measurement). Overall 82% of the women questioned were reported to have responded that they wanted clearer sizing on clothing.38

As many commentators, including Treleaven have already observed, the practise of ‘vanity sizing’ (labelling a larger sized garment with a smaller size), however flattering it may feel, has contributed to this confusion.39 In addition to these issues, larger sized women are far more likely to experience problems with clothing fit because, as Bougourd reported, in many cases these garments are mathematically ‘graded up’ from a smaller size, without consideration or understanding of larger body shape.40

Through this overview, a picture becomes clear of larger sized women with apparently improved retail purchasing choices but still having difficulties in finding well fitting commercially made clothing. It would seem that high fashion prefers not to cater commercially for larger sizes, and according to the comments gathered through this research, the provision of clothing at mainstream level for real larger sized women’s body shape remains substantially out of touch with their preferences. There are exceptions to the this, for example designer Anna Scholz, whose larger sized clothing range is sold through independent, specialist boutiques, and who told the researcher during an interview in 2011 that she considered knitwear a valuable part of her collection and easy to design for larger sizes precisely because it is fluid

and has stretch. Whilst Scholz was speaking from experience gained working exclusively with larger body shapes, she is not a specialist knitwear designer, and can command a higher price than most multiple high street stores; charging for example £199 for a silk/cotton jumper in 2011. Scholz’s knitwear for Spring/Summer 2011, sized from UK 20-30, included fully-fashioned fine gauge (14gge) loose fitting classic shapes and short ‘shrug’ style cardigans, thus avoiding the problem of tightness on the stomach and hips identified already in this chapter.

1.5.1.1 Sizing in knitwear manufacture

A search of literature specific to knitwear sizing revealed that this can be chaotic and confusing. In a 2007 study, Power and Otieno analysed the use of anthropometric data in knitted garments. One of their conclusions was that knitwear manufacturers preferred to work from generalised size codes rather than specific bodily dimensions. Myers McDevitt Davis, in A Complete Guide to Size Specification, confirmed this when discussing sizing of knitted apparel. She designated an S as a US size 6, an M as a US 10, and so on until an XL equated with a US size 18. She also commented that when fitting knits, “... the stretch property of the knit allows for ease of movement. However a woman with fuller hips, stomach, buttocks and thighs may find that the knit fabric unwittingly clings to her body”. This supported Power’s observation that the stretch of knitting was being used to bridge fitting discrepancies, a finding in line with the original premise of this research. Further evidence of this exploitation of the accommodating nature of knitting was provided by Anna Scholz’s

41 Scholz: n.pag.
45 Myers McDevitt.246.
46 Power and Otieno. " 379.
disclosure, discussed earlier, regarding the stretch of knitting being useful when designing for larger sizes. Part of this situation was clearly attributable to manufacturers' reluctance, and sometimes inability, to produce larger sizes. Tobin, a former buyer for Mackays and designer at Evans, observed during an interview in 2011 that manufacturers did not like producing larger sized knitwear for three main reasons. Firstly larger sizes used more materials, secondly fewer pieces could be knitted on a machine in a given time, and thirdly retailers, and ultimately the consumer, did not want to pay a premium on the clothing despite these additional manufacturing costs.47 (Appendix E) Although referring to Santoni (circular) seamless production, similar problems are described in relationship to sizing of circular knit seamless garments in Fellingham’s 2007 Seam-Less Knitting Technology. These would certainly adversely affect the production of larger sized garments by this method as well.48

In Knitting International of 2011, Brownbridge observed that knitwear manufacture in general requires, ‘...a different set of parameters [from woven goods] regarding use of body measurement data to achieve satisfactory fit’ and that in addition sizing practitioners do not seem to understand, ‘...which key body measurements are appropriate when specifying and programming complete garment dimensions’.49 She continued with a report on her ongoing research at Manchester Metropolitan University into complete knitted garment sizing which has concluded that current anthropometric data is, ‘...limited, restrictive and inappropriate for complete garment production’.50 Whilst this research was focused on developing a

---

47 Frances Tobin, Interview, 12th October 2007. n.pag.
new combination of knitting methods, it mirrored parallel current concern with ‘real’
body shape and the fit of knitwear as reported by Brownbridge.

In 2011, even in highly specialised, custom made knitwear, Petersen described how
body measurements were being taken manually. When documenting Shima Seiki’s
Ordermade which offered individual, custom-made knitwear, Peterson reported that a
shop assistant took the customer’s measurements. Although he added that the
measurer was skilled in clothing design, he neglected to indicate their level of
understanding of body shape, or indeed what measurements were taken, and which
ones the Ordermade system would accept.51 From these examples and discussions it
became clear that knitwear garment sizing is indeed chaotic. As such it forms part of a
continuing apparel sizing problem as described in Faust and Carrier’s 2007, Discard
"one size fits all" Labels!, in which they discussed the design, application and
configuration of a simple tool to enable mass customised size labelling.52

To conclude this discussion on clothing fit and that of knitwear and its stretch and
fitting problems and capabilities in particular, it is appropriate to consider individual
and cultural perception of clothing fit. In his 2003 Sizing and clothing aesthetics,
Lewis reflected on how women look in the mirror and manipulate their clothing to
achieve a personally satisfactory representation of fashion’s latest fit, i.e. tightly,
exactly or too big on the body. 53 In his further assertion that fashion displaces the
concept of fit he was stating that absolute fit does not exist and that instead, clothing
fit is totally subject to fashionable taste, dependent on what he termed the

51 Joel Peterson, et al., "Mass Customisation of Flat Knitted Fashion Products: Simulation of the Co-
52 Marie-Eve Faust and Serge Carrier, "Discard "one size fits all" Labels!", Handbook of research in
mass customization and personalization, ed. Mitchell M. Tseng Frank T. Piller, vol. 2. (Singapore:
‘intangibility of measurement’, and changes from loose to close fitting and back as part of the fashion cycle.\textsuperscript{54}

Loose fitting apparel being used to disguise a personally, or culturally unacceptable body shape was described by Liu in his 2006 paper, \textit{Perceived body size affected by garment and body mass index}, and has resonance with some of the preferences encountered during this research.\textsuperscript{55} This offered important understandings of how satisfactory clothing fit could be a personal choice, but was likely to be influenced by external factors and how the personal and cultural evaluation of ‘good fit’ changed with fashion.

Clothing fit matters to all ages, and the literature related to research into ageing body shape included that by Ashdown, Goldsberry, Anderson and Scholfield.\textsuperscript{56} In 2000 Church Gibson in \textit{‘No one expects me anywhere’}, discussed the plight of older women and their available clothing choices. In that text she observed how one male journalist commented to her, “‘You can't really expect young designers to think about older women - they'd rather think about sexy 20-year olds’.\textsuperscript{57} The sentiment of this comment was found to be in direct contrast to the wishes and needs of modern older people as described in 2007 by the fashion commentator Gok Wan and Emma Soames, editor of \textit{Saga} magazine. Both agreed that the ageing ‘baby boomer’ generation (those born between 1946 and 1964) wanted to continue wearing

\begin{footnotesize}
\begin{enumerate}
\item Lewis.313.
\item Pamela Church Gibson, " 'No one expects me anywhere': Invisible women, aging and the fashion industry", \textit{Fashion Cultures: Theories, Explorations and Analysis}, eds. Stella Bruzzi and Pamela Gibson. (London: Routledge, 2000).84.
\end{enumerate}
\end{footnotesize}
fashionable clothing and had no wish to fit into a mould, whatever their age. A similar interest in this large and lucrative market was reflected in the September 2011 report by the EU SERVIVE (Service Oriented Intelligent Value Adding Network for Clothing-SMEs embarking in Mass-Customisation). The report identified the ‘affluent greys’, people in the 50-60 year age group, as a fruitful target market for mass-customisation of clothing, and knitwear in particular to be important in this area.

1.5.2 Larger size: its effect on clothing satisfaction, perceptions of self and femininity

Dissatisfaction with clothing fit, as already noted here, has been suggested by Kaiser as engendering dissatisfaction with the self, and is considered by LaBat to do the same with specific parts of the body; a concept described as ‘body cathexis’. Kaiser contextualised depression with poor self esteem, and suggested that if this is true, then depression might have a negative impact on the concept of the self as valuable. In another study looking at women’s physical size, body cathexis and apparel shopping, Shim found that there were links between positive body cathexis and clothing fit, whilst LaBat and Delong in their research into body cathexis and satisfaction with clothing fit, made similar correlations. These conclusions, in particular those of Chowdhary, strongly suggested that dissatisfaction with the fit of available clothing might contribute to a lower self-esteem amongst larger sized women than that found amongst ‘standard’ sized women. If this is the case, then an improved fit in an item of knitwear may indeed encourage a more positive body

58 “Is the fashion industry catering for the over fifties?”. Women's Hour. BBC. 11 June 2007.
61 Kaiser. 175.
62 Shim and Kotsiopulos: 1038 LaBat and DeLong: 47
cathexis, and thereby contribute positively to the self esteem of a plus-size woman.

Body image issues, which have their roots in clinical research including that of eating disorders, personality, and psychological studies, has been central to the practise and debate in this research. Radika and Hayslip, in *Projective Techniques to Assess Body Image*, when reviewing clinical assessment methods, concluded that the analysis of qualitative data gathered from these methods may offer ‘unique value’, above that of purely clinical results.63 Body image in relationship to clothing had been researched largely in just this way, employing qualitative survey and questionnaire methods.

Body cathexis is a concept related to the more commonly discussed issue of body image. Kaiser in her 1997 *Social Psychology of Clothing* discussed the difference between the two concepts, and defined body cathexis as a considered level of satisfaction with a part of the body, whilst body image was the degree of satisfaction with the overall concept of one's own body, which might not match an observer’s perception. Cathexis might she warned, be effected positively or negatively by social constructs of physical desirability.64 This effect was also studied by Monteath and McCabe in 1997, who concluded that body satisfaction, (they did not differentiate between cathexis and image), was indeed dependent on social factors, but was equally influenced by self-esteem and BMI (body mass index).65 This supported the core of Kaiser’s argument that feeling good in clothing can raise self-esteem, which in view of Monteath and McCabe’s findings, may at the same time inculcate a positive body

64 Kaiser.98 and 108.
In an earlier related study in 1990, Markee looked at the difference between clothed and unclothed body cathexis. His findings also reinforced Kaiser’s view, that, ‘...clothing is not merely a body covering,’ and that it might, ‘...create, while it is worn, a new and better perception of the body’.67

Connections between body image and body cathexis have been recorded in studies of clothing related to clothing fit preferences conducted by Alexander, Connell and Presley, who concluded that body type, rather than body image, dictates body cathexis, but that the level of satisfaction with upper body parts was constant across body type.68 However Kaiser reported that research into body cathexis had repeatedly found more dissatisfaction with the lower body parts.69 In 1990, Damhorst, Littrell and Littrell, studied seven hundred and fifty one American cheerleaders, (chosen because they represented a role model for their peers), and linked weight, hip and thighs as being important to adolescent girl’s assessment of clothing appearance.70 Similarly LaBat and DeLong, researching at the same time, found that the lower body scored poorly on body cathexis and was more problematic for fit satisfaction. Furthermore their research confirmed the argument for the correlation of an individual’s satisfaction with clothing fit with their feelings about their body.71

It was interesting that in Shim and Kotsiopulos’ 1990 study, a similar if lesser

---

66 Kaiser.174.
69 Kaiser.98.
71 LaBat and DeLong:46
correlation between body cathexis and ‘general fit of clothing’ was noted.\(^{72}\) In this research, tall/large sized women were classed as a separate category. It was found that this group exhibited the lowest confidence in choosing clothing, although their interest in this process was equal to that of the other two groups of women in the study (average and petite).\(^{73}\)

In the same year Shim and Kotsiopulos were suggesting that larger women’s lack of self confidence when shopping for apparel was a fertile area for further research. More recently in 2000, Kind and Hathcote recommended revising sizing standards to overcome consumer dissatisfaction. Their research focused on younger women and found that within that group those with larger body size were the most dissatisfied with clothing fit.\(^{74}\) These findings prompted questioning whether dissatisfaction with clothing led to low self esteem, a relationship which Kaiser explored. Based on the premise that clothing is a vehicle for elevating self esteem and self worth she suggested a positive solution, reasoning that a personal belief that one looks good in clothing engenders a feeling of what she termed ‘mattering’.\(^{75}\) Kaiser’s ‘mattering’ can be interpreted as acquiring positive social currency, and believing that one’s presence and opinions have value to others.

Age has also been thought to influence body cathexis and body image and here research results are perhaps unexpected. Mark in 2000 found that young women were more susceptible to body image disturbance, and that higher self esteem was related to greater life satisfaction and health consciousness, this often being age dependent.\(^{76}\)

\(^{72}\) Shim and Kotsiopulos:1040
\(^{73}\) Shim and Kotsiopulos:1040
\(^{74}\) Kind and Hathcote:323
The older person’s ‘proximity of clothing’ to self was studied by Lee in 2006. By posing questions around clothing in relation to self, self esteem, body image and cathexis, Lee found that there was a connection between the positive perception of self and clothing, but that age identity was not affected by this. It was broadly but significantly concluded that as people become elderly, their body image and cathexis may deteriorate in relation to clothing, which in turn may in fact impact on their psychological well being.77

We live in a society where the perfect, thin body is extolled, and under the influence of this cultural attitude, ‘normal’ people’s bodies are generally considered imperfect. The historian Roberta Seid in Never too Thin, and Susan Bordo in Reading the Slender Body, both identified the first quarter of the twentieth century as when this negative attitude to larger size crystallized and suggest that thereafter eating disorders proliferated.78

A search of feminist literature revealed the exploration of an effect of this on women’s personal and social well being, and therefore that these writings too contribute to this discourse. The title most likely to be recognised on this subject is Fat is a Feminist Issue, written in 1979 by the psychologist Susie Orbach. Orbach described Euro-American fat women as being seen to have a ‘social disease’ and under immense cultural pressure to conform.79

Orbach used clothing as an example of how women view themselves when fat or

thinner, because they reported wearing different clothing in each state.\textsuperscript{80} She observed for example, that, ‘It is not a criminal act to tuck in your blouse, shirt or sweater when overweight. It rarely makes you look larger to be more defined.’\textsuperscript{81} In parallel with Orbach, but taking a longer political and cultural view, Naomi Wolf in \textit{The Beauty Myth}, argued that late Twentieth century women replaced economic subjection with that of beauty subjection.\textsuperscript{82} Both authors shared the opinion that although many Western women now have material strength, they are nonetheless being subdued psychologically through exploitation of guilt and anxiety centering on how they look, particularly in relation to youthfulness and thinness.\textsuperscript{83} Whilst Orbach focused on the inner fear this engenders, Wolf methodically reviewed the effects that striving for bodily perfection have on the role of women at work and in their leisure time.\textsuperscript{84}

The powerful hostile prejudices experienced socially by larger sized women were described by one of Marcia Millman’s interviewees in \textit{Such a Pretty Face}, as, ‘...the equivalent of being a homosexual.’\textsuperscript{85} Although she was writing about 1970s America, when this had far stronger discriminatory connotations than today, we can nonetheless appreciate the power of the observation. Millman reinforced this prejudice by describing occurrences of ‘fatism’ in employment, whilst Wolf cited the dismissal of an airline stewardess for being overweight.\textsuperscript{86} Millman argued that low self esteem can be engendered by ‘shabby treatment’, rather than preceding it, and that low esteem may therefore be a product of prejudice rather than a personal response to

\textsuperscript{80} Orbach.93-94.
\textsuperscript{81} Orbach.95.
\textsuperscript{83} Wolf.64-65;Orbach.40-41.
\textsuperscript{84} Orbach.103;Wolf.23-24 and 33-34.
\textsuperscript{86} Millman.93;Wolf.33.
body size or shape. 87

Millman further suggested that large women were generally considered to be able to be ‘thin tomorrow’, and if they did not avail themselves of this ability to transform (however much a misapprehension this may be), they might be viewed by themselves and others as weak and undeserving of looking good or being loved. 88 It was this view amongst so many interpretations of femininity and fatness, that was perhaps most pertinent to this research’s aims.

This research has built on this debate and sought some resolution to it by offering processes which can positively influence the clothing satisfaction of larger women. Through improving fit in knitwear, and thereby potentially elevating the body image and body cathexis of larger sized women, it was anticipated this might discourage feelings of negativity in relation to self-view and self-esteem. This issue has been developed and tested and a concluding account is given here in Chapter Five.

The literature discussed so far clearly provides important background to the research idea. The research of Kaiser, Monteath and McCabe and LaBat and DeLong has been particularly helpful, and provided an understanding of connections between clothing fit, body shape and self-esteem, whilst Wolf, Orbach, and Milman provided insight into the cultural, social and personal effects of larger size on femininity.

Cultural variations in preference for body size have been identified by ethnologists Anderson, Crawford, Nadeau and Lindberg. 89 They partly attributed these differences to ‘food security’, meaning that in developing countries where poverty is likely to exclude the majority of the population from access to abundant food, larger body size,

87 Millman.94.
maintained by eating well, is admired.

Within the considerable amount of literature available about social and cultural influences and preferences for body size, the most relevant to this research have therefore been acknowledged here. Those that were reviewed quite clearly demonstrated that such differences existed, and required acknowledgement when discussing body size, clothing preferences and the ‘viewed’ body.

However, whilst bearing all this in mind, this research has endeavoured to remain outside the fashionable and philosophical aspects of fit and knitwear, concentrating instead on the more pragmatic relationships between body surface and textile which will, in light of the connections made throughout the literature, contribute practical, positive resolutions to these social and psychological issues.

Finally in this overview of the literature it is necessary to include the age issue, as similarities were found to exist between large body shape and the ageing body shape. These parallels, as reported by Wells, included increased waist girth in both sexes and enlarged upper body girths in women. Wells analysed SizeUK data to show that BMI (body mass index) generally rises steadily with age, thus placing older body shape within the realm of larger body shape, and therefore within the realm of this research. BMI is commonly used in both the health and fitness fields as an indicator of obesity. Wells however concluded that BMI is not a reliable indicator of body shape, because BMI is, ‘...insensitive to age-associated changes in the distribution of body weight’.90 This means that even if a person maintains the same weight and BMI throughout their life, they are highly unlikely to retain the same body shape, and in all probability will develop a larger waist girth in relation to their other body girths.

This was considered to be significant to the broader impact of this research idea as the world has an increasingly aged population. According to Kalache this is likely to escalate so that by 2050 there will be 2 billion people over 60 (there were 606 million in 2002). He explained that in 2000, for the first time, it was a global fact that there were more people over 60 than there were children under 5 years old, and further estimated that this ‘silent revolution’ will represent a proportional increase of 300% of those over 60 within the world’s population.91

The totality of the literature discussed here suggested that there are significant links between clothing and how women feel about themselves, whatever their age or body shape. As shown, specialists across a number of academic fields clearly consider self esteem, social comfort and psychological well being to be partly dependent on reactions to clothing. This acknowledgement places the value of this research in a wider contextual field, extending beyond that of knitwear and fashion. The literature further established that there were parallels between the ageing body shape and larger sized body shape. In combination with an increasingly older population, this suggests that an even broader audience might be available than at first envisaged for future application of this research.

1.5.3 Larger women and fashion

It was significant to the development of the research rationale that large sized women have been reported, and recognised, as a growing consumer sector. The Health and Social Care Information Centre report, *Statistics on Obesity, Physical Activity and Diet in England: 2011*, showed that in 2009 24% of women aged 16 and over in England were categorised as obese (BMI of 30+).92 The report forecast that by 2015

---

this will have risen to 28% and that, if this trend continues, by 2025 36% of all adult women in the UK could be classified as obese.\textsuperscript{93}

Even in the first decade of the twenty-first century, the average woman in the UK was, according to SizeUK results, larger than her counterpart of fifty years ago. The average UK women’s size was reported by Allen et al in the 2004 publicly available results, \textit{SizeUK: Average measurements for MEN and WOMEN}, as being equivalent to a size 16.\textsuperscript{94} A comparison with the women’s clothing size charts of major UK clothing retailers \textit{Marks and Spencer’s} and \textit{BHS}. showed that the SizeUK average bust girth of 98cm fell between a size 14-16, the 86cm waist fell between a size 16-18, and the 103cm average hip girth from SizeUK fell between a size 12-14 in \textit{Marks and Spencer}, but was a size 14 in the \textit{BHS} chart.\textsuperscript{95} Thus it could be seen that the average woman’s size as reported by SizeUK, although not necessarily a standard size 16 in all her measurements, was shown to be a size 16 or over at the waist. (Table 1) Wells further reported that women had, on average, gained 16cm around the waist despite being only 4cm taller.\textsuperscript{96} Reflecting this effect in 2007, \textit{Just Style} reported that over 47% of the UK female population wear over a size 16, and within this increase in size there was an exponential increase in women over a size 20.\textsuperscript{97} Evidence of a high level of consumer awareness around clothing size and fit amongst larger sized women has already been discussed here in section 1.4. This discerning attitude is of significant importance in view of the reported demand for plus size fashion clothing


\textsuperscript{94} Allen, et al.: n.pag.


\textsuperscript{96} Wells, et al.: 422

Table 1. Charts comparing the findings from SizeUK, made publically available in 2004, with women’s clothing sizes as defined by UK major retailers Marks and Spencer and BHS in 2012. This comparison shows that the average women’s upper body measurements as reported by SizeUK were close to those classified as a size 16 on the UK High Street, and in particular that the SizeUK waist measurement was in excess of a size 16.

<table>
<thead>
<tr>
<th>Women (from SizeUK: Average measurements for MEN and WOMEN 2001)</th>
<th>Height</th>
<th>Chest</th>
<th>Waist</th>
<th>Hips</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rounded (cm/Kg)</td>
<td>163</td>
<td>98</td>
<td>86</td>
<td>103</td>
<td>65</td>
</tr>
<tr>
<td>Rounded (Inches/lbs)</td>
<td>64.5</td>
<td>38.5</td>
<td>34</td>
<td>40.5</td>
<td>143.5</td>
</tr>
</tbody>
</table>

Sizes 12-18 Extracted from Marks and Spencer women’s Formal Sizes chart 2012

<table>
<thead>
<tr>
<th>UK Size</th>
<th>Dimension: cm (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bust</td>
</tr>
<tr>
<td>12</td>
<td>91 (36)</td>
</tr>
<tr>
<td>14</td>
<td>96 (38)</td>
</tr>
<tr>
<td>16</td>
<td>101 (40)</td>
</tr>
<tr>
<td>18</td>
<td>106 (42)</td>
</tr>
</tbody>
</table>

Sizes 12-18 Extracted from BHS women’s Dress Sizes chart 2012
http://www.bhs.co.uk/cms/pages/static/static-0000036631/static-0000036631.html

<table>
<thead>
<tr>
<th>UK Size</th>
<th>Dimension: cm (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bust</td>
</tr>
<tr>
<td>12</td>
<td>92 (36.5)</td>
</tr>
<tr>
<td>14</td>
<td>96 (38)</td>
</tr>
<tr>
<td>16</td>
<td>100 (39.5)</td>
</tr>
<tr>
<td>18</td>
<td>105 (41.5)</td>
</tr>
</tbody>
</table>

This comparison shows that the average women’s upper body measurements as reported by SizeUK were close to those classified as a size 16 on the UK High Street, and in particular that the SizeUK waist measurement was in excess of a size 16.
for all ages. According to Richard Kirk, C.E.O. of Bonmarché, and quoted by Just Style, a quarter of all Bonmarché sales in 2007 were of extra-large sized clothing.98

In the same report, Verdict analyst Carly Syme observed that there was amongst this and significantly for this research, a growing demand for fashionable larger sized clothing amongst younger consumers.99 Further evidence of a trans-generational plus size fashion market was reported in the Just Style 2010 UK plus size report, in which it was clearly indicated that the 4.4% increase in plus size clothing sales between 2006 and 2010 was not exclusive to an older demographic.100 It was clear from these reports that a significant segment of the female UK population had been a size 16 and above for a number of years before the inception of the research and that this group would continue to grow.

However, whatever age they may be, if larger women are to be able to buy fashionable clothing that fits them well, in the sizes they needed, the product must be available to purchase. The dissemination of fashion innovation is discussed extensively in fashion theory literature by, amongst others, Entwhistle, Etcoff, Emmison, and Sweetman.101 These authors all attributed the original ‘trickle down’ theory of innovation to Veblen in The Theory of the Leisure Class, and its application to fashion to Simmel in his 1904 text Fashion.102 Assuming acceptance of this theory,
then availability of fashion clothing that flatters and fits larger body shape must originate with high fashion. However, in 2003 Evans suggested that the fashion industry abhorred fat and the ageing process, whilst extolling thinness which symbolised wealth, youth, beauty and power.\footnote{Caroline Evans, *Fashion at the Edge* (London: Yale University Press, 2003).94.} Wolf found that fashion rejected real bodies and promoted its products on models with up to 22% less than average body fat, thus establishing a cultural ideal of thinness for those whom fashion clothing is designed, whereas the average young women might have as much as 30% body fat, increasing to 38% by middle age.\footnote{Wolf.192.} Meanwhile, a trend towards increasingly thinner fashion models was reported by Nussbaum in 2007.\footnote{Emily Nussbaum, "The Incredible Shrinking Model", *New York*, Feb 26, Spring Fashion, 18th February (2007): 5. Web. 26/5/10.} It is interesting to note Caryn Franklin’s initiative *All Walks Beyond the Catwalk*, launched in 2010, which reflects the underlying principle of this research, and promotes the use of ‘real’ bodies in fashion design and on the fashion catwalk.\footnote{“What is All Walks?”, *All Walks*, 27/9/2010. <http://allwalks.org/?p=1229>: n.pag. Web. 19/10/2010. Caryn Franklin, "All Walks Beyond the Catwalk", Design for Ageing Well, (2011), Wellcome Institute. n.pag}

At the time of writing, high fashion, as represented by the work of UK fashion designer Mark Fast in 2009, and Jean Paul Gaultier in 2011 have at last acknowledged large size, but whether this is more of a public relations exercise than a serious commercial wish to become associated with truly larger sized women remains still to be seen.\footnote{Sarah Mower, "Mark Fast", *Style.com*,Style.com, 19/9/2010. <http://www.style.com/fashionshows/review/S2010RTW-MFAST>: n.pag. Web. 9/9/2010.; Lindsey Golwert, "Beth Ditto, size 28, rocks the runway for Jean-Paul Gaultier for Fashion Week in Paris," *NYDaily News*, 4th October (2011): n.pag. Web. 7/7/2011.;} It seems improbable that Fast’s dresses were designed specially to compliment the build of the larger models, as similar styles were worn by all his models, an opinion shared by Fisher in the *Guardian*.\footnote{Alice Fisher, "London Fashion Week: catwalk row over size 14 models," *The Guardian*, 20th September (2009). Web. 9/9/2010.} (Figure 2)
Figure 2. Three dresses from Mark Fast's 2010 ready-to-wear collections. Left and right: Spring/Summer 2010, middle: Cristal Renn in Fall 2010 catwalk show. Images from Style.com. Accessed 18/2/2011. (ORIGINAL IN COLOUR)
It was noticeable that, although billed as ‘plus size’, Fast’s models were actually size 12 and 14, unlike Beth Ditto who was a size 28 and appeared in Gaultier’s Spring/Summer 2011 show. This unrealistic, indeed evasive, attitude to size was expressed by larger sized model Cristal Renn in 2010 when she reported in the *Independent* that, ‘In the [fashion] industry a size eight is considered plus’. In 2010 Fisher reported in the *Guardian* that Marc Jacob’s was working on a ‘plus-size’ range. Opinion on Jacob’s plans differed; in line with Renn’s observation Fisher reported that this to only go up to a size 14, but Alexander’s *Vogue.co.uk* report stated that Jacobs already offered a size 16, and was to increase this to a size 18 and over in this new venture. It is therefore difficult to differentiate between genuine interest in larger size and possible exploitation of the sensational public relations ‘wow’ factor of big female celebrities, for example Gaultier’s inclusion of Ditto in his Spring Summer 2011 ready to wear show. This appeared revolutionary, but was reported by Goldwert in the *New York Daily News* to have been considered by Alexandra Shulman (editor of *Vogue*) as a ‘cause célèbre exception’, rather than a true sea-change in the attitude to large size in fashion.

Rebecca Arnold considered that as a woman’s socio-economic status rose, she acquired the financial ability to achieve the ideal, fashion oriented female body shape, but as this financial security was not usually attainable until middle age, real body shape became further and further divorced from the ideal, and progressively harder to

---

109 Golwert: n.pag.
112 Golwert: n.pag.
achieve and maintain. As a result of these pressures, larger size, which has been reported to significantly correlate with low income, was being relegated to ‘low fashion’, a term used to refer to budget apparel, but also in this case referred to ill fitting, poorly styled clothing in mediocre fabrics.

This literature review has shown that there has been an increasing need for fashion for larger sized clothing across all age ranges. It further established that high street retail has been responding to this growing market, however poorly in terms of design and fit. High fashion however, despite certain exceptions, did not in general cater well for larger sizes, and was in some cases actively prejudiced to larger sized women. Some more recent inclusions of larger sizes in high fashion might indicate a change in attitude, but were found to be limited and using celebrity for public relations rather than demonstrating a true interest in fashion for larger sized female body shape.

1.5.4 Larger sized women’s experience of shopping

Although culturally associated with middle age, larger body size was found not to be exclusive to ageing; Abbot and Sapsford wrote in 2001 that female teenagers over a size 14, “…find it difficult if not impossible to purchase the clothing that is seen as fashionable, and are thus…excluded from teenage fashion”. This research’s online survey, as will be discussed in depth in Chapter Two section 2.4.1., was deliberately targeted at larger size, with 34% of all the responses being from women with a self-reported upper body size over a size 24. Analysis of this data, based on extracting reported age in relation to upper body size, found that larger size was not limited to older women, although there was a higher incidence of larger size in the older age

groups.

Primary sources in this research, as discussed in section 1.4 and detailed in Chapter Two, section 2.4.1, revealed that women from the age of sixteen onwards encounter difficulty buying larger sized clothing at a price they can afford, especially in the UK. One participant, (Desdemona), explained that she had not always been large sized. As a teenager in the 60s she was, “... the perfect shape, I was like a beanpole, flat, no shape. Well I always had a little bit of a waist because I’ve been quite broad in my hips but I was skinny, oh it was lovely.” (See Appendix E)

These observations, and the literature reviewed indicated persistence amongst fashion designers, manufacturers and retailers in perpetuating the mythical, ‘ideal’ of the perfectly proportioned, slender woman. It is of significance to this research that this situation appears to run contrary to commercial interests.

1.5.5 Knitwear as fashion

Whilst it is inappropriate here to include a detailed history of women’s commercial knitwear in the Twentieth century, it is necessary to site this research in the historical context of the development of commercial fashion knitwear manufacturing. An analysis of commercial knitwear in the Hodson Shop collection dating from 1920 - 1950, was carried out to this end, and can be found in Appendix F. During this it was found that a number lacked brand labels, and so it was not possible to establish their manufacturer. Although there were obvious differences in manufacturing methods between the cut-and-sewn and the shaped garments it was also not generally possible, even when there was some indication of the manufacturer, to deduce on what type of knitting machinery they might have been knitted.

It was however possible to confirm from garments in the Hodson Shop collection

116 Desdemona (Participant 2), Interview 1: 1.
that machine knitting was used for mass-made fashion garments as early as the 1920s. All the examples from this period were cut-and-sewn, whereas the knitted items dated after 1950 included some examples of shaped and fully fashioned knitwear. Therefore, the evidence in the Hodson Shop collection suggested that commercially machine-knitted shaped fashion knitwear was not widely available until the 1950s. An example of a hand-shaped, manual machine knitted intarsia (see Glossary of Terms) garment being made in Scotland in 1961 was found in a documentary film about the Pringle knitting factory in Hawick in the Scottish Film Archive, which evidenced the labour-intensive manufacture and therefore high cost of shaped knitwear at this time. (Figure 3)

There were two UK designer knitwear revivals during the 1970s and 80s, both of which focused on manual techniques in hand knit yarns such as mohair, deliberately distancings itself from industrial, mass market knitwear. Since then, and alongside sport and medical driven knitting developments, interest in fashion knitwear has been stimulated and maintained throughout the last two decades by fashion designers including Vivienne Westwood, Clements Ribiero, Alexander McQueen, Lainey Keogh, Julien Macdonald, and Lainey Keogh, all of whom have featured both hand and machine made knitwear in their collections. (Figure 4)

No artefact study can be carried out in chronological isolation, and it was important whilst establishing the importance and novelty of this research to understand commercial knitwear’s historical and contemporary place in fashion. Contributing to

Figure 3. Manual Intarsia being carried out in the Pringle factory, Hawick. It is just possible to see the pattern the knitter is following written on the paper hanging on the left; the pattern is a classic ‘Argyle’ one. c.1961. This machine may have been one of the thirty hugely successful 1930s Dubied ‘00’ intarsia machines that Pringle purchased in 1955, as described by Hugh Barty-King on p130 of his book Pringle of Scotland & the Hawick Knitwear Story. Still image extracted by the author from Scottish Film Archive material, Ref 5117.
Figure 4. Knitwear by some of a number of designers who have stimulated its design since the 1990s. Top left: Lainey Keogh, A/W 2001. Top right: Julien Macdonald, late 1990s. Bottom right: Clements Ribiero 2001. Bottom left: Vivienne Westwood 1988-9. Images in same order courtesy of: lainykeogh.com; Mark Large for the Mail online; V&A museum; McDermott, 'Made in Britain', p 76. (ORIGINAL IN COLOUR)
this, a literature review was conducted, and a unique collection of Twentieth century commercially knitted garments and knitwear has been researched, imaged and analysed. The collection contained a number of larger sized garments. Overall there were thirty eight knitted garments in the collection, three of which were shaped, the rest being cut-and-sewn. Thirteen of the thirty eight were labelled as outsize, including all three pieces of shaped knitwear. This was of particular value in establishing the long term recognition in the knitting industry of the issue of making for large sized women, however limited its response. All the decorative knitted pieces were cut-and-sewn and dated 1920-50, and made of a variety of fibres, predominantly artificial silk or wool, plus plated combinations of these. Two of the shaped pieces were dated to the 1950s and made of wool and the other was dated to the 1960s was made of Courtelle. Further details and images of this analysis of the Hodson Shop collection at Walsall museum can be found in Appendix F.

Brackenbury in his 1989 essay, A Fashion History of Knitting, and Chapman in Hosiery and Knitwear, attributed the very existence of a UK knitting industry to the male fashion of wearing knitted hose for over two hundred and fifty years, starting sometime during the reign of Henry VII (1457-1509). Therefore fashion would appear to have been fundamental to the development of the early knitting industry. It was not until 1900, as agreed by experts Brackenbury, Chapman and Power that a significant change occurred when machine knitting, formerly relegated to underwear, began to be accepted as fashion outerwear. The next main step in the development

of knitwear as fashion was during the 1920s when, according to de la Haye and Smith, 
la mode sportif was inspired by Chanel jersey wear and Patou’s ‘sweater dressing’.  
These high fashion, draped and relaxed styles led the way for mass-made machine
knitted cut-and-sewn garments, such as those in the Hodson Shop collection,
becoming fashionable. (See Appendix F)

The rather more conservative field of shaped knitwear manufacturing moved into
fashion styling a little later, and as reported by Barty-King, in 1945 the Pringle Board
of Management proudly acknowledged that their company manufactured ‘fashion
knitwear’. During the 1950s fashion demand for fully-fashioned, shaped sweaters,
cardigans and twinsets was stimulated by the ‘College Girl’ look that filtered across
the Atlantic.  Towards the end of the 1950s, and partly attributed by Power to rising
wool prices, the increasing use of new synthetic fibres had a considerable impact on
commercial knitwear. Nutting expressed the opinion that synthetic fibres,
“...reinforced the change from woven to knitted fabrics for women's outerwear'.

Meanwhile in 1964, the Assistant Managing Director of Wildt Mellor Bromley,
knitting machine manufacturers, was reported as asserting that the new 9RJ-36
machine would, “...give a real shot in the arm to an industry that is essentially fashion
conscious”. These examples, spread throughout the twentieth century, clearly
demonstrate that the knitting industry considered itself to be part of the fashion world
even if the fashion world did not yet consider knitwear in the same light.

---

124 Power, “Functional to Fashionable: Knitwear’s Evolution throughout the Last Century and into the
Millennium”: 5
Fibre and yarn developments continued to contribute to knitwear being viewed and purchased as fashion items. Marks and Spencer and Dupont’s joint development of Lycra stretch knitting yarns enabled extensible, yet shape-retaining knitted fabric. These elastane yarns, in combination with increasingly sophisticated digital knitting technology enabled what Power described as ‘comfort dressing’ to become widely accepted as fashion clothing during the 1990s.127

At whatever time the acceptance of knitwear as fashion occurred, it was noticeable that fashion knitwear in general did not feature heavily in fashion history literature. ‘Knitwear’ was a term used generically by the authors to describe a piece of knitted clothing without detail of whether this was shaped or cut-and-sewn. When knitwear was included, methods of manufacture were rarely described, and therefore it was difficult to ascertain whether an item was shaped, fully-fashioned, or sewn from knitted fabric. This might be, as suggested by Brackenbury, because, “...knitwear and knitted articles are mostly regarded as accessories in the fashion industry”.128 Brackenbury, who was writing in 1989, further suggested that couture and ‘named’ designers working at that time did not design knitwear because they did not understand it.129 This may explain why it was not until Black’s 2002 Knitting in Fashion that this highly specialised and innovative section of fashion was discussed as a separate entity. In this and her other publications, Black links knitwear to fashion, seeking to elevate it from its general categorisation as, ‘...a parallel production of staples and classics’ .130

During the 1970s and 1980s, a seminal knit design breakthrough occurred when

---

127 Power, "Functional to Fashionable: Knitwear's Evolution throughout the Last Century and into the Millennium".9
130 Black, Knitwear in Fashion.121.
Japanese designers Miyake, Yamamoto and Kawakubo used knitting outside traditional European garment shapes and in draped and wrapped clothing. Wilcox in *Radical Fashion* of 2001 pinpoints what could be considered as the resurgence of knitwear’s importance in fashion, and its early adoption as a media for social comment when she wrote,

‘The Comme des Garçons black wool sweater from Autumn/Winter 1982-83...is a seminal design from this period. Punctured with seemingly random holes, the hand-knitted garment is a challenge to the flawless perfection of machine knitting.’

Knitting, as a direct reflection of cultural shifts, continued to be covered in more recent publications. These however did not originate from an interest in the commercial industry, but rather from the art, conceptual and cultural areas of the field, and include Turney’s 2004, *The Culture of Knitting*, and Gschwandtner’s, *Knit Knit* of 2007. It is clear that Turney entirely omitted industrial knitting, with no reference to its historical or economic importance in Europe and the USA, although she professed to, ‘...address knitting in all its guises’. Instead she focused largely on issues of gender, politics and identity within the context of mostly domestic hand knitting, only including fashion when it was pertinent to the discourse. Turney mentioned Edina Ronay’s 1980s fashionable re-invention of Fair-Isle knitwear in luxury fibres, and Vivienne Westwood’s 2001 post-modern re-working of the traditional Fair-Isle cardigan in the style of, ‘...Miss Marple meeting Marilyn Monroe’. Turney referred to these as ‘re-appropriations of history’, and considered this parody of traditional patterns and styles to be a challenge to national identity, class and couture, thereby suggesting that knitwear was so deeply rooted in tradition that it could not transcend

Figure 5. Black hand-knitted sweater, asymmetrical and holed. Rei Kawakubo for Comme des Garçons, Tokyo, Japan. 1982. Collection of the V&A museum, London.
this cultural perception to become fashionable. Turney also referred to Radvan’s
innovative knitwear for disabled women when discussing ethical knitting, and points
out that in parallel with this research, Radvan, ‘...fits clothes for bodies’. In
Gschwandtner’s text, although reference was made to knitted garments, including for
example those of Risto Bimbiloski, knitwear designer at Louis Vuitton, fashion and
clothing were not central to the book’s theme. Therefore neither of these texts was
found to deal with issues of knit technology and commercial knitwear manufacture at
all. One of the recent texts on knitting, Hemmings’ In the loop: Knitting Now,
published in 2010, which continued the themes of these earlier texts, did at least
acknowledged the commercial industry. Essays within this publication, namely
Black’s Knitting technology comes full circle, and Shaw’s, Looking backwards to look
forwards, finally discussed the potential of modern industrial knitwear technology for
design and commercial production and its relationships to knitwear as fashion.

An equally positive approach to collaboration between fashion, this time high
fashion, and industrial technology, was described by the fashion designer Issey
design development using digitally programmed industrial warp knitting, a technology
he had been using in his A-POC work since 1999. In his A-POC (A Piece of Cloth)
collection Miyake showed that knitted clothing, (although not knitwear as defined by
this research) could be high fashion. APOC offered customisation opportunities to the
consumer, who could create their personalised garment shape by cutting selected
garment outlines which had been embedded into a knit structure fabric, thereby

133 JoanneTurney.67 and 68.
134 JoanneTurney.103-106.
136 Black, "Knitting Technology Comes Full Circle".120-127.: Annie Shaw, "Looking Backwards to
modifying the end item to their individual requirements. 137

More familiar fashion knitwear was discussed by McDermott in her 2002, *Made in Britain*, about contemporary British fashion. Unusually, and possibly reflecting the new interest in knitting, a section was dedicated to knitwear not only from traditional manufacturers Smedleys, Pringle, Ballantyne and Lyle and Scott, but also including that of designers Vivienne Westwood, Nicole Farhi, John Rocha, Clements Ribiero and Julien MacDonald. 138 However mass machine made knitwear was not addressed and it was clear that knitting was not the specialist area of the author in her vague description of intarsia and cable ‘stitching’. 139 This shortcoming, as discussed earlier, was found to be common to even those texts which did include knitwear and knitting within contemporary fashion.

Apart from Black’s *Knitwear in Fashion* and Brackenbury’s *A Fashion History of Knitting*, little of the literature was found to address fashion through the context of knitwear and its specific technology of making. Indeed most maintained knitwear’s separation by treating it as subordinate or peripheral to what they considered to be more elite aspects of fashion clothing. Where the few connections were made between fashion, knitting and knitwear, these demonstrated quite clearly that knitwear is an integral fashion item and indeed that the knitting industry was developed in response to fashionable demands. Research highlighted some new paths of development within fashion knitwear combined with technological understanding, not only those which relied on the latest technology. In particular this research found resonance with Miyake’s adaptation of an existing machine knitting technology to produce fresh, re-

---

138 McDermott.70-71 and 77.
139 McDermott.73.
thought outcomes in fashion knitwear with the potential for future development in the field of mass-customisation.

1.5.6 Historical knitting capabilities

In order to establish the innovative and fresh directions taken in this research a search of this literature analysis, focused particularly on that relevant to the development of the technology of making shaped knitwear. Texts addressing the knitting industry’s four hundred year history have been written from perspectives as various as economics, social history and industrial archaeology, but as will be shown here, within any history of the knitting industry, technology plays a pivotal role.

Since 1589, when the knitting machine was invented, innovations including the Derby rib frame of 1759, Decroix’s and Brunel’s circular machines of 1789 and 1816, the highly significant latch needle of 1847, the V-bed machine of 1863, and finally but importantly, the Cotton patent flat-bar machine of 1864 have all contributed to the development of modern digital machine knitting.140 Throughout this progression, the production of knitwear ran in parallel with fibre and yarn developments. Synthetic fibres, starting with artificial silk in the 1920s, and followed rapidly between 1940 and 1959 by Nylon, Polyester, Acrylic and Elastane, also contributed to this progression, offering cheaper alternatives to luxury and natural fibres.141 Their use in knitting began in the 1920s, and continued throughout the pre-electronic stage, when patterning and shaping devices were refined on both circular and flat machines, and the modern machine builders were established.

The twenty five years between 1970 and 1995 could be described as the early digital stage of knitting machine technology, in which rapid innovations in electronic needle selection methods removed much of the physical labour and complexity from the actual knitting process.\textsuperscript{142} This may be seen as a reaction to the preceding dominance of circular knitting, and an attempt to capitalise on the strengths of V-bed knitting machines. We are now in the stage of digital knitting production and complete garment technology. All modern electronically controlled machinery of the twenty first century and the knitwear manufactured on these are products of this time-line. (Figure 6)

It seems to have been common for knitting factories to keep older machinery in use not only because of costs, but also because of its importance to their established production, regardless of age. Davenports of Hinkley were reported by Webster in 2009 as having recently had, ‘... thirty or forty 21gge fully-fashioned Cotton machines’, which he reported they have since replaced with new 12gge Wholegarment® machines.\textsuperscript{143} The basic technology of Cotton type machines dates from 1861, and the earliest Wholegarment® technology became available in 1995, representing almost a hundred year lag in updating technology.\textsuperscript{144} This example from the UK knitting industry suggests that it is conservative and pragmatic in its retention of technology when it remains useful, whatever its age. It also is possible that this situation is the result of adapting existing knitting technology to suit new market demands in a manner not intended by the original machine manufacturer. These issues contribute to the discussion of technological determinism in the context of the knitting

\textsuperscript{143} Richard Webster, (2009), Interview with Sales Director of Shima Seiki Europe Ltd., 22nd July: 40.
\textsuperscript{144} Nutting.58; Spencer.237.
Figure 6: Timeline showing the pivotal developmental stages of industrial machine knitting and knitted clothing 1589-2011. (ORIGINAL IN COLOUR)
industry. The subject is largely beyond the scope of this text, but must be included as historically the knitting industry clearly not only responded to consumer demand and social change, but had equally been a driver of these.

A number of authors on knitting technology have written inspirationally about future technical developments, including Felkin, who in 1867 reported on a bar and wheel jacquard apparatus which knitted in, “...most perfect imitation of hand-knitted or netted articles”. Chamberlain, writing in 1926 in *Knitting Mathematics and Mechanisms*, displayed prescience in his conclusion to a chapter on selecting mechanisms, when he recognised that the commercial production of coloured and patterned knitting required, ‘... a proper type of jacquard mechanism in which cards are used as the selecting mechanism’.

In similar speculations on possible technological advances, sixty years later, Spencer in his 1989 essay, *Into the Weft Knitted Future*, discussed whether ‘bi-partite’ or compound needles (needles made of two parts) might, “...offer the chance of electronically controlled movement and individual needle selection”. It was possible that Chamberlain’s earlier work of 1951 in which he discussed patents registered ‘some years ago’, in both Great Britain and the USA, for ‘bi-partite’ needles may have inspired Spencer. In retrospect it was clear that these issues around needle selection for both pattern and shaping had been effectively resolved by Shima Seiki with their SWG-X, multi-bed machine and slide needle design of 1995, as described by Richard Webster during an interview with the author. (See Appendix

---

By 2011 it could be seen that earlier authors speculations had indeed been realised in modern electronic machine knitting technology, which had been further enlivened in the 1980s by the new concept of complete garment knitting. Complete garment technology was mainly attributed to Robinson and Bett’s 1966 invention of the Presser Foot, an invention of relevance to this research as it enabled the 3D knitting methods discussed in Chapters Three and Four.¹⁴⁹

Seven years later Nutting discussed the potential for three dimensional knitting, deploring the situation where the presser foot, which had been invented to enable seamless knitting, was instead being used only for decorative three dimensional texture effects.¹⁵⁰ Nutting’s observation was seen to highlight the huge impact research and development into full electronically controlled needle selection, in combination with digital programming and precision engineering, has had on commercial knitting and knitwear during the short period of time since 1989 when compared to the four hundred year development of machine knitting.

Between concept, manufacturing technology and the finished piece of fashion knitwear, the designer and knitting technologist translate the design into knitting production. It became clear that although always important, the role of the knitting technologist had become increasingly important to the translation process. In 2006, Sayer, Wilson and Challis investigated the design skills gap in seamless knitwear, exploring whether the advent of this latest technology had potential to affect what were perceived as sometimes hostile relationships between designer and technician.

¹⁵⁰ Robinson.n.pag; Nutting.62.
This situation still persisted, despite Eckert’s 1997 recommendation to include more technical content in knit design training as a way to prepare the industry for a future high-tech knitting industry. Sayer et al recognised that complete garment technology, “...presents a new way of making clothing, forcing the designer to reassess ancient hand techniques”.

It would appear that Eckert and Challis inspired change, because in 2010, as reported in *Knitting International*, Cuden found that in both flat bed and complete garment knitting, despite maintaining some different viewpoints, both designers and technicians saw mastering production technology and machine options as indispensable to high quality knitwear design. This belief is shared by the author and exemplified within this research.

### 1.5.7 Digital knitting technology and its relevance to the research rationale

Digitally enabled technological advances in knitting appeared to have largely outstripped knitwear manufacturer and retailers' perceived customer fashion knitwear requirements. Evidence of this was seen in the slow take-up of complete garment technologies in fashion knitwear manufacture, and the continuing popularity of traditional V-bed, albeit electronic, knitting machinery as described by Richard Webster of Shima Seiki Europe Ltd. (see Appendix E). As a consequence of these circumstances and in particular the sustained popularity of V-bed knitting machinery, it was a deliberate and considered decision to develop the research idea based on this already proven knitting technology which was widely available in the international

---

153 Sayer, *et al.*:41
155 Webster: 20.
industry.

Since the development of electronic controlled needle selection that started with Protti’s first model in 1975, the two main developments that have revolutionised the knitting industry and knitwear since the 1980s were, according to Webster and Hunter, needle developments and complete garment knitting. Indeed Hunter went further, and directly attributed the 1990s revolution in shaped knitwear manufacture to the Shima Seiki SES series of machines. Meanwhile, complimentary and extensive research and development by all the machine manufacturing companies has brought pattern preparation and machine control software to a simplified interface aimed at including the designer in the process as well as the technician.

Probably the most comprehensive contemporary text on modern industrial machine knitting is still David Spencer’s *Knitting Technology* of 2001, and his text was highly informative to this review. Spencer included digital knitting technology and covered the emergence of V-bed complete garment technology and seamless garment circular knitting machines. Since then, complete knitted garment and seamless knitting technology have contributed to new developments in knitwear manufacture.

This evolution in garment manufacture occurred with the advent of Shima Seiki Wholegarment® in 1995 and Stoll Knit and Wear® complete garment technology in 2003. Garments could now be knitted without seams and include integral shaping of a highly specific nature to match design requirements or body shape. This technology is

---


157 Hunter, ”Needles and Knitwear Technology”: 34.


however taking some time to move into mass manufacturing. The machinery is more expensive than traditional V-bed machinery, was initially limited in its capabilities, and its programming is complex, requiring highly skilled technicians, all of which may have discouraged its uptake.

As recently as 2002, Tony McBryan, general manager for Shima Seiki USA Inc acknowledged that, ‘...convincing the textile industry to try the new technology is difficult’. However for the product to be successful, McBryan stressed that consumers also needed to be convinced of the value of this technology.

Larsson concluded, based on the Swedish Knit on Demand project that consumers did not differentiate between the knitting technologies used to manufacture their garments, but sought only well fitting, fashionable knitwear. Larsson’s conclusion had a significance for the future for both manufacturing and consumption of complete garment product that is outside the remit of this discussion but was influential on the choice of knitting technology for this research. Complete garment knitting is still, at time of writing, a relatively fledgling technology, in which knitwear manufacturers face the economic dilemma of initial high machinery cost versus the advantages of a technologically advanced but potentially unappreciated product. This was seen to be compounded by an international shortage of trained programmers as highlighted by Siddons and Sayer.

This research however focused on knitting methods that are possible on a wider range of electronic machines, for which the knit programming is not so demanding, rather than complete knitted garment technology. This does not however, preclude the

---


future transfer of the research outcomes onto complete garment technology
machinery.

Research into aspects of complete garment knitwear as already discussed in section
1.5.1, was found to be taking place at Manchester Metropolitan University in 2011.\textsuperscript{163} The same complete garment focus was reported to be shared by Black during her
2008-9 study into personalised fit in knitwear as part of the Considerate Design
project at the London College of Fashion.\textsuperscript{164} This placed this research idea, started in
2005, in a unique position; developing 3D fit in knitwear through exploiting
programming capabilities in combination with the ‘standard’ knitting technologies
that are widely available to manufacturers. The contextualising of this into fit for
larger body-shape brought additional currency and further innovation and originality
to the research idea as this positioned it firmly within the developmental scope of the
future mass-customisation of knitwear as suggested by the SERVIVE report of
2011.\textsuperscript{165}

1.6 Aims and objectives of this research

This research was conceived in order to address the issues of ill fitting
commercially knitted, fully-fashioned knitwear for larger women. In doing this it
questioned the traditional reliance of knitwear manufacturers on the inherent stretch of
knitting to make knitwear fit, and through resolving these problems to improve the fit
of knitwear for larger sized women.

\textsuperscript{163} Brownbridge, “Complete fit”: 32. Brownbridge, “The Development of a Conceptual Model for
Anthropometric Practices and Applications regarding Complete Garment Technology for the UK
Women’s Knitwear Industry”: n.pag.
\textsuperscript{164} Sandy Black and Claudia Eckert, “Developing Considerate Design: Meeting Individual Fashion and
Clothing Needs Within a Framework of Sustainability”, \textit{Handbook of research in mass customization
\textsuperscript{165} SEVENTH FRAMEWORK PROGRAMME NMP-2007-3.1-2 , SERVice Oriented Intelligent Value
Adding nEtwork for Clothing SMEs embarking in Mass Customisation (SERVIVE), 9,18 and 54.
There are three primary aims of this research. The fundamental aim is to challenge stretch as a method of fitting fashion knitwear to larger sized women’s 3D body shape. In order to establish the validity of this, an objective of this research was to produce prototype 3D shaped, machine-knitted garments which are not reliant on stretch to fit, and which demonstrate an improved fit for large sized women whose clothing size is a UK 16 and above. These garments therefore embody a new approach to knitwear; that knitwear should not have to rely on stretch and are fundamentally designed to fit aspects of larger sized body shape.

The second aim is to develop both theoretical and practical frameworks for future developments of the research outcomes based on the methodologies developed during the research. Objectives that will enable this framework include measuring larger body shape specifically for knitwear, knitting samples that exemplify the 3D knitting methods developed to fit body shape, and the creation of digital templates using these 3D shaping methods from which the prototype knitwear (toiles) are knitted. It was always intended that the prototype research knitwear would be toiles or ‘fitting shells’ for future fashion knitwear designs that could be developed from these with the addition of colour and styling details to the underlying shape. To this end the research has been designed to follow commercial knitwear design and manufacture processes so that it will have validity and an end-use value for future commercial applications, including the emerging field of mass-customisation of clothing.

To achieve these primary aims and objectives, another objective of the research has been to work with real women’s body shapes, and to develop a three dimensional understanding of these from which to develop these 3D knitted toiles. Furthermore, the evaluation of the knitwear toiles would be more effective as it would be from the viewpoint of both researcher and wearer.
The third aim is to make the results as widely accessible as possible. Therefore the objective has been to work with widely available digital knitting technology when producing the prototype knitwear. Finally, it has been an objective of this text, that rather than producing an isolated practise based research project, the research practice should be set into its historical and contemporary design, industrial and critical contexts.

1.7 Conclusion

In conclusion it is necessary to re-iterate the definition of knitwear for the purposes of this research as a knitted fashion garment that is either fully or partly shaped, and has an integral hem, welt or rib, even if cut-and-sewn elsewhere. This enabled the knitwear produced by this research to be viewed separately from the wide range of commercially produced jersey-wear and cut-and-sew knitted garments. In order to do this, this research has been placed in its historical context of fashion, fashion knitwear, knitted garments and their manufacture. It has been equally important here to establish that apart from traditional fully fashioned jumpers and cardigans, the fashionable mid 1950s ‘twinset’ being an example of this, shaped mass-produced knitwear could only really compete as commercial fashion after 1990. This was because the increasingly sophisticated knitting technologies of the 1990s enabled the efficient co-existence of shaping and a choice of both complex colour patterns and textures in the same machine knitted garment.

Through the relevant primary research data and literature review included in this chapter, a clear of dissatisfaction with clothing fit and availability of clothing for, and a lack of understanding of, the shape of real and larger bodies clearly emerged. If this dissatisfaction had ever been dealt with, there would have been no need for this or any other related projects. Yet, despite the fact that SizeUK took place in 2003, eight years
later there seems little evidence of change, especially in the size and fit of commercial
knitwear for larger sized women. In this context there was obvious need for research
that focused on the specific needs of larger women for an improved fit in knitwear.

This neglect of larger sized women’s clothing by manufacturers and retailers, as
demonstrated here, would appear, as discussed here, to be in direct conflict with the
economic consequences of demographic change. In 2000, according to Gardyn the
North American plus size market was worth $32 billion (20% of the total market)
having increased by $8 billion in four years and the prediction was that it would have
reached $47 billion by 2005.166 It was not surprising then that in 2008 it was reported
by Just Style, the apparel and textile intelligence service, that plus size sales had
grown to be worth $62 billion and were growing by 10% a year, whereas other annual
clothing sales were only increasing at 3-4%. It was further reported that as such the
plus size market was accounting for three quarters of all US clothing sales.167
Meanwhile, according to the Financial Times, the UK has the fastest growing rate of
obesity in Europe, and Verdict retail analyst Carly Syme reported that the UK plus
size market share increased from 18.7% in 2006 to 23.2% in 2011. She predicts that it
will rise by a further 28.6% (£6 billion) by 2015, having risen by 6% to £4.9 billion in
the year 2010-11 alone. 168 Despite this there is still a surprising lack of larger sizes
in what consumers deem to be desirable clothing, and it would seem commercially
sensible for many more manufacturers to target design, manufacture and retail at this
lucrative, growing and increasingly discerning UK market. This research sought to
redress this by offering design templates which will improve the fit, and hence the

166 Marshall Cohen, The NPD Groups Fashionworld research division in Rebecca Gardyn, "The Shape
of Things to Come", American Demographics 25.6 (2003).2
167 "Outsize is in, but will apparel retailers latch on?".
Syme: n.pag.
fashion value and desirability of commercially machine-made knitwear.

Sizing in knitwear has been shown here to have been rudimentarily introduced only in the 1930s. Since the 1950s despite sizing becoming more standardised, the actuality of this has always ignored the requirements of specific fitting to the body shape of larger women. Plus sized knitwear has only recently become more widely available through large high street retailers and mail order companies, but this still remains a niche market and larger sized knitwear still relies on the fundamental stretch properties of knitting to achieve a fit across various larger sized body shapes.

Future application of the research outcomes of this study offer opportunities within this rapidly growing niche market of larger size knitwear to manufacturers who may not have access to the latest knitting technologies. The decision to focus this research on developing widely available, technologically simpler methods than complete garment technology offers the potential for outcomes that are accessible and commercially valuable and viable for a large section of the UK, and indeed the international, commercial knitwear industry.

This research’s review of relevant literature confirms that fashion knitwear and technology are now inextricably linked. Through the analysis of historical knitwear and knitted fashion garments undertaken for this research, and shown in Appendix F, the emergence of truly commercially available machine knitted shaped fashion knitwear can be placed to the 1950s, coinciding with the period in which mass produced fashion knitwear for women finally ‘came of age’ as fashion. This means that the development of new, technological and design thinking in shaped fashion knitwear manufacture spans less than a quarter of the history of the mechanised manufacturing of knitting.
This study has shown that the development of knitting machinery that is capable of manufacturing the product of such new ideas has only been available since the mid 1970s, and only truly commercially viable since the late 1980s. Thus this research which focuses on knitwear for larger women’s body shapes is embedded within, and is an outcome of, this ‘new wave’ of thinking about knitwear and body shape. It draws on new technologies in both knitting and 3D body shape acquisition to enable fresh and innovative approaches to commercial knitwear targeted at larger sized women.

This is confirmed in the brief history of knitting technologies undertaken here. This has shown that progressively more technologically sophisticated V-bed knitting machinery has encouraged design and development which deals with the problem of how mass produced garments can be innovatively knitted. This has also shown that currently, and for sound commercial reasons, sizing in knitwear is a highly current topic for research, particularly as discussed here, when pursued in combination with research into larger body shape. From its inception, these factors have placed this research at the forefront of new thinking in the design and manufacture of knitwear for larger women’s body shape.

There is a recurring, thematic discourse within knitwear design and manufacture and knitting machine manufacturing which stems from the fusion of the fashion cycle, and its continuous introduction of ever new designs, and the technologically complex industrial space in which knitting is sited.¹⁶⁹ There are unresolved attendant issues which touch on the new training needs of the high-tech industry that knitting has become, and creative aesthetic design concerns about maintaining originality and high quality fashion in view of the proliferation of machine builders' downloadable patterns

that were described by Sayer as a ‘jigsaw approach to creating garments’.\textsuperscript{170} It was not the intent of this research to attempt to resolve this particular argument, which is beyond the scope of this research. It would however be avoiding one of the core discourses within the discipline if this study was to research and write about commercial knitting issues without acknowledging the existence of these particular concerns.

Based on the literature reviewed here it is clear that there is still a gap to be bridged between the capabilities and design potential within the new technologies that will be outlined here, not only in relation to complete garment technology, but also electronic knitting technology as a whole. These technologies remain largely unexplored by knit designers, and their potential has only truly been seen in the advanced technical samples developed by the knitting machine manufacturers. These have rarely, so far, been translated into high street garments.

This chapter has explained the background to the research rationale. It has addressed some of the dilemmas faced by larger sized women in the context of their desires for involvement with the world of fashion overall, and when specifically seeking well fitting knitwear. This chapter has also identified and clarified their resultant garment satisfaction when offered well fitting, shaped knitwear for larger body shape, without the stretch-to-fit characteristics of commercial high street knitwear. Finally this chapter has described the aims and objectives of this research in their socio-cultural and historical background contexts.

\textsuperscript{170} Sayer, \textit{et al.}:44
2 Research themes, research methods and activities, and related literature review

2.1 Introduction

The first step of development towards establishing the research themes for this study was a review of literature that would inform research perspectives, methodologies and methods relevant to this study.\textsuperscript{171}

As the research ideas and practices developed, it clarified that these into three main areas of interest: larger female body shape and clothing anxieties, clothing fit and industrial knitwear manufacture. Therefore an interdisciplinary conceptual framework specific to this research was established which blended participatory, visual and user centred methods for gathering data. Details of these methods when applied to working with participants, measuring the larger body shape, and knitting for larger body shape are described briefly here, but are discussed more fully in Chapters Three and Four.

It became progressively clearer that the success of this research would be dependent upon developing independent and unique information and understandings specific to larger women’s body shape. Finding suitable participants, obtaining body measurements, garment dimensions and subjective and objective evaluation were clearly key to the practice element. Developing an understanding of the participants’ perceptions of their body shape, size and clothing needs past and present would be necessary, and of equal importance was creating a pool of primary data about larger women’s clothing interest to inform the design process, socio/psychological reflections and debate of the research. These three strands required different methods and subsets of research techniques which were designed for the pilot study and then

\textsuperscript{171} This was undertaken as part of the course content of the University of Brighton Postgraduate Certificate in Research Methods attended 2005-6 (Distinction).
re-crafted before the start of the main study following analysis of their success.

2.2 Research themes

2.2.1 Larger body shape and size

It was necessary to clarify for the purpose of this text, that larger or ‘plus-size’ has been classified in this research as women above a UK size 16. This places this research’s findings at the lower end of the ‘average’ size as described by the publicly published results of SizeUK.\textsuperscript{172} This research was however, working with larger body shapes, not sizes \textit{per se}. Throughout this text, apparel sizes, such as ‘size 16, 18’ etc., have been used because these are a recognised generic descriptors of women’s standard body size, but it was the 3D body shapes of women who have bodily dimensions of a size 16 and above that were used, in conjunction with these dimensions, to develop the outcomes of this practice based research.

Selection of digital knitting equipment on which to carry out the practice development was supported by the researcher’s accumulated knowledge of knitwear and knitted textile design, knitting technology and computer aided design and manufacture (CAD/CAM) of knitting over a period of twenty seven years. The SES 102ff electronic knitting machine was selected because the SES series is the biggest selling type of flat V-bed knitting machine; at least this was the case in 2009 for Shima Seiki.\textsuperscript{173} The significance of this popularity to this research was that although specialist complete garment machines offered new technology, and the latest generation of the traditional V-bed machine had improved production and flexibility, the underlying electronic V-bed design of both types was highly versatile. Thus the means to achieve fresh knitting responses to unusual body shapes challenges, as


\textsuperscript{173} Richard Webster, (2009), Interview with Sales Director of Shima Seiki Europe Ltd., 22nd July: 8.
developed in this research, would be accessible to a large segment of the flat bed machine knitting industry.

2.3 Literature review of the research themes and methods

2.3.1 Body shape in relation to clothing size and fit

Whilst the average woman had been proved to be larger than her ancestors, as seen in the results of the various sizing surveys carried out during the past decade, sample sizes for models at fashion shows were, conversely, shrinking. Nussbaum in 2007 reported them as falling from a US 6 (UK 8, European 36), to a 4 (UK 6, European 34) and even a size 2 (UK 4, European 32) which equated to an 82.5cm bust, 61cm waist and 87cm hips. All of this was in direct contrast to the most recent literature on clothing sizing and fit which recommended working with real sized body data.

Bougourd in her chapter *Sizing Systems*, in the 2007 text *Sizing in Clothing*, wrote about consumers seeing good garment fit as synonymous with quality, and described how ‘fit models’ and mannequins, based on data from SizeUK, could be used to ensure that real body size underlay clothing size and fit. In the same text, Loker took her 2005 research on improving fit by analysing size-specific body scan data a step further, into a discussion about its application to mass customisation.

Branson and Nam, in their chapter *Materials and Sizing*, discussed stretch fabrics,

---


particularly knitted ones, in the context of fit, and remarked, “...it is erroneous to assume that a stretch fabric garment will automatically fit in all the right places”. They further commented, confirming the preliminary comments made here already, that ‘trial and error’ had commonly been used to modify patterns for knits. 178 (They were writing here about knit fabric that was cut-and-sewn, with particular reference to underwear rather than shaped knitwear).

At the same time as this development of a focus on size and fit, there was a parallel popular interest in body shape and size. In 2007 Woodall and Constantine on their ‘Trinny and Susannah’ website and in conjunction with their television shows, held a survey of women’s bodies divided into twelve categories identified by shape not size.179 Another example of continuing popular media interest in non-standard body shape and clothing problems was the Channel Four series How to Look Good Naked, presented by Gok Wan, which had run for six series.180

One of the few texts dedicated to women’s larger sized clothing design, construction and evaluation, was Cooklin’s 1995 text, Master Patterns and Grading for Women’s Outsize. In this Cooklin laid down rules for 2D pattern cutting that catered for larger bodily dimensions rather than 3D shape. He did however describe basic body types, linking them to the American psychologist Heath-Carter’s ‘somatotypes’.181 Cooklin defined body shapes as the Ectomorph, with a long, slim body, and little body fat, the Endomorph, with a tendency to roundness and noticeable body fat in the abdomen, upper arms and thighs, and the Mesomorph with above

average muscular development and low body fat.\(^{182}\) He modelled these on Heath-Carter’s basic descriptions, developed for anthropological identification, which defined a series of specific terms; ‘endomorphy’ referring to ‘relative fatness’, ‘mesomorphy’ as referring to, ‘musculoskeletal robustness relative to height’, and ‘ectomorphy’ as ‘relative linearity’.\(^{183}\) Close similarities were obvious, but neither went further than the physiological classification. What they overlooked is that within each category, body shape varied.

In her arguably less academic, but more inclusive 1999 book, *Sewing for Plus Sizes*, the American Barbara Deckert divided larger shape into additional categories. Possibly because larger body size was already established within the title, Deckert explored shape rather than size, and paid unusual attention to the details of body shape encountered within this pre-defined group of women.\(^{184}\) Both these texts pre-dated 3D body scanning and therefore relied on traditional methods of visualising body shape.

Vuruskan’s work on body shape classification was reviewed for determining the body shape classifications for the survey and selecting participants.\(^{185}\)

Following analysis of data from the 2002-4 SizeUK population sizing survey, it was reported by Bougourd that in an unpublished report, Crawford (director of Sizemic which provides ‘customised fit’ and generic mannequins to the clothing trade made from SizeUK data), wrote that there appeared to be more variations amongst

\(^{182}\) Cooklin.6.


larger sized fit models ordered than amongst smaller sized ones. This suggested that larger bodies required closer calibrated and more varied size ranges for clothing to fit them correctly.

In 2002, when discussing existing understanding of real body size, Pechoux and Ghosh in the *Textile Progress* publication ‘Apparel Sizing and Fit’, remarked that women’s clothing manufacturers have, “lost touch with real body measurements”, and that sizes have become,”...abstract numbers”. They further suggested that because of this, women no longer knew or understood how to take their correct body measurements. This may indeed have been (and still be) the case, because in 2004 the publicly published SizeUK findings indicated that the average woman in the UK was a size 16, yet this research’s evidence, gathered between 2005 and 2010 as can be seen in the Appendix E and Chapter One section 1.1.3, demonstrate that there is limited availability and poor choice of clothing over a size 16.

### 2.3.2 Participant involvement

In the field of ergonomics and anthropometrics, which are central to this specific research, Pheasant in *Bodyspace*, his 2001 authoritative text on anthropometrics, wrote about user-centred design. He allied this concept closely to design and working with human bodies, describing it as, ‘...dealing with people as they really are’ whilst aiming to fit the product to the user. Without participants to evaluate and feedback on the garments in this research, only theoretical analysis would ever have been possible in this research. Therefore based on Ashdown, Chowdray and Bye’s participatory research methods, and in conjunction with Pheasants’s user centred

---

perspective, a basic framework involving a group of participants was established for this project.\textsuperscript{189}

Researchers into larger body sizes had, since the 1980s, employed varying research frameworks, the most relevant of which are highlighted briefly here. Both Chowdhary’s study of clothing interest and satisfaction, and that of Kind and Hathcote, which detailed retail and fit, employed participant questionnaires. The resulting data from both of these studies was then analysed using quantitative, statistical methods.\textsuperscript{190} However neither Ashdown, in comparing sizing systems to anthropometric data, or Salusso when seeking alternative sizing for older women, elicited participant input. Instead both analysed existing size charts for developing their conclusions.\textsuperscript{191}

Shim, and LaBat and Delong’s research proved useful for their separate studies into body cathexis, apparel shopping and fit.\textsuperscript{192} Both studies used a five point Lickert scale to elicit respondent’s levels of satisfaction with these issues, and their results were statistically analysed to reach conclusions. More recent research into apparel sizing systems and body scanning, such as Loker’s 2005 study to improve size specific fit, compared existing data and participant questionnaires to generate


-91-
quantitative results. Ashdown’s 2004 research into 3D body scans for fit analysis, which used an expert judging panel, was empirically based, involved participants and visual analysis, and results were more descriptive of the body than the others discussed. Ashdown has a successful history of empirically based ‘testing’ of theory in clothing size and fit research, therefore selected methods from her practice based research were adopted and adapted as a methodology for this study, and as will be shown.

As Apeagyei notes, ethical issues may arise when working with participants, in particular those who may be sensitive about their size. Those identified in this research, including the preparation of participant information and consent forms, were addressed and the proposals accepted by the University of Brighton Ethics Committee.

The relevant participant forms can be found in Appendix. ?.

2.3.3 Gathering background and supporting data

Various methods through which to gather background data specific to the purpose of this enquiry were considered, including focus groups, formal and informal interviews and a survey. Based on the literature search, and in particular the advice of De Vaus who, in Survey Research, highlights the impracticalities of administrating a broad, qualitative, paper questionnaire in small scale research, an online survey was

193 Loker, et al., "Size-specific Analysis of Body Scan Data to Improve Apparel Fit". (North Carolina State University)
194 Ashdown, "An investigation of the structure of sizing systems: A comparison of three multidimensional optimized sizing systems generated from anthropometric data with the ASTM standard D5585-94". (Emerald)
chosen as the most appropriate.\textsuperscript{197} As highlighted by him, this simple format would provide focused answers to a set of ‘specific variables’ whilst at the same time placing this research in a wider context as recommended by Preece.\textsuperscript{198} In view of this, a short, structured, descriptive style, multiple choice online survey was designed.

In order to deploy the survey, the literature search indicated that Chowdhary’s example of recruitment of plus sized participants by plus sized women had been a successful and focused method.\textsuperscript{199} To ensure that the survey was professionally acceptable and accessible, prior to making the survey ‘live’, the advice of a professional marketing and design management consultant was sought on the wording and format of the survey.\textsuperscript{200}

\subsection*{2.3.4 Clothing fit and ease}

The space between body and garment, which is crucial to where a garment collides with the body shape beneath, is termed ‘ease’; usage which both Huck, and Rasband in \textit{Fabulous Fit} corroborate. The important relationship between ease and the fit of clothing is recognised in the literature. Rasband defines garment ease as, ‘the difference between the actual measured size of the body and the measured size of the garment as intended by the designer’, whilst Huck writes that ease is, ‘...the difference between the size of the garment and the size of the wearer’.\textsuperscript{201} What is of particular interest to this research is that Huck was looking at the relational effects that fit (or poor fit) in one area has on another area of the garment. In this she was examining the

\textsuperscript{198} de Vaus. 172; R Preece, \textit{Starting Research an Introduction to Academic Research} Longman, 1994).
\textsuperscript{199} Chowdhary and Beale:784
\textsuperscript{200} E mail communication with Nina Shephard,, Marketing and Design Management Specialist, <http://www.ninashephard.co.uk>
concept of unequal levels of ease throughout a garment in order to achieve fit, comfort, mobility and wearer acceptance.\(^{202}\) This concept of unequal ease was extremely important to this research and is discussed further in section 2.4.7

2.3.5 Commercial customisation of knitwear

Interest in the potential of the latest complete garment knitting technologies was seen to have attracted interest for customisation of knitwear. This had led to the Swedish School of Textiles pioneering a co-design, ‘one piece fashion’ project entitled *Knit-on-Demand*. This project was built on Wajima Kohsan Ltd’s *Factory Boutique Shima* operation and the Shima Seiki *Ordermade* principles. These two Japanese projects are described by Peterson as having started soon after the introduction of the first Wholegarment® machine in 1995.\(^{203}\) What is significant in these projects is that, as Peterson writes, “…the outcome will not be a free fashion design, as the customer has a restricted range of options”.\(^{204}\)

An example of the use of *Ordermade* in a commercial situation was included by Petersen in *Mass customisation of knitted fashion garments: Factory Boutique Shima – a case study*, in which he described the production process of customised complete garment knitwear.\(^{205}\) Hunter also discussed the use of this customisation system in a retail setting in 2009.\(^{206}\) However it was noted that apart from *Knit on Demand*, there was little evidence of traditional knitting being developed in this direction.

Larsson described how *Knit on Demand* worked on similar principles to

\(^{202}\) Huck, *et al.*:45-46


\(^{204}\) Peterson, *et al.*:9


Ordermade, using a fit assessment of a standard sized garment to gauge the eventual custom-made garment size.\textsuperscript{207} It is apparent from the literature that the Swedish project had been developed as a test of mass customisation rather than to enable fit to unusual body shape, although as Larsson reported, customers chose *Knit on Demand* garments because they found the fit of standard sizes unsuitable.\textsuperscript{208} The project finally used cut-and-sew methods rather than fully fashioning for its garments, and therefore it is debatable whether it represented a forward or retrograde step in knitwear development.\textsuperscript{209} It did however provide insight into the mass customisation process and displays parallels with the concept of the schema template library developed through this research.

Some evidence of combining digital knitting technology with 3D body scanning for customisation of knitwear was found between Shima Seiki and [TC]\textsuperscript{2}. According to the guide to the *SPESA (Sewn Products Equipment & Suppliers of the Americas) Expo* and an email communications with Dr Bruner of [TC]\textsuperscript{2} these companies entered into a brief collaboration in 2007 to demonstrate the use of 3D body scanning with complete garment technology.\textsuperscript{210} (see Appendix E) The author was later informed by Dr Bruner in a telephone conversation in 2008 that he understood that this was terminated without real end product due to the time (and therefore expense) involved in the practicalities of knitting. This example of problematic time and access issues demonstrated why studies similar to this research idea were found to be rare, and were taken into consideration whilst developing the research idea. It was concluded that as the researcher was able to fulfil all the roles required and had access to a suitable

\begin{itemize}
\item[\textsuperscript{208}] Larsson. 7
\item[\textsuperscript{209}] Larsson. 5
\end{itemize}
knitting system that the research idea had a high chance of success

2.3.6 Measuring body size and shape

There is a lot of literature and information available about methods and results of measuring body size and shape, not all of which was relevant to this research.

Literature about measuring the body for designing apparel reports that historically key dimensions were physically measured whilst others were calculated from a table of proportions, to which processes Bye attributes the standard sizing tables in use today.211 A progression from this model may be seen in 1990 Cooklin’s text Master Patterns and Grading for Women’s Outsizes in which, although he did not describe how to locate bodily landmarks, pertinent positions of where to take body measurements where shown, and reference was made to different figure types.212 Aldrich’s Metric Pattern Cutting however ignores body shape variations, concentrating instead on linear measurements between points that are not clearly described, and although used as occasional reference, was not influential on the development of the measurement technique for this research.213 In 1992, Gazzuolo is described by Kwong in Garment Design for Individual Fit, as employing anthropometric measurements in combination with photographs to calculate pattern dimensions.214 Finally in 1995, Ashdown rejected the established idea that sizing is based on a linear relationship between height and width, and instead based her research into developing well fitting clothing for older women on a series of

212 Cooklin.7-8.
measurements of the actual bodily proportions taken between landmarks. In the same year, Watkins in, *Clothing the Portable Environment*, recommended anthropometric landmarks for clothing sizing; in particular suggesting adding markers over bony protuberances. By 2002, Tatara and Shanley, in *Pattern Master Boutique Instruction Manual* were demonstrating that even home dressmakers were familiar with the landmarking technique. Thus it appeared that landmarking was a relatively new, but helpful and well received concept in measuring the body for apparel design and manufacture. These skeletal markers enabled reference points to pinpoint between which the convexity or concavity of the body surface could be measured and observed.

Pheasant’s *Bodyspace* was considered a seminal text on anthropometry and ergonomic design, being used primarily for product design, because he focused on the way the body moves through space relative to inanimate objects. His text was considered to be relevant to this research because he described the use of anthropometric skeletal markers. Simmons’ 2003 *Body Measurement Techniques* offered similar information, with the additional valuable comparison between anthropometric and 3D body scanning methods.

Data which was particularly relevant to this research was that gathered during the national SizeUK and SizeUSA surveys carried out between 2001 and 2003. The surveys were carried out in very similar ways, and the methods used have influenced

---

218 Pheasant.
219 Pheasant.32-33.
the processes of this research.  

During SizeUK, 1.5 million measurements were taken from the 3D bodyscans of 11,000 volunteers in order to establish whether new sizing was required for clothing. Sixteen UK retailers and the Department of Trade and Industry commissioned the survey which was a collaborative project involving a number of academic institutions. Analysis of the results is only available through Sizemic who market the data on behalf of the consortium. However this research does not require access to the minutiae of the data, as its focus is on the individual, not the average, and that of larger body size in particular.

Not only was it timely to update population body size data from that of Kemsley’s 1957 study, but the 3D body scanning technology captured body shape as well as surface dimensions. Unlike Kemsley’s survey, only eight measurements, including weight and height were taken manually and the remaining 130 measurements were taken via a 3D body scan. Although technological details of 3D body scanning are outside the scope of this text; a brief description will explain its appropriateness to this research.

The [TC]$^2$ NX12 scanner, as used in SizeUK, collected raw 3D data during a ten second ‘white light’ scan. From this data, a 3D point cloud was produced, (literally a dense cloud of up to 300,000 digital reference points) that maps 3D body shape. 3D software could then be used to generate a wireframe or smooth surfaced body shape from the data, and view the body shape from different angles. (Figure 1)

---

222 Crawford.
225 Crawford, *UK National Sizing Survey (SizeUK) Information*, 1.
Figure 1. Two 3D body scan images of Portia. The one on the left shows 'point cloud' data, the one on the right has been surface rendered in 3D software (CtrlView). The images have been turned and inclined. Images courtesy of [TC]2. (ORIGINAL IN COLOUR)
Proprietary software enabled location of body landmarks and electronic measurements to be taken between these. Horizontal slices of cross sections of different parts of the body could also be taken, so that between bodies of a similar girth measurement, shape variations could be identified.\(^{226}\) This technology was being used by 3D data companies such as Optitex, which were working towards creating accurate representations of 3D body shape for virtual try-on of clothing.\(^{227}\) In 2007, according to Bougourd; a recognised authority on 3D body scanning, the technology for consumers to evaluate garment fit prior to purchasing was not widely available, or particularly successful.\(^{228}\)

D'Apuzzo reported in 2009 that 3D body scanning, which was originally developed at the University of Loughborough in 1989 for anthropological surveys, was being researched extensively as a design tool for apparel in both industry and academia.\(^{229}\) The main companies involved include [TC]\(^{2}\) and Cyberware in America, Vitronic in Germany and Wicks and Wilson in the UK.\(^{230}\) Research of particular relevance to this area was also being carried out at Cornell University by Ashdown and Loker.\(^{231}\)

---


\(^{228}\) Bougourd.139.


\(^{231}\) "The 3D Body Scanner - Virtual Try-on".
2.3.7 Evaluation of clothing fit

‘Fit is the aspect ‘most crucial to success’ of any garment’. This opinion, quoted by Kwong in *Garment design for individual fit*, was originally expressed in 1996 by Barnes in *Fitting Solution*.232 Barnes’ original text continued by outlining that simple but universally challenging goal, ‘clothes that fit well and look good’.233 Her statement recognises that clothing is naturally subjected to assessment by a number of viewers and viewpoints. Central to all these is the consumer themselves, who as wearer will experience the contact of clothing with body and have individual responses to this based on experience, likes and dislikes, and planned use of the garment. Their satisfaction with fit will draw on personal experience of similar situations, future knowledge of planned use, and preference for loose or close fitting clothing. Decisions will also be influenced by their perceived body image, body cathexis, and social and cultural fashions as already discussed in Chapter One, sections 1.2.2. and 1.2.3.

In 2005, Anderson, Brannon and Ulrich et al, published their report, *Understanding Fitting Preferences of Female Consumers*, which confirmed again that there were strong links between fit preference, body shape and cathexis. They also found, significantly for this study, that what they term, ‘figure flaw compensation’ (choosing fashion clothing that disguised flaws), increased as body shape moved away from the ‘hour-glass’ or ‘triangular’, both of which have a distinct waist. Only 16.9% of ‘rectangular’ (without a pronounced waist curve) shaped respondents to their survey indicated that they were likely to wear fitted clothing.234 In addition to this,

Anderson reported that Hwang, in his 1996 doctoral study, *Relationships between body cathexis, clothing benefits sought and clothing behaviour*, found that satisfaction with apparel was more likely in people who were satisfied with a particular body part.  

In the light of all these findings, it is interesting to note that in 2003 when Fan carried out research into perceptions of body size, he found that when wearing loose fitting clothing obese bodies were perceived as thinner. Anderson recommended that future development of objective measures for clothing fit preference should reflect, ‘...body shape, body cathexis, clothing benefits sought and personal profile of the consumer’.  

The correlations of these earlier influences, when investigated by Alexander, Connell and Presley in their 2005 survey, *Clothing fit preferences of young female adult consumers*, revealed that body shape did not significantly influence clothing fit preferences for lower body garments, although it may do so for upper body apparel. This finding has particular significance for this research which concentrated on upper body apparel. Meanwhile, Hwang, Anderson, Fan and Alexander’s research findings contribute significantly to the premise of this research; namely that within practical limits, knitwear for larger women should only collide with the body at the wearer’s preferred body points.

The aforementioned research, and that discussed in Chapter One regarding body image body cathexis and body size, has dealt primarily with subjective evaluation by the wearer. A differentiation between subjective and objective views of clothing was made by Yu, Fan, Hunter and Lui in their 2004 text, *Clothing Appearance and Fit:*

---

Science and Technology, in which they discuss what they termed the ‘subjective assessment’ and the ‘objective evaluation’ of clothing appearance and fit.\textsuperscript{239} It needs to be highlighted here that this research, although concerned with the wearer’s evaluation is not seeking information about appearance in itself, but instead is gathering data on comfort of fit from the wearers and an informed evaluation of knitted textile behaviours and the relationship of knitting to body shape. For the purposes of this research this was termed the professional view, assessment or evaluation. In order that the wearers’ evaluation would focus on their feeling of fit rather than appearance of the garment, their assessment of my prototype garment was initially carried out in a room without a mirror. This approach is similar to that of Kawakubo’s first Comme des Garçons shop which opened in 1976 in the Minami-Aoyam district of Tokyo. Kawakubo’s shop had no mirrors because she apparently, ‘wanted women to buy clothes because of their feel rather than how they looked’.\textsuperscript{240}

Assessment of clothing, as mentioned earlier, can be subjective or objective. The judgement of clothing appearance, which includes fit but not exclusively, is described by Fan in, Subjective assessment of clothing appearance, as the ‘industrial norm’, the subjectivity of which he ascribes to lack of suitable specific objective measuring systems. His definition is based on visual evaluation, including that of ‘fabric surface smoothness’, which covers wrinkle recovery and pilling, seam appearance, and post-laundering smoothness.\textsuperscript{241} As demonstrated in the literature about the assessment of


\textsuperscript{241} Fan, "Subjective assessment of clothing appearance".15-26.
clothing fit, visual methods are particularly suited to this subject.

Visual evaluation is discussed by Rasband, in her 2006 text, *Fabulous Fit*, a text recommended by Yu as a ‘comprehensive guideline of clothing fit’, an opinion shared by this author. Rasband’s 2006 text was therefore consulted at an early stage of this research.²⁴² Both Rasband and Fan and Hunter (when discussing subjective fit evaluation in, *Clothing Appearance and Fit: Science and Technology* of 2004) recommended visual wrinkle analysis as a valuable tool.²⁴³ Likewise, Brackenbury in 1992, although writing predominantly about the technology of knitwear manufacture rather than the aesthetics of the finished garment, discussed visual examination’s use as an additional quality control tool.²⁴⁴ He further pointed out that utilitarian issues of manufacture can be overridden by design, suggesting that garment appearance is more important to the consumer than perfection in manufacture.²⁴⁵ In this Brackenbury’s opinion correlated with Petersen’s conclusions regarding the Knit on Demand outcomes as discussed in section 2.3.5.

As well as more objective methods, according to Yu, fit evaluation can be subjectively carried out by the wearer. When attempting to describe this in *Subjective assessment of clothing fit*, he quoted Cain, whose definition is particularly apposite to knitwear and to this research. Yu wrote that in 1950, Cain commented, ‘Fit is directly related to the anatomy of the human body and most of the fitting problems are created by the bulges of the human body’.²⁴⁶ Although presenting an uncompromising view of human shape, Cain’s statement recognises the same relationships addresses by this

²⁴⁵ Brackenbury, 175.
research. There remains however, in Yu’s opinion, an inconsistency about the understanding of fit within the clothing industry. This forms the theme of his discussion in which he highlights the incompatible relationships between the fashion industry’s tall, slim ideal, the socially acceptable body shape, real body shape and satisfactory clothing fit.247

In direct parallel with this research, Yu reported that live models were used extensively in the clothing industry for assessing fit because, ‘...real human bodies are involved and their comments on the clothing are sensible’.248 However he qualified this by recognising that models may make personally biased, qualitative judgements, and that choice of models' body size and shape can affect the feedback, an effect that will be taken into consideration when debating the results of this research.249 Additional concerns around the lack of precision in subjective assessment led Yu to speculate that verbal descriptors of fit are in turn also subject to interpretation.250

This use of written evaluation forms is described by Shen in, Bodice Pattern Development Using Somatographic and Physical Data, when in 1993 he devised a ‘subjective scale’ to assess fit in upper body garments. In this he divided the garment into parts and assessed fit of each part of the garment separately

In attempts at standardisation, researchers have been developing fit assessment protocols. Huck reported in, Coveralls for grass fire fighting, that when evaluating fire-fighters' coveralls for comfort and acceptance in 1997, she devised a range of movements during which the wearer was photographed, after which they were asked

248 Yu, "Subjective assessment of clothing fit".33.
249 Yu, "Subjective assessment of clothing fit".34.
250 Yu, "Subjective assessment of clothing fit".41.
to link the movements with experiences of fit and mobility.\textsuperscript{251}

Throughout the relevant literature, body movement was found to be equally important when evaluating clothing fit. Watkins described a comprehensive selection of methods for evaluating clothing fit during movement in her 1995 text, \textit{Clothing - the Portable Environment}, as did Regan, Kincade and Sheldon in their 1998 \textit{Applicability of the Engineering Design Process Theory in the Apparel Design Process}. Regan et al’s methods were described when applied to fit evaluation by Mitchka in 2009 in, \textit{Problem Structure Perceived}.\textsuperscript{252}

Clothing fit testing was recently discussed by Bougourd in her 2007, \textit{Sizing systems, fit models and target markets}, in which she described the commercial process in detail.\textsuperscript{253} Bougourd’s view was rooted in practical experience of body shape and fit issues as she was involved in the benchmarking of scanners for SizeUK and was directly responsible for data collection from participants, as well as having had a long career in the clothing industry.\textsuperscript{254} Her recommendations for the future included establishing protocols for fit sessions, and most importantly for this research, as discussed earlier, the separation of assessment of style design from evaluation of fit.\textsuperscript{255}

The use of mannequins for the evaluation of clothing fit is recommended by both Bye in her 2004 \textit{Analysis of Body Measurement Systems for Apparel}, and Bougourd in \textit{Sizing systems, fit models and target markets}.\textsuperscript{256} Bougourd further highlighted the

\textsuperscript{253} Bougourd.134.
\textsuperscript{255} Bougourd, "Sizing systems, fit models and target markets".135.
\textsuperscript{256} Bye, \textit{et al.}, "Analysis of Body Measurement Systems for Apparel".76; Bougourd, "Sizing systems, fit models and target markets".133.
valuable understanding of body shape both designer and manufacturer can gain from mannequins made from real body shapes.

2.3.8 Design process

It was important that in order to achieve transferable and reproducible results, the design and evaluation of the research knitwear followed a repeatable process. In order to develop an individual method for this research, literature relevant to the complete process of functional design and evaluation was reviewed. Amongst these, Watkins discussed such a design process at length in *Clothing - the Portable Environment*, and what they termed a ‘functional design process’ was explored by Regan, Kincade and Sheldon in 1998. In Huck’s reports of her studies into industrial clothing, there is an additional example of developing a functional design process protocol focusing on fit and mobility as factors in wearer comfort and acceptance. From these examples, a design process was developed for the research which included, as Watkins recommends, ‘clear design criteria’.

2.3.9 Stretch in knitting

Loop density, sometimes called stitch density (see Glossary of Terms), is a technical knitting term which describes the number of stitches within a pre-defined area of measurement on the fabric when ‘resting’. When knitting is stretched, the number of stitches within this area alters, thus affecting the resultant look of the fabric. The effects of stretching that were of particular importance to this research were that stretch makes single knit fabric more see-through, and that when convex shapes collide with the under surface of the knitting and stretch it, they become highlighted through stitch distortion and subtle colour change. Smirfitt and Spencer wrote

---

257 Watkins.227;Regan, *et al.*:36
258 Huck and Kim, "Coveralls for grass fire fighting":347 and 348. (Emerald)
259 Watkins.354.
extensively and in detail about loop density, but the technical aspects and formulae do not need to be included here, as this text is concerned more with the aesthetics of the knitting in its relationship with the body than with fundamental knitting technology.\textsuperscript{260}

A simplified explanation of why loop density is critical to the appearance of knitwear is that when initially sampling the knitting, the most aesthetically attractive and technically viable loop density will have been set as a numerical value of $X$ loops and $Y$ courses in a predetermined area, for example 50 wales (vertical lines stitches) and 80 courses (horizontal rows of stitches) per 10 centimetres.\textsuperscript{261} This is the ‘loop density’ of the fabric. This will then be set as an exact standard during the subsequent manufacturing process, often nowadays using digitally controlled yarn controllers such as Shima Seiki’s \textit{Digital Stitch Control System} which precisely control consistency of loop length.\textsuperscript{262} If however, when the garment is worn, the fabric is extended, the ‘legs’ of the stitches no longer lie at their passive angle, which is diagonally inwards from the top of the loop until they interconnect with the top of the loop below. Instead they stretch laterally, causing the stitch to widen and shorten overall. This in turn affects each interconnected stitch in the course, ‘robbing’ yarn from others, changing their shape and distorting the fabric structure and surface. (Figure 2) When the stretch goes beyond that intended when the fabric is manufactured, the loop density will move outside the original pre-set desirable parameters with attendant effects including distortion (leading to clinging) and reduced opacity.

\textsuperscript{261} Smirfitt.12; Spencer.17.

-108-
Figure 2. Three photographs of the research knitting with embedded grid, the top shows the relaxed knitting, the middle demonstrates the same knitting under mild extension, and the bottom image is of the same knitting with an irregular shape underneath, distorting the stitches and rows. (ORIGINAL IN COLOUR)
Brackenbury, when writing about the tolerances for assessing knitting quality observes that loop density, ‘... is the most important one in defining knitted fabric properties, and is directly related to appearance, weight per unit area, thickness, drape and many other factors’. It follows therefore that if this crucial element of the fabric is distorted beyond its original loop density when stretched over prominences like the bust, stomach, and buttocks it will essentially change the originally intended aesthetic and technical qualities of the garment.

2.3.10 Knitting methods

For usage and methods of shaping knitwear to 3D body shape, reference was made in part to what could be considered ‘lay’ texts, including Riley Duncan’s Knit to Fit, Righetti’s Sweater Design in Plain English, Stanley’s A Handknitter’s Handbook, and in machine knitting, Lewis’s, A Machine Knitters Guide to Creating Fabrics, and Kinder’s Machine and Hand Knitting Pattern Design. These authors however discuss shaping in relation to body shape, unlike the industrial knitting technology texts that concentrate on technical aspects and production processes. Eckert highlighted a similar literature gap in the context of knitwear design in her 1997 thesis, Intelligent Support for Knitwear Design.

It is significant to this study that domestic hand knitting experts have recently begun to address issues of stretch and fit in larger sized knitwear with the publication of designer-authors Moreno and Singer’s Big Girl’s Knits, and More Big Girl’s Knits, Sharon Brant’s Knitting Goes Large, and Shroyer’s Knitting Plus most recently

263 Brackenbury.158.
published in 2010. Solutions to avoid stretch for successful larger sized hand knits include: measuring correctly between carefully determined body points, adding sufficient ease to prevent ‘cling’, and eliminating bulk by selecting suitable yarns, structures and silhouettes. Moreno however is the only large sized knitwear author to truly address stretch by including short rows (see Glossary of Terms) as a bust dart technique, although in 1990 Righetti had suggested this as a general bust and shoulder shaping technique in her *Sweater Design in Plain English*. There is also a specific and informative section on larger sizes in Diane Newton’s *Designing Knitwear*, in which she suggests accommodating a larger hip-to-bust measurement by increasing the length of underarm bind-off on body and sleeve, so that the sleeve cap can still be shaped with the normal amount of curve, but the body can be wider below the armhole to fit a larger hip girth.

The decline in the popularity of domestic machine knitting since the 1990s has resulted in no recent texts being published that might have explored these techniques further in this area of the field. Texts on industrial knitting technology relevant to this research are reviewed in Chapter One, 1.2.7. Yarn choice and knitted fabric structure, which were equally important during the development of the research garments will also be discussed separately in section 2.5.3.

2.4 Research activities

2.4.1 Survey design

As has already been established, larger or ‘plus-size’ women were classified in this research as being above a UK size 16. However, to inform this research it was considered necessary to discover the variations in larger body shapes within the group

---

of women above a size 16, rather than the how and why their body shape and size came about.\textsuperscript{269} To this end, and to supplement directly gathered, primary source measurements and body shape information, further specifically targeted survey data was considered necessary to the research. Whilst the results of the SizeUK survey supplied national average figures on body size on which this research draws, unique data, specific to the purpose of this enquiry was sought.\textsuperscript{270}

As has already been identified through discussion of six key themes: body size, body image and body cathexis, body size and clothing size, femininity in its socio-cultural context today and themes of unhappy, larger size woman and shopping experiences, the theoretical framework of the research required some real-life data to support its themes. As one of the research aims was to make the study relevant to larger female body size and it had already been established through reading of relevant literature that there were physical and psychological consequences to larger body size, it was considered useful to gather not only quantitative data about body size, but also qualitative, anecdotal data about the latter issues.

Examples of clothing research discussed during the literature search showed that surveys can provide just such supporting data adequately and efficiently. It was therefore decided to design a survey that would gather both body size and shape data plus anecdotal evidence which could provided insights into the way in which larger sized women experience shopping and their relationship with their clothing. (See Appendix E for survey questionnaire).

Working as an independent researcher it would have been difficult to administer, gather and collate a paper based survey, whereas a suitably focused online survey can

\textsuperscript{269} de Vaus.173.
\textsuperscript{270} Allen, et al., "SizeUK:Average measurements for MEN and WOMEN". 1.
be easily administered and analysed by an individual researcher. Therefore a web-based online survey was the medium chosen for the research survey, as this provided automatic distribution to interested parties plus digital responses which were easier for an individual researcher to collate and analyse.

It was evident that the practical and theoretical outcomes of the research would be stronger if they included real life reports, personal stories and anecdotes from larger women that would reinforce the consumer need behind the research idea.

2.4.1.1 Target age range of the survey

Key female age groups for the research survey were identified in order to gather data from women when they had passed through periods of recognised changes in body shape. The youngest age group was identified as 16-20 years old, which would scope the younger audience as bone growth plates close at the end of adolescence and growth stops on average at age twenty.271 The second category was the 20-35 young adult stage, and the third was women towards the onset of middle age (35-55), by which time those women who have had children are mostly likely to have experienced any associated shape changes. The penultimate group of 55-65 years old was chosen because according to Cutler and Benktzon ageing affects body shape and many post menopausal women experience increased curvature of the spine including kyphosis and compacted vertebrae due to the natural ageing process or osteoporosis.272 According to Franzon, the average age for menarche is fifty-one, therefore this became the post menopausal category.273 Women generally gain weight until age


seventy, with fat deposits collecting on the middle of the body, particularly the stomach. After age forty, muscle tone and bone density drops, with a subsequent loss of height of an average one centimetre for every ten years. These changes in fat and muscle cause an aged person to develop a heavier-appearing body with thin arms and legs. Interestingly, and of importance to this research, they report that the arm span does not change with age, and unless there is pronounced curvature of the spine resulting in a concave chest, shoulder width does not alter. Based on this understanding of the effect of the ageing process on body shape the final group, originally categorised as 65-70, was subsequently revised to 65+ to encourage responses from older women.

2.4.1.2 Purpose of the survey

Through requesting response by front silhouette body shape, side view postural silhouette, upper and lower body size and age group, it was planned that data could be sorted and analysed in a number of ways. For example, (and as discussed in section 2.3.1.6. of this chapter), these questions enabled comparative analysis between body shapes within each age category and incidence of size by age group. The survey results informed the selection criteria of participants for the pilot and main study by supplying data on the most frequently reported body shapes.

2.4.1.3 Formulating the questions

Alongside standard body size categories as described, when designing the research survey, bra cup size information was considered to be a potential indicator of proportional shape. An example of this is that a 44” busted woman with an A cup would be considered more likely to indicate a wide back and a deep front-to-back body depth measurement; as this cup size has a smaller surface area and projects less

---

far into space, and as a result composes less of the overall measurement. Whereas the same bust girth, but paired with a D cup, may indicate a proportionally narrower back width and smaller front-to-back body depth. It is recognised that variables outside the control of the research, (for example how supportive the respondents’ undergarments were) may have influenced these answers. The final numerically quantifiable variables on which the data discussed here was analysed were identified as upper body size, lower body size, bra cup size and age.

In order to establish parallels with existing research into customisation of clothing, the literature was consulted with particular reference to body shape identification. In 2002 Kartsounis, Thalman and Rodrian reported on the E-TAILOR project, which was looking at European sizing inconsistencies and the infrastructures for customisation of clothing and virtual shopping. In this they described bodily features significant for automatic shape classification for women. These focused on the shoulders, hips, abdomen and back, with particular reference to posture. Although working with 3D body scanning and virtual technology, the morphological descriptions, especially ‘protruding abdomen’, ‘overly erect back’, ‘rounded upper back and shoulders, forward head’, and ‘ swayed back forward pelvis tilt’, contributed to those developed in this research. It was considered that to have a body shape described as ‘correct posture’, as there was in the report, would be in direct opposition to the purpose of this research and therefore this example was not followed. Side view images were used for the postural identification images as developed for this research.

Qualitative variables were identified as frontal silhouette, side view posture and stomach and buttocks shape (flat, rounded, very rounded). It was recognised that self-reporting requires an elevated level of self awareness and that body image issues as

discussed earlier in this text may have influenced the data. To ensure maximum external validity of the data, and to establish universality as recommended by Preece, carefully chosen descriptors based on simple standard terms for body shapes were developed for the questions.276

Through the methods described here, overall body shape and posture, plus an indication of standard sizes for upper and lower body were gathered from each of the identified key age groups.

As the research aimed to provide information for the field of mass-customisation, a question regarding respondent’s likelihood to purchase custom made clothing was also included.

2.4.1.4 Format of the survey

In order to reach the maximum audience and in line with theme of visual research methods found in the literature about clothing research, visual representations of body shapes were included in the survey. Respondents were asked to pick the one most similar to their own front view body shape and also to choose a side view that was the most similar to their posture. Simple radio buttons were used from which respondents selected upper and lower body size as separate responses. Because the survey was deployed internationally, a chart was provided relating UK sizes to the American and EU equivalents.

User input of individual, anecdotal information was encouraged to supply qualitative data for this thesis. In order to allow this, a free text field was included for respondent’s to add any relevant anecdotal information.

Responses were collected via a script that sent them to a pre-defined mail box from

276 Preece. 26.
which they were gathered, printed and collated. Numerical data was entered into an Excel spreadsheet and anecdotal responses added to a Filemaker Pro database.

2.4.1.5 Survey deployment

As it was necessary to keep the responses focused, the decision to target a specific sector of women was based, as already discussed on Chowdhary’s example. This earlier research, transposed to current technologies, suggested a route for accessing a target population via online plus size retail outlets and specialist web sites. This method of deployment would discreetly approach an interested section of the population to encourage survey responses. It was however recognised that results based on a non-probability survey such as this could be biased and would therefore be valid only to this research.

A survey designed on these lines was undertaken successfully and ran for a period of 18 months, during which 310 responses were received, the 294 useable ones of which became the survey sample and responses which have been discussed in Chapter One. Body size and shape data gathered through the survey has been analysed to provide the information on which this section has drawn. (See Appendix E for survey questionnaire)

2.4.1.6 Survey analysis methods

As already stated, there were a total of 310 responses to the online survey, of which 294 were useable with age, upper and lower body, bra cup, silhouette and posture data fields completed. The data gathered through the online survey was analysed in a number of ways. Initially reported upper and lower body sizes totals were sorted by size groupings. Across both upper and lower body size, the largest group of responses was 36% reporting a lower body size of a UK 24 or above, whilst only 32% had

277 Chowdhary and Beale:784
indicated they had an upper body size of UK size 24 or above. (Table 1) and (Table 2)

Table 1. Chart showing lower body size by % groupings of total responses to survey.

Table 2. Chart showing upper body size by % groupings of total responses to survey.

The third largest single group of nearly 17% reported a lower body size of a UK size 20. (Appendix E) Amongst other things, these figures demonstrated that of the 36% with a lower body size of 24+ at least 4% had a different upper body size, a situation that had been noted in the raw data, the anecdotal information and interviews
with participants.

Further analysis was conducted to discover how this difference between upper and lower body size was distributed amongst the body shapes identified in this research. The data indicated that this disparity occurred more in women who reported themselves to be a size 16, 18 or 22 in either upper or lower body size. For example, it can be seen that 22% of the respondents aged 55-70 reported having a size 18 upper body, compared to only 13% who reported this as their lower body size, meaning that 9% of those aged 55-70 with a size 18 upper body had a different lower size. (Table 3)

![Graph showing comparative incidence of upper and lower body size](image)

**Table 3. Comparative graph of the incidence of upper and lower body size amongst the 55-70 year old respondents, based on reported size of purchased clothing. Of the total 294 respondents, 68 were in the 55-70 year age group. (ORIGINAL IN COLOUR)**

The data was also analysed by occurrence of equal or different upper and lower clothing size across each body shape as identified by this research. Of the Type A shaped respondents who described themselves as having ‘wide shoulders/upper body’, 67% reported having the same size at bust as at hips. (Table 4) Meanwhile of women who described themselves as either, ‘wide-waisted with a round tummy’ (Type D), or 'generously proportioned with undefined waist' (Type E), only 36% of each group reported themselves as being the same size at bust as at hip. (Table 5) and (Table 6)
Table 4. Type A body shape and body size data from the research survey. This table shows the percentage of self-reporting Type A (‘wide shoulders and upper body’) respondents who indicated an equal lower to upper body size and the percentage that indicated different lower to upper body size. (ORIGINAL IN COLOUR)

<table>
<thead>
<tr>
<th>Upper body size</th>
<th>Lower body size</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>14</td>
<td>16</td>
</tr>
<tr>
<td>14</td>
<td>0.00%</td>
<td>11.11%</td>
</tr>
<tr>
<td>16</td>
<td>0.00%</td>
<td>22.22%</td>
</tr>
<tr>
<td>18</td>
<td>11.11%</td>
<td>0.00%</td>
</tr>
<tr>
<td>20</td>
<td>0.00%</td>
<td>11.11%</td>
</tr>
<tr>
<td>22</td>
<td>0.00%</td>
<td>0.00%</td>
</tr>
<tr>
<td>Grand Total</td>
<td>11.11%</td>
<td>33.33%</td>
</tr>
</tbody>
</table>

Table 5. Type D body shape and body size data from the research survey. This table shows the percentage of self-reporting Type D (‘wide-waisted with a round tummy’) respondents who indicated an equal lower to upper body size and the percentage that indicated different lower to upper body size. (ORIGINAL IN COLOUR)

<table>
<thead>
<tr>
<th>Upper body size</th>
<th>Lower body size</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>14</td>
<td>16</td>
</tr>
<tr>
<td>14</td>
<td>2.17%</td>
<td>0.00%</td>
</tr>
<tr>
<td>16</td>
<td>4.35%</td>
<td>4.35%</td>
</tr>
<tr>
<td>18</td>
<td>0.00%</td>
<td>8.70%</td>
</tr>
<tr>
<td>20</td>
<td>0.00%</td>
<td>2.17%</td>
</tr>
<tr>
<td>22</td>
<td>0.00%</td>
<td>0.00%</td>
</tr>
<tr>
<td>Grand Total</td>
<td>6.52%</td>
<td>15.22%</td>
</tr>
</tbody>
</table>
Table 6. Type E body shape and body size data from the research survey. This table shows the percentage of self-reporting Type E ('generously proportioned with undefined waist') respondents who indicated an equal lower to upper body size and the percentage that indicated different lower to upper body size. (ORIGINAL IN COLOUR)

Data was additionally analysed to establish the percentage of respondents by reported size within each age bracket. Of the youngest, 16-20 age bracket, 8% reported themselves as a size 16 and another 8% as being over a size 24, the remaining 84% being in the smaller sizes. (Table 7) Of the 20-35 age group over half reported being above a size 16, with 16% of total respondents in the group being over a size 24. This group was the most evenly distribution across the sizes, with approximately a quarter being a size 14 or smaller. (Table 8) In noticeable contrast, the 35-55 year old category displayed a majority group of 38% to be over a size 24, with only 9% being a size 14 or smaller. (Table 9) The highest incidence of larger size within a category was found in the 55-70 age group, with 94% being over a 16 and a third of these being in the 24+. Within this group only 6% reported sizes smaller than a 14. (Table 10)
Table 7. Chart showing percentage of 16-20 year old female respondents (13 of 294) to the online survey who wear dress sizes 8-24+. (ORIGINAL IN COLOUR)

Table 8. Chart showing percentage of 20-35 year old female respondents to the online survey who wear dress sizes 8-24+. (ORIGINAL IN COLOUR)
Table 9. Chart showing percentage of 35-55 year old female respondents to the online survey who wear dress sizes 8-24+. (ORIGINAL IN COLOUR)

Table 10. Chart showing percentage of 55-70 year old female respondents to the online survey who wear dress sizes 8-24+. (ORIGINAL IN COLOUR)

Thus it is clear, based on the new and specific data gathered by this research, and by the informed opinions discussed here, that larger size is trans-generational. Although there is a smaller incidence shown amongst teenagers, it is significant that of the 14% over size 16, half of these are a size 24+. This may in the future affect what at
present appears to be an even distribution between smaller and larger sizes amongst women aged 20-35. There are clear indications that larger size becomes more prevalent after age 35, possibly influenced by the physiological effects of child-bearing, and that after 55 the majority of women are a size 18 or above in their upper body, which again may be partly attributed to age-related physiological changes.

### 2.4.2 Case study

A qualitative, single case study method as described by Yin was chosen as the most appropriate research method for this study, as it involves in-depth longitudinal study of individual, contemporary, real-life context cases rather than working with samples, averages and variables across a large population.\(^{278}\) It also usefully embodies user-focused research based on Yin’s theory of ‘convergence of evidence’ (wherein multiple evidences contribute to supporting one fact).\(^{279}\) All of this established a path within the research for implementing user data and has been incorporated as formative evidence as illustrated. (Figure 3)

Yin wrote,

> “The preparation for doing a case study includes the prior skills of the investigator, the training and preparation for the specific case study, the development of a case study protocol, the screening of candidate case studies and the conduct of a pilot case study.” \(^{280}\)

This passage aptly described the research path adopted for this research, which closely matched existing skills and working practices as already discussed. A pilot study undertaken in 2004, for which the participant was code named Juliet, helped to define the problem to be solved, allowed for the crafting and re-crafting of questions, and led to the main study, which started in 2006, being designed in a clearer, focused

---


\(^{279}\) Yin.100.

\(^{280}\) Yin.57.
Figure 3. Convergence of evidence recognised as a basis for this research. Adapted from Yin, (2003), Case Study Research: Design and Methods. (ORIGINAL IN COLOUR)
and more formed fashion.\textsuperscript{281} The participants for the main study were code named Desdemona and Portia. Participants were selected from volunteers based on criteria which are discussed in the following section.

When writing about the planning of practice based research, Newbury describes three approaches: completing research prior to practice and the inverse situation where the research becomes a reflection of the practice, and the practice of ‘doing’ where the practice itself is the research process.\textsuperscript{282} This research deliberately included elements of all three approaches. Initially there was a clearly defined planning stage lasting approximately nine months, followed by the previously discussed pilot study to test and reflect on methods and to deal with reflexive responses to problems encountered during the practice, for example the addition of 3D body scanning to acquire data, all of which have become part of the final successful research process.

2.4.2.1 Participant recruitment for the pilot and main studies

It was recognised from the start that managing a large number of participants might prove difficult for an independent researcher and require more resources than were likely to be available. In view of the nature of the research, that of working with non-standard bodies across the whole research project, plus the desire to develop a relationship to encourage user participation, from early on in the research design a smaller group of participants was proposed as the most viable. Additional practical considerations regarding the knitting of numerous garments, contributed to the final decision to conduct the research as a set of small, individual, but interrelated studies, the findings from which would provide conclusions for the research.

Primary criteria for the participant selections were body size and shape. Drawing

\textsuperscript{281} Yin.79-80.
on the online survey design methods, responses and related literature, it was decided
that recruiting three participants whose body shape spanned the most common larger
female body shapes would be the most suitable choices. These had been identified in
this research, as body shape Type C (wide hips and round tummy but smaller upper
body) and D (wide waist and round tummy and equal upper body width). In this way
participant selection was based on the research survey responses regarding anterior
(front) view body shapes as discussed in section 2.4.1.3 of this Chapter. Respondents
had picked from a selection of front view body shape silhouettes and these were
reported as Type C (38%), followed by Type D (26%). Both these body shapes
represented significantly larger percentages of the total than the other four shapes, of
which the next largest grouping was Type E (14%). (Table 11)

When recruiting participants, this process of self-categorisation was also requested
from the applicants. Juliet selected her front view body shape as a Type C with
tendencies towards a Type D as she had a smaller bust size, but a large waist.

Table 11. Chart of front body shapes by type as a percentage of total responses to the online
research survey. (ORIGINAL IN COLOUR)
Desdemona classified her body shape as Type D with tendencies towards an E as her waist was quite undefined. Portia selected Type C as her body shape, which was considered to be an accurate choice as her waist-to-hip ratio (WHR) at 0.91, was slightly lower than Juliet and Desdemona’s. These ratios were calculated by dividing the first value by the second as used by Furnham and Singh.283 The mid body girth was used as the waist for this calculation and the positioning of the waist in this research is discussed in detail in Chapter Four. These self categorisations were verified by visual assessment during the measuring sessions. All three participants were found to have high WHRs, which together with a rounded stomach were body shape characteristics established through the survey analysis as required for this research.

The posture classification of the participants was as follows. Juliet, who had rounded shoulders and a protruding tummy clearly fell into the P1 category, however as her upper body leant back and her bottom tucked in slightly, she was categorised as a Type P2/P3. Desdemona had an upright stance but with a tendency for a lordotic pronounced inward curve to her upper back, therefore her posture was established as a Type P1/P2. Portia had significantly rounded shoulders, and held her head forward of her body, but did not have an overly S shaped spine, so was classified as a Type P2 as defined by this research.(Table 12)

At this point, some technical knitting limitations had to be taken into account when establishing these criteria. The particular criteria affected were maximum garment width and bra cup size, (these were set at one metre and ‘C’ respectively). An

<table>
<thead>
<tr>
<th>Front view body shape type</th>
<th>Juliet</th>
<th>Desdemona</th>
<th>Portia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type C-D</td>
<td>‘Wide hips, round tummy’, small bust-narrower shoulders ‘Wide waist with round tummy’</td>
<td>Type D-E ‘Wide waist with a round tummy’ ‘Generously proportioned with undefined waist’</td>
<td>Type C ‘Wide hips and round tummy’</td>
</tr>
</tbody>
</table>

| Side view posture type    | P2+P3 ‘rounded shoulders and a bit of a tummy’ P3 ‘Swayback, a tucked in bottom and bit of a tummy’ image’ | P1+P4 ‘Upright stance with a bit of a tummy’ P4 ‘S-curve back and slight pocking out bottom’ | P2 ‘rounded shoulders and a bit of a tummy’ |

Key to body shapes and postures as defined in this research:

**Front view body shape type**
- **Type A**: Wide shoulders/upper body compared to hips, flat tummy.
- **Type B**: Wide hips, compared to upper body size, flat tummy.
- **Type C**: Wide hips and round tummy
- **Type D**: Wide waist with round tummy
- **Type E**: Generously proportioned with undefined waist
- **Type F**: Tall and evenly proportioned

**Side view posture type**
- **P1**: Upright stance with a bit of a tummy
- **P2**: Rounded shoulders and a tummy
- **P3**: Swayback, a tucked in bottom and bit of a tummy
- **P4**: S-curve back with a slightly poking out bottom

Table 12. Table of the three participant's body shape and posture related to the descriptions and images defined for the online research survey. (ORIGINAL IN COLOUR)
explanation of how this affected the knitting methods will be discussed in Chapter Four, section 4.4.

Recruitment of participants for the main study was by online advertisement, and initial responses were filtered through questionnaires establishing physical suitability based primarily on body shape. A final personal interview established the ability of the participant to provide adequate feedback and their individual temporal and geographical availability. Participants were given information sheets about the study and their anticipated role within it, and it was explained that they could withdraw at any time. (See Appendix A)

2.4.3 Diaries

Record keeping was a commonality amongst all the research projects already noted, so it was adopted here, including the research diary as advised by Newbury. Pages with particular significance to this text have been included in the Appendices, and the diaries form part of the exhibition of practice-based work that accompanies this text. (See Appendices and exhibition)

2.4.4 Measuring larger body shape

A measuring system specific to larger bodies was devised with reference to a the existing work of a number of experts, including Pheasant’s Bodyspace, Heath Carter’s somatotypes in adult women, Karla Simmons on anthropometric measuring and Beazley’s advice on body measurement surveys. Techniques and landmarks were also adapted from domestic and commercial 2D pattern making, knitwear

---


measurement methods, and the *Japanese Human Characteristics Database*.\(^{286}\) Latterly Bye’s review of measuring methods informed the validity of the adapted methods and Jeni Bougourd’s generous help with understanding of 3D body scanning methods aided the adoption of new technology.\(^{287}\)

It is relevant to this text to note Watkins’ assertion that manual measuring is, “...related to the way the landmarks are identified”, and that, “...it is a skill that is developed through practice”.\(^{288}\) Therefore the challenge to this research was to identify suitable landmarks on a larger sized body and establish their dimensional relationships in order to map the body shape of larger sized women.

From an early stage, these pertinent prior uses of 3D body scanning technology, and the unique body shape information available through the scanning process suggested that the inclusion of 3D body scanning would be useful to this research. It was necessary however, before embarking on this course of action, to find out what information was needed in order to landmark and map larger body shape, and whether this differed from that required for standard sizes.

### 2.4.4.1 Clones

As will be discussed in more detail in Chapter Three, section 3.2.8., it was considered desirable at an early stage in the research planning to make an exact replica of each participant’s torso shape as a mannequin to support the design process. For this purpose full sized torso ‘clones’ were made after each measuring session in both pilot and main studies. Both Bye in her 2004 *Analysis of Body Measurement Systems*...
for Apparel, and Bougourd in *Sizing systems, fit models and target markets*, considered mannequins to be important for evaluating fit. In 2008 Bougourd further highlighted the valuable understanding of body shape both designer and manufacturer can gain from mannequins made from real body shapes.\textsuperscript{289}

### 2.4.4.2 3D Body scanning

Although only adopted later on during the research, 3D body scanning had been found during the literature review to be of interest to other projects looking into mass customisation and knitwear. These included the collaboration between Shima Seiki and [TC]\textsuperscript{2}, makers of the NX12 body scanner discussed in section 2.3.5, and the E Tailor project into systems for mass customisation.\textsuperscript{290} Once it had been established as a suitable tool for this specific study, this digital method of capturing body shape as well as measurements was incorporated into the research process by purchasing scan-time on an NX12 3D body scanner situated at the London College of Fashion.

### 2.4.5 Selection of machinery

When selecting which knitting system to work with for this specific research project, geographical availability, costs, personal skill level and final outcomes were considered. Computerised, V-bed, weft knitting equipment was the natural choice for this research as the mechanical and technological capabilities of this type of machine, in combination with sophisticated programming systems, have made them the leading producers of fully-fashioned knitwear.\textsuperscript{291}

The Japanese company of Shima Seiki Mfg., Ltd is one of the two leading flat bed knitting machine manufacturers in the world, the other being the German company of

\textsuperscript{289} Bye, et al., "Analysis of Body Measurement Systems for Apparel":76; Bougourd, "Sizing systems, fit models and target markets", 133.


\textsuperscript{291} Webster.
H. Stoll GmbH & Co. This factor, together with the author’s familiarity with the system, contributed to Shima Seiki equipment being selected as the core equipment for this research. Prototype garments from the research have therefore been knitted on a Shima Seiki SES 102ff V-bed machine, (a model from a series that is closely comparable to those of the Stoll CMS series). This choice not to use a new complete garment machine was deliberate, because the V-bed machines are still, at the time of writing, found by machine manufacturers to be the most prevalent in knitwear production. Indeed the machine model that was chosen, the SES, is described by the knitting press as ‘the workhorse’, and 60,000 have been sold worldwide into the fashion knitwear industry since their introduction in 1989. Hunter considered the SES to have been fundamental to the 1990s revolution in shaped knitwear production, an opinion with which Webster concurred. All these factors reinforced the suitability of this machine for the research and its desired aims and outcomes as discussed in Chapter One.

Design and knitting programming has been carried out on the SDS®-ONE, an industry standard system capable of programming knitting for all Shima Seiki knitting machines at time of writing, but recently superseded in 2010 by the SDS®-ONE Apex 3. Due to the fundamental understandings of knitting structures, methods and body shape that underlie this research, with some adaptive programming the principles have potential to be applied to other makes of automatic transfer, flat, V-bed machines. These include those manufactured by Stoll, Steiger (another surviving European machine manufacturer recently acquired by an Asian company) and their Asian competitors, or even complete garment machinery such as Shima Seiki’s

292 Webster.
Wholegarment® and Stoll Knit and Wear®. However this research is primarily aimed at knitwear production on existing and new generation V-bed machines such as the Shima Seiki NSSG and the latest Stoll CMS compact and multi-gauge models.

As already discussed in section 2.4.2.1, participant selection was influenced by knitting width and maximum flèchage depth. The SES102ff machine available to the research had a knitting width of less than one metre, therefore could not produce garments that exceeded this width, and did not have ‘sinkers’ (see Glossary of Terms). The latter was a deciding factor in the maximum bra cup size with which it was possible to work as has been discussed in section 2.4.2.1.

As has been established, the machine of choice for this research was the Shima Seiki SES 102ff, a 12gauge (twelve needles per one inch), compact V-bed knitting machine with a one metre wide knitting width. It had: eleven available intarsia type feeders, presser feet, take down, loop length selection, digital stitch length control and variable stroke, all of which are computer programmable. The independent controller (P Rom computer unit) had a three and a half inch floppy disk interface, manual overrides, and interrogative software for examining knitting failures.

The knitting machine was programmed via the SDS®-ONE system, updated in June 2009 to version A61 of the Shima Seiki software. This system was based on the Windows 2000 platform, and used mostly standard hardware with patent and copyright protection integrated into the software and internal components. Other Windows based software could be run on the same system, making it possible to network and send files to and from other computers, an important factor for the future industrial potential of this research.

The template schemata and knit programmes for this research were developed on
all three software options: PGM (2D pattern drafting software), Paint (Lite version of Shima High End Paint), and Knitpaint. In addition to preparing the base garment template schema Knitpaint was also where knitting instructions were inserted and any manual override of automatic software took place. Finally a knitting instruction file was prepared via the Auto Process menu, during which final tweaks could be made to the information, which was then saved to the floppy disk. This was then transferred to the P Rom controller on the SES 102ff machine. (See Appendix B and C for example template schemata)

In the main study, some patterns were drafted in PGM and then imported into Knitpaint. Paint was used primarily for generating schema images for printouts, as its main use is for working with colour and imagery, neither of which were relevant to the research at this stage. It was however used to develop colour combinations for the ‘Australia’ version of the Juliet2 garment which is discussed in Chapter Five, section 5.2.2.1, and Appendix B. Knitpaint, which was the core software, allowed immediate drawing of patterns, importing from PGM, or pattern making by size from base patterns on the system. All of these were implemented during the development of the garments. (see Appendix B and C for examples)

At the beginning of the research practice, in 2005, the Knitpaint sub-programme contained fewer options for automatic software and pattern shaping integration. A series of updates since then have increased ease and flexibility of use, and items attached in Appendices B and C reflect this progression.

Since the start of this research, rapid technological advancement has meant that the SDS®-ONE programming system was succeeded in 2008 by the SDS®-ONE RD2
and RD2 Apex systems. Likewise the machine itself has been updated into the SSG® and SIG® series, offering carbon feeder blocks and WideGauge® variable gauge needle technology. In 2011 Shima Seiki introduced the next model in the SES series, the SSR112, and Hunter reports Shima are aiming this machine at, ‘...emerging markets where hand-flat machines and mechanical machines are being phased out in favour of computerized machines with higher productivity’. All of this indicates a strong, lively, active and industrially based interest in the SES102ff and its antecedents, validating the decision to use this specific equipment for this research. Essentially the new models are the same type of machine as the SES102ff, being traditional two bed V-beds - not specialised, multi bed, complete garment machines. Therefore the latest SIG, SSG and SSR112 model machines are highly suitable for knitting this research’s outcomes.

2.4.6 Selection of suitable yarn and establishing a base knit structure

Before commencing knit sampling, it was necessary to form a clear definition of the research aims in the context of the required knitting and garment outcomes. To confirm this again, the aim of this research was not to produce a seasonably fashionable completed garment, but rather to create an initial industrially compatible prototype to which design developments could later be added. Before commencing knitting developments, sampling yarns to determine their suitability for the above ran concurrent with fabric structure sampling.

2.4.6.1 Yarn selection

Yarn choice was obviously an issue of fundamental significance to the success of this research, and depended on a number of factors; machinery gauge, fibre quality and finishing considerations were the primary determinates, followed by secondary, but not subordinate ones of colour and texture.

In order that the research knitwear would display optimum individual fit properties and clearly illustrate stitch distortion, un-dyed, cream or ecru was the ideal colour. This colour is visually easier to work with than bleached white, shows stitch behaviours well, is aesthetically less challenging to the wearer and available as stock from most suppliers.

When selecting a yarn, the choice was made from those that were 100% wool or contained a high percentage of wool, and were commonly seen in commercial knitwear. A number of large high street stores including Marks & Spencer, H&M and online retailers Boden and Lands End featured Merino wool knitwear during the course of the research, which brought validity to this choice.298 (Figure 4) Modern synthetics fibres, although recognised as highly technically developed, were considered to be unsuitable because of the perceived devaluing of their content in fashion knitwear, acrylic being a clear example of this. Additionally, their recent promotion as sport-tech fibres was not one of the drivers of this research. Although some synthetic fibres offer ‘wicking’, (moisture transfer), which might have been useful to the research because larger bodies tend to retain heat and perspire more, this consideration was still outweighed by the fashion knitwear element of the research.

http://www.marksandspencer.com/Autograph-Front-Military-Cardigan-Merino/dp/B004DYZLRQ
Figure 4. Examples of Merino wool garments on sale between Autumn/Winter 2010 and June 2011. Top: French Connection, bottom: Boden.
Barbara Deckert when discussing fabric/fibre choices for ‘plus-sized’ bodies recommended the use of natural fibres.\(^{299}\) She advised avoiding Acrylic due to its tendency to be bulky and pill, but did concede that it is an easy care fibre. Polyester, another synthetic in wide use in yarns was once again not suitable as in her words it, “…can make you feel as if you’re wrapped in plastic wrap, which is indeed the case”.\(^{300}\) Blends were also not recommended, for both poor durability and aesthetic reasons, as the mixed fibres can demonstrate both the good and bad characteristics of both fibres, and may pill more readily than single fibre content.\(^{301}\) Deckert’s overall advice was also to avoid occlusive fibres, which hold in body heat and moisture.

Wool however has traditionally been seen as a natural, quality fibre, and as Brackenbury points out, had been most widely used in fully-fashioned production, with little being used for cut-and-sewn as knitwear.\(^{302}\) The exception to this was the recent rise in interest in Merino wool in sport base layers. Companies such as *Icebreaker* from New Zealand, *Howies* from Wales and the main stream *Nike* brand all offered Merino as a fibre choice. These garments were cut-and-sewn from extremely fine-gauge knitting production, probably from circular machines, and therefore represented a different trend than that previously described as fully-fashioned knitwear.

Unlike cotton and linen, wool has good elastic recovery properties, a preferred quality in knitting yarn.\(^{303}\) Worsted-spun wools were seen to be particularly successful in finer gauge knitwear, being made of predominantly longer, finer, combed fibres, making a smoother, finer thread than woollen or condenser-spun

\(^{299}\) Deckert.42. \(^{300}\) Deckert.48. \(^{301}\) Deckert.47-48. \(^{302}\) Brackenbury.164. \(^{303}\) Brackenbury.164;Spencer.4.
yarns. Modern shrink-resist treatments meant that garments knitted with these required minimal finishing, eliminating the shrinkage and felting of traditional woollen yarn garments.

The use of a worsted-spun, shrink-resist yarn by this research was therefore seen to eliminate associated costs and potential technical problems of wet finishing throughout the project, whilst working with a demonstrably suitable knitwear yarn. There were some concerns about using Merino wool because of ecological and animal rights issues, (overgrazing, the heavy use of chemicals and the practice of ‘mulesing’ to prevent fly-strike in sheep), but this was considered to be outweighed for the purposes of this research only by the potential positive benefits of encouraging longevity of use through user engagement with a well fitting garment. The final choice of yarn for this research resulted from satisfactorily sampling 2/30s nm Cashwool from Zegna Baruffa of Italy, a shrink resistant, stock service, worsted spun 100% Merino wool yarn.

The development of elastomeric yarns and their significance in knitwear has been discussed in Chapter One section 1.1.6. and 1.2.5. This category of yarns included the low power stretch Bilorex yarn used in this research, which was developed by Wykes of Leicester to circumvent the need for coloured, covered Lycra yarns. Bilorex was so fine it became almost invisible and could therefore be plated with any yarn, one common use being to add stability and density to fine yarn on coarser gauge machinery.

305 Brackenbury.164.
306 Dr Joan Farrer, "Sustainability", Design Futures, (2004), University of Brighton, Faculty of Arts. n.pag
307 Kit Blake, "Stretch Knitwear, Creating Order from Chaos", Knitting 2005, Global Challenges, Innovative Solutions, (2005), University of Manchester. n.pag
2.4.6.2 Establishing a base knit structure

Yarn and structure work in symbiosis. Therefore choices over these are vital to the success of knitting. In developing a fabric structure to test shape, a hierarchy of desirable qualities was drawn up to be considered in the following order: knitability, readability, drape, handle and appearance. Knitability ranked highest as the fabric has to be repeatable, needing no further adaptation to knit consistently throughout the project. Readability of the structure followed closely as without this the experiments would not fulfill their purpose. Drape allows fabric to follow body contours, highlighting protuberances but skimming depressions. Drape is dependent on fabric properties, fibre content and yarn construction and is closely related to handle. This relationship, which is according to Brackenbury, a result of loop density, is essential when establishing a satisfactory fabric. 308

The extensible property of single bed ‘plain’ knitting that is exploited in knitwear is its predominant horizontal stretch, which is traditionally used around the body to accommodate size variations. 309 This stretch is not to be confused with drape, is not a pre-requisite property in knitting for this research, and was to be avoided as a contributing factor to fit.

Handle ranked slightly lower, however a pleasant handle would benefit the prototype evaluation as participant feedback should not be influenced by an unpleasant tactile experience. Brackenbury explores this drape-handle-tactile relationship with the end user when describing lay observers reactions to sample fabrics, and their recognition of a ‘normal’ knitted fabric as one that is, “...neither too tight and stodgy nor too loose and floppy”. 310

308 Brackenbury.158.
309 Brackenbury.24.
310 Brackenbury.161.
Finally, whilst appearance ranked lowest in the knitting hierarchy, it was essential that the garments should display an element of aesthetic integrity, because ultimately they are to become desirable fashion commodities and participants would need to engage with the garments. Appearance was taken to include density of colour and opacity of fabric, a factor that is governed not only by colour of the yarn but also by the ‘cover factor’ of the knit. Cover factor is related to ‘loop density’, which is discussed in section 1.3.9, but refers to the fabric at rest not under tension. In this case it was an evaluation of the aesthetic appearance of the knit fabric without stretch being applied. Brackenbury described the ‘cover factor’ of knitted textiles as, “...a ratio of the area of a knitted fabric covered by yarn to the area covered by the gaps in between loops”.³¹¹ Spencer however uses the term ‘tightness factor’, and repeats Munden’s definition as, “...the ratio of area covered by the yarn in one loop to the area occupied by that loop”.³¹² The Textile Institute’s *Textile Terms and Definitions*, similarly associates the term tightness factor with weft knitting.³¹³

From these descriptions it was clear that a less dense cover factor; meaning a higher ratio of space to yarn per loop area will be more transparent. Transparency, as already explained in section 2.2.6., is something that is undesirable to this research, therefore a higher cover or tightness factor was required, but not at the cost of the former qualities. Consequently the parameters for a balanced fabric that met the needs of this research had to be established. This hierarchy of colour, yarn, structure, drape, handle and appearance dictated the sampling method for both yarn and fabric which will be discussed further in Chapter Three.

³¹¹ Brackenbury.161.
³¹² Spencer. 281.
³¹³ Tubbs and Daniels, eds. 72.
2.4.6.3 The embedded topological evaluation grid developed for this research

From literature consulted regarding clothing evaluation, it was clear that a method was required to measure movement of the knitting across the body and to highlight collision between fabric and body. There are only three basic knit stitches; knit, miss and tuck, and although Shima Seiki now offers twelve knitting techniques for Wholegarment® production, these basic forms underlie them all. The versatility lies in automatic processes controlled by sophisticated software which can anticipate knitting requirements, such as inserting an automatic transfer between double and single bed knitting, (thereby avoiding manual intervention). These automatic processes, in combination with an understanding of combined stitch behaviours, (for example in single bed knitting a reverse (purl stitch) row after a face (plain stitch) row will result in a raised line of stitches), enable purposeful textural patterns to be embedded into a fabric. Thus a digitally enabled permanent marker grid, that will be seen to aid evaluate of stretch as discussed earlier, will be embedded into the knitting providing immediate visual feedback about what is happening to the structure under stress. This creates a novel and elegant solution to assessing the fit of knitwear whilst at the same time intentionally designing a visually pleasing fabric. The development of this stretch evaluation tool will be discussed in detail in Chapter Three, sections 3.6.2 and 3.6.3. The conclusion to embed a visual measurement and evaluation tool directly into the knitting fitted seamlessly into the research methods and will be shown to provide satisfactory and effective results. Whilst the grid facilitated assessment of fit from without, the participant’s evaluation of the garment knitted to her body shape was clearly needed to assess wearer satisfaction and will be discussed in Chapter Five.

2.4.7 Template development

The proprietary Shima Seiki SDS®-ONE software has the facility to cut-and-paste parts of knitting structure diagrams (schema). This suggested the possibility of utilising this flexibility to create templates of the knitting methods to be developed by this research for 3D shaping for knitwear for larger body shape. These unique combinations of information could then be moved between the research templates as and where necessary to replicate the 3D shaping for similar features of body shape on a knitwear template, even if the overall body shape for which the new template was intended was different.

An additional value was immediately indicated for the templates. Based as they would be, in the commonly used, shared, visual language of digital machine design technology, they would be ‘readable’ by other knitting technicians, and therefore be widely transferable.

2.4.7.1 How this led to garment shaping – knitting methods

The methods and processes of the knitting practice were in certain ways predetermined by the programming software and machinery. For example, as discussed in detail in section 2.4.2, there was a maximum knitting width and a maximum depth of flèchage shaping (and therefore bra cup size) achievable on the research machinery. There were also processes for producing a knitting CAM programme that had to be followed in order for it to work. The knit programming system and machinery used were extremely sophisticated, versatile, and comprehensive, and it required proscribed and focused use to exploit these attributes strategically within the garments. In other words there was an element of discreetly ‘dumbing down’ the programming capabilities and exploiting knitting techniques that have been more prevalent in hand knit shaping than in traditional knitwear production.
These techniques were employed in a new application, to shape knitwear in 3D to match non-standard, larger 3D body shape. The resulting garments with their novel approach to body shape would be the toiles, preparatory to developing these into fashion knitwear as a future development. This concept at first seemed contrary to Larsson’s conclusions regarding Knit on Demand as discussed in section 2.3.5, that, ‘...fashion always comes first’. It was understood however, that Larsson’s observation took into consideration an existing implicit understanding by the customer that the underlying customised shape of the knitwear fitted them well. Techniques which initially presented as suitable were combinations of flèchage (knitting short rows of stitches to alter the length of areas of the knitting), mechanical shaping (ribs, tucks), wale transfer fashioning (transferring groups of stitches laterally within the knitting field which alters the width of the knitting field), edge fashioning (transferring an edge stitch laterally to alter the width of the knitting field) edge shaping (binding off an edge stitch to alter the width of the knitting field) and fully fashioning (transferring multiple edge stitches laterally to alter the width of the knitting field). (See Glossary of Terms)

2.4.7.2 The developmental route: from body shape to template to garment

It was the original research idea that body measurements, whether manually taken, or from 3D body scanning would be input as figures to generate a garment ‘blank’ using one of the methods included in the SDS®-ONE knitting programming system. This process and its eventual form will be discussed in Chapter Four, section 4.3 in more detail. At this stage the visual 3D shaping knitting information would be strategically added, with close reference to the measurements and body shape of the intended wearer. From this template, the technical knitting instructions would be

---

315 Larsson. 2
developed to suit the requirements of the 3D knitting methods used. For example, adding the presser feet to facilitate flèchage knitting. Templates for front, back and both sleeves would be separately stored and therefore could be independently interrogated and sections 3D shaping cut-and-pasted between templates as required into other templates.

It had been the intention from the start to create a capsule collection of prototype knitwear toiles with supporting samples, and a complete library of research templates to provide full technical developmental documentation of this. (See Appendices B, C, D for examples of templates and the accompanying exhibition for the complete digital collection). Proof-of-concept garments, using original files from the research were eventually knitted by technicians at Shima Seiki Europe’s headquarters on an SSGSV122 machine using the research templates, and this will be discussed further in Chapter Five, section 5.4. The success of this process has finally validated the underlying principles and confirmed transferability.

2.4.8 Garments - participant and objective evaluations

Taking the example of Huck’s practice based research as discussed in section 1.2.4, a more modest but adequate, range of movements were devised for the evaluation of the garments for this project as can be seen in the photographs in Appendix D. Drawing on Shen’s example, a method was developed for evaluating fit of the prototype knitwear on the underlying body shape at specific points rather than seeking a homogeneous result.316 These specific areas of the garment were highlighted on simple illustrations in the participant evaluation forms, as suggested by Yu, in an attempt to avoid any possible problems with verbal definitions.317

The evaluation methods which were applied to the garments, both subjective and objective, centred on visual methods, using photography and video of the participant evaluation sessions as visual methodology research tools as described by Rose, validated by Ashdown and discussed in the context of garment development by Fan and Hunter.\textsuperscript{318} Verbal feedback and context specific evaluation sheets were also collected during assessment. (See Appendix D)

Body movement was considered equally important when evaluating the prototype garments in this research. Whilst the movements chosen were not as comprehensive as those described by Watkins and Huck, they included simple day-to-day movements such as bending, reaching and stretching.\textsuperscript{319}

Watkin’s advice on evaluation contributed usefully to this research in that she enumerates a variety of methods, one of which is that evaluation is not the end but part of a continuing process; it becomes a review of earlier decisions in the design process that contributes to future development. Watkins also describes how, because apparel is relatively inexpensive, evaluation of part-made pieces can be made, and complete prototypes can even be assessed on real people.\textsuperscript{320} This was indeed found to be an important constituent of what Watkins termed the ‘clear design criteria’ for the design process of this research.\textsuperscript{321} An example of the design process as developed for this research can be found in Chapter Four.

Criteria for this research therefore included: to work in a single, carefully selected yarn and colour, to work within the capabilities of the Shima Seiki SES 102ff machine, as discussed in section 2.5.2, to work with real women’s dimensions and


\textsuperscript{319} Watkins. ‘227

\textsuperscript{320} Watkins.351-352.

\textsuperscript{321} Watkins.354.
body shape, and to use participants’ feedback to develop further prototypes.

Establishing these design criteria did indeed enable evaluation as Watkins predicted, because as she pointed out, they provide a baseline for, ‘...the physical aspects of an acceptable product’. 322

Working within these specific design criteria made the assessment of fit, from both wearer and professional view easier than if there had been distractions such as fashion, colour and style choices involved. Therefore evaluation of fit of the prototypes was, as suggested by Huck, purely about relationships between garment and body shape.323 These relationships were however, specific to where the garment and body collided, not standard throughout the garment. The evaluation of fit in this research was therefore to include that of ease in the garment to allow for body movements, and collision of fabric and body surface, but most importantly, as recommended by Huck, this would be of unequal levels of ease, and site-specific collision dictated by body shape rather than convention.324

If therefore, based on the expert opinions discussed here and in section 2.2.4., objective evaluation is taken to mean employing electronic or mechanical means, then it is reasonable to say that the evaluation processes for this research involved mainly subjective methods. They were however developed from methods used extensively in apparel research evaluation of fit, comfort and mobility as well as in industry, and reflected the considered application of a planned design process.

2.5 Conclusion

The literature review into the research methods used by other clothing related research suggested that as this research project was to be practice based, visual

322 Watkins.354.
323 Huck, et al., "Protective overalls: evaluation of garment design and fit":45. (Emerald)
324 Huck, et al., "Protective overalls: evaluation of garment design and fit":45. (Emerald)
methodologies would be needed to evaluate the garments. Therefore visual evaluation tools were incorporated into the research design process from the start. Throughout the duration of the study a combination of highly specific visual, sociological, and anthropological methods were developed and employed. Included amongst these was a tightly focused online survey which was designed to gather both quantitative and qualitative supporting data as background for the research. Analysis of this data has verified, for the purpose of this research, that larger size is trans-generational, but with a lower incidence amongst than women aged 16-20 and an increasing incidence in women over 35. Amongst the 16-20 year old age group, 7% reported themselves as a size 24 or over, indicating the need for young fashion input in knitwear for larger sizes as well as for the more mature woman.

The research was developed using a case study methodology, based on a small, specially selected participant group which provided empirical data. The participants were deliberately selected from volunteers who were at least a size 16 when recruited, and whose body shapes matched those most frequently reported in the research’s online survey. For reasons as stated in section 2.4.2.1., it was impractical to make garments using the proposed knitting methods with women who had bra cup size above a B, or for whom the compact machine’s knitting width might have been inadequate.

All of these will be discussed in further detail in later chapters.

Regular record keeping has been key to all these activities, not only of the survey but of participant contact and the numerous, complex re-iterations of knitting involved. These records can be seen in the exhibition and selected pages from the research diaries are included in the Appendices.
This research set out to address the range of issues raised here in a systematic approach, and developed prototype machine knitted garments which aimed to resolve issues of poor fit for larger women’s body shape. In the course of this process the following issues were addressed: designing and managing the study; methods of working with participants; working within machinery and time constraints; issues of construction processes with which to measure larger sized, non-standard bodies; and the evaluation of knitwear’s fit and comfort from the view of both wearer and observer. The historical context of the development of knitting technology, considerations of knitwear as fashion, and larger women’s clothing purchase experience were considered throughout and have been used in this text to support and inform resolutions and outcomes.

As this study showed, larger women find it hard to buy well fitting clothing, of which knitwear is a substantial element, and thus there was clear commercial potential for research into the fit of knitwear for larger women. Preference has been demonstrated amongst people of larger body size for looser fitting clothing, particularly at points of their bodies with which they are least satisfied. Research into knitwear manufacture has also shown that sizing is vague, using S, M, and L rather than measurements. It has further established that this is due to manufacturer’s and retailer’s belief that the stretch of knitting will accommodate body size and shape differences across a larger range than in tailored clothing. As this study will emphasise, there is conflict in these understandings. When knitting meets a bodily protuberance such as bust, stomach or buttocks, unlike woven fabric it will stretch to accommodate the shape. However this requires the knitting to extend, with a resulting deterioration in cover qualities. The knitting becomes thinner, consequently the transparency of the fabric is increased, the colour lightened and opacity is reduced.
consequence of lateral stretch is that when the stitch legs extend sideways the stitch
losses its natural configuration and shortens, causing each course of stitches to narrow.
Similarly, in knitting that is stretched vertically, the loop narrows, allowing the legs to
extend vertically and the whole piece reduces in width. Therefore knitting stretched
laterally shortens at the point of stretch, and when stretched vertically it narrows at the
point of stretch. These deformations of knitting, caused when it collides with bodily
protrusions, result in unattractive clinging to the body plus increased transparency and
discoloration at precisely the points larger sized women prefer to disguise. Thus there
is clearly a contradiction of understanding between knitting stretching to fit larger
body size and the desired fit and behaviour of knitwear required by larger sized
women.

3D body scanning technology has already been used successfully to re-measure the
body size of the population of a number of countries, including the UK in 2002-4
(SizeUK), America in 2004, (SizeUSA), France in 2006 (Campagne National de
Mensuration), Spain in 2008, and in 2006 Allen reported that a Brazilian survey was
to commence after 2009.325 Commercial analysis of SizeUK data, as discussed, has
shown that as bodies become larger, body shapes become more varied, therefore
larger sized clothing sizing integers may actually need to be at closer intervals and
more complex. Technology now exists that can capture body shape and size of an
individual and store this data in a readily accessible format. Yet despite SizeUK it
appeared that only limited change in garment sizing and availability of larger sizes
had occurred in the UK before the start of this research. Testament to this is the

325 Press Office [TC]2, “SizeUSA National Sizing Data”: n.pag. 23 February.;“Special Issue on Size”. 1-
3.; ”The anthropometric study of the female population has revealed the existence of three generalised
body types, which should serve as a more accurate basis for sizing”, Instituto Nacional del
Consumo, Government of Spain. <http://www.consumo-
SERVIVE project report of 2011 which recommends further research into larger sizes, and knitwear in particular.\textsuperscript{326}

As SizeUK data was not available to research without paying substantial fees, independent data had to be gathered for this study. For this process, manual measurements were taken from a smaller, specifically selected group of larger sized women, giving new insight into larger women’s body shape in relationship to knitwear. In the latter part of the main study, and after careful deliberation, the [TC]\textsuperscript{2} NX12 3D body scanner, (as used in SizeUK), was chosen to acquire 3D body scan data from the main study participants.

This chapter has addressed and confirmed the main research themes through a literature review. In this it explored the physical and psychological consequences of larger female body shape, the evaluation of the fit of clothing and new thinking about producing well fitting clothing including that of mass-customisation. Research activities have also been described, including the development of a design process, the online survey and knitting developments. Most importantly connections were established between the empirical outcomes and the supporting data from the online research survey through explaining the rationale for the selection of the participants. Resulting knitwear was required to display novel resolutions to any unusual body shapes encountered. This knitwear would be achieved using the knitting technology available to the research and during this process transferable digital templates for future developments would be produced. This chapter has explained and confirmed the reasons why the Shima Seiki SES102ff machine was selected as equipment of choice for this research.

It was anticipated that the development of these research themes and this new design technology approach would provide fashion knitwear that was more acceptable and accessible as a fashion choice to larger sized women. The development of the prototype garments and their close relationships to the body shape of the participants for whom they were designed will be discussed in the next two chapters.
The development of a practice-based research framework for body measurement and 3D knit shaping for larger female body shapes

3.1 Introduction

The aim of this chapter is to describe the challenges encountered when developing a research framework that would enable the practical aims and outcomes of the research. These challenges included taking linear measurements, capturing body shape and knitting 3D shape into garments to not only fit their body shape, but so that the garments would provide aesthetic and clothing satisfaction for the wearer.

In order to achieve the aim of improving the fit of larger sized knitwear it has been necessary to review current garment sizing standards in the UK, and to find out how these are actualised in commercial knitwear available to the average consumer.

This required not only an understanding of body shape in relation to clothing but most particular to this research, as an entity separate from bodily dimensions. Consequently methods and standards for body measurement had to be reviewed, and one suitable to this research established. Manual body measurement methods had to be learned and then adapted to suit larger body shape. In tandem with this, the findings of the SizeUK body size survey published in 2004 have provided valuable and confirming evidence as well as adding validity to the study. SizeUK influenced the methods and outcomes of the research, prompting the consideration of 3D body scanning for data collection. Through body scanning, further knowledge has been gained about the body shape of larger sized women, findings that SizeUK itself did not publically publish. This also contributed to more streamlined and accurate transmission of measurements into the knitwear.
3.2 The challenges in terms of measurement issues

The manual measuring of Juliet during the pilot study was carried out at the same time as yarn selection and sampling of knitting structures. Those of the main studies of Desdemona and Portia, as previously explained, were carried out consecutively, developments being based on the preceding experience.

3.2.1 Methods for capturing body shape and dimensions

Pheasant’s *Bodyspace* described the way the body moves through space relative to inanimate objects, using examples of doorways and chairs, whereas this research focused on the space between the body surface and clothing; an intimate relationship around the body which must allow for the body’s movement. Nonetheless, Pheasant defined dimensions and landmarks that were apposite to this research, although symmetry and upright posture was not assumed as it is in his text. Using Pheasant as a starting point meant that an understanding of the measurement needs of anthropometry versus those of apparel was required. To achieve this, comparisons of landmarks and measurements from both disciplines were made throughout the body and are discussed in the following sections.

Before landmarking and measuring unusual body shape, it was necessary to become familiar with the accepted anthropometric descriptors of body shape and bodily dimensions. To help this understanding, a version of Simmon’s diagram of the planes of the body was developed based around a larger sized body. (Figure 1)
Figure 1. Diagram of the principle anthropometric planes and terms of orientation (after Simmons 2001). (ORIGINAL IN COLOUR)
3.2.2 Landmarks and dimensions for larger body size

Surface landmarks, as will be discussed further on, can be misplaced and displaced due to tissue and muscle movement. Skeletal landmarks remain constant across variations in physique, therefore as in anthropometry, the skeleton was chosen to provide the basic landmarks. Once landmarks were found on the body, marking them directly on the skin offered the most accuracy, but it was necessary to remain reflexive and remember that each subject may need different treatment.

An important first step in defining larger 3D body shape was to find the spatial relationships between the pre-defined critical landmarks. With the landmarks acting as nodes, connecting measurements relevant to larger body size and those for upper body knitwear were drafted to map the topological space of the body’s surface. Diagrams charting the location of the major landmarks for measuring larger size body and those of the actual measurement positions have been developed as will be shown. The following sections describe the theoretical and practical stages of designing a measurement protocol to describe larger sized 3D body shape.

3.2.3 Measuring session protocol

Replication and consistency of measuring across subjects required a protocol to be established. Therefore the following conditions and arrangements were decided upon. To take successful measurements the subject must be minimally dressed in close-fitting clothes to allow surface measurements as near to the skin as possible. These clothes were not to restrict the body by being too tight or the measurements would have been inaccurate. Alternatives to underwear were suggested as a leotard or a stretch vest and pants. Whichever they chose, the brassiere should be their favourite style, and to maintain continuity it was requested that the same style be worn for both clone making and fitting sessions.
3.2.4 Establishing lower torso landmarks

Pheasant’s hip height was measured to the, “…greater trochanter (a bony prominence at the upper end of the thigh bone, palpable on the lateral surface of the hip)”\(^{329}\). This was not the traditional clothing measurement hip point for apparel, which has a vertical relationship to the waist. Aldrich for example, in *Metric Pattern Cutting* describes the hip as 21.5cm below the waist on a size 18.\(^{330}\) This was based on two suppositions; the first is that the subject had a clearly defined waist from which to measure, and that the waist was in a constant position across a range of people. The second was that bodies are proportionally balanced in girth and height, i.e. being a certain size means you are a certain height, a concept with which Ashdown disagrees, as has been discussed earlier. On Juliet, the pilot subject, who was between a size 16 and 18 around the hips, a measurement of 21.5 cm up from the widest hip point reached to nearly under her bust. Despite her description of herself as having a high waist this was clearly too high. Her actual measurement from widest hip to narrowest part of the mid body was 19.5 cm, which established the importance of defining a non-traditional widest lower body landmark height and measurement, plus the need to identify the waist in a fresh manner.

The greater trochanter was quite difficult to find, particularly when there was a thicker covering of flesh. Repeated attempts to locate the greater trochanter on different subjects (by palpation as recommended by Pheasant) were intermittently successful, and even when it was located it did not consistently prove to be at the widest girth in the hip area.\(^{331}\) The presence of a bulge on the lower abdomen meant that the traditional landmark and measurements of the waist and hip required adaptation.

\(^{329}\) Pheasant. 32-33.


\(^{331}\) Pheasant.32.
Therefore it was decided to designate the position of widest girth below the navel as the thigh circumference and the widest point of the body from frontal view below the navel as the hip. An additional landmark would be sited at the most forward protruding point of the stomach, designated the ‘tummy point’. Although informative, this landmark proved difficult to find manually but became easier with body scanning. Measurements at these points would all then be taken in relation to the narrowest torso girth and the traditional waist. In the pilot study it was found that the combination of buttocks, stomach and fleshy padding on the upper hip can influence the body depth below the navel, and that this should affect the categorisation of larger body shape as much as frontal plane width. Whilst a tape would measure girth, a calliper was required for depth and width. The above mentioned examples of various interpretations of terms for landmarks and dimensions are the reason for establishing the clarity of descriptors for this research at an early stage.

3.2.5 Defining the waist in manual measuring and 3D body scanning

The waist has been found to be significant across a number of disciplines and epistemologies, not only those directly related to the practicalities of apparel design. In 1955, Jourard’s research into body cathexis and satisfaction concluded that a proportionally narrow waist played a positive role in this. When LaBat and DeLong explored body cathexis in relationship to apparel fit in 1990, they defined the body as above or below the waist, clearly considering it a pivotal point of the self-perceived body.332 In 2004, Pechoux reported that a 1994 Korean study had found that the

---

height and circumference of the waist was a key dimension for apparel fit. Whilst discussing apparel sizing specifications, McDevitt Davis defined the high hip as being 4” (10cm) below the bottom edge of the waistband, with the hip 7” (17.75cm) below, and as much as 8” (20.25cm) below for larger sizes. This assumed that the waist height on the body was a constant, which Ashdown’s research into postural variation demonstrated to be incorrect.

Waist-to-hip ratio (WHR) and waist- to-bust ratio (WBR) has been used to describe body shape; a low WHR ratio depicts a torso with a waist that is narrower in relationship to the hip girth, whilst a high one indicates less difference between waist and hip girths. Petrova and Ashdown selected candidates for their 2008 research into trouser fit by WHR, as did Vuruskan in 2010, and the waist plays an equally central role in relevant sociological studies. Both Singh and Young in 1995, and Furnham in 1997 used the WHR, this time as a measure of female attractiveness. The diversity of these references stressed the significance of the waist across a number of disciplines, thereby suggesting its correct placement should be central to designing a fresh and original method of measuring for larger body size.

Consequently, definitions for the waist were considered, and it was decided that in this research ‘the natural waist’ should mean the narrowest dimension of the torso.

between the bust and the hips. Indeed the question, “Does the natural waistline matter to this research?” was given considerable attention, and in this process the following was taken into account. In skirts and trousers the waist is a critical point, holding the garment in position and defining the body shape, although in upper garments its position may not be as important, particularly in classic fully-fashioned knitwear styles. It was indicated by the literature, especially by Raband, that in upper body garments it is the shoulder width, bust and largest circumferences of the mid body and hip that are crucial to good fit. Therefore minimum and maximum upper girths, and their vertical relationships with each other, were considered significant by this research for where upper body garments for larger sized women with rounded stomachs might require 3D shaping.

The 2001 European standard for measuring the body, BS EN13402-1:2001, described the waist as, ‘the girth of the natural waist-line between the top of the hip bones (iliac crests) and the lower ribs, measured with the subject breathing normally and standing erect with the abdomen relaxed’. Simmons’ description of the ‘natural waist’ reflects this, being sited at the ‘greatest indentation on the profile of the torso’ and located at the fold between the lowest rib and hip when the body bends sideways, (as defined by the American Standard for Testing Materials). She also included a second definition of the ‘waist’ as being on the Omphalion (the centre of the navel).

The waist position is important because it has a close relationship with the hip line,
the front and back shoulder slopes (taken diagonally from the shoulder point to the
centre line at waist level) and other dimensions that include for example, centre front
neck to waist, and body rise (crotch to waist). During the pilot study it became clear
that it was necessary to maintain an open mind about the waist height. Therefore two
landmarks were defined and eventually used, E = the central body marker point, mid
way between the lower rib and the top of the pelvic bone, and E2 = the natural waist,
positioned at the narrowest point of the torso. (Figure 2) (Also see Appendix A)

This research has found that although larger women’s torsos may appear to be
narrowest just above the navel when viewed from the Coronal Plane (front), they are
not necessarily so when viewed from the Sagittal Plane (side) as they tend to have a
protruding abdomen. This protrusion can increase the girth and may affect the position
of the natural waist. (Figure 3) Depending on their physiology, larger women’s
natural waistline, as defined in this research, may lie further up their torso. If there is a
“midriff bulge” above the navel, their narrowest mid section may be under the bust, or
just below this bulge near the navel. Because of these variations, the underarm which
in general remains constant was selected as a more consistent horizontal landmark
from which to take vertical measurements.

3.2.5.1 Locating the natural waist, landmarked as E2, in both
manual and body scanning

Whilst for lower garments the waist may need height limitations, on upper body
apparel finding the narrowest torso girth correctly enables styling such as waist shape
to be aligned with the body shape. The placement of the narrowest point of the torso
can become quite extreme, particularly when sought with 3D body scan software, as
without carefully defined parameters the measurement can migrate towards the
Figure 2. Diagram of body landmarks for larger sized female bodies, with descriptions of how they are positioned. Main study version, October 2006. (ORIGINAL IN COLOUR)

BODY LANDMARKS
A - Centre front vee of clavicle.
B - Shoulder points at end of clavicle and top of shoulder ball joint, where flesh ‘dimples’ as arm goes up and back.
C - Side neck point, directly below hollow behind ear
D - Nape of neck, on protruding cervical vertebrae around C5.
E - Central marker point, mid way between lower rib and top of pelvic bone, 5th lumbar vertebrae at back.
E2 - ‘Natural waist’; narrowest part of the abdomen.
F - Underarm horizontal; mark front and back for constant.
G - Tummy point - at most protruding point of stomach, level line around body.
H - Widest frontal view hip line, level line around body
Thigh - largest girth below navel
Figure 3. Waist and hip girth body slices extracted from Portia's bodyscan. These slices illustrate how larger body shape can deceive the eye about the narrowest point of the torso. In the top left hand image this would appear to be lower than the yellow line. However as can be seen in the top right image, the tummy bulge to front causes the 'waist' to rise. Images courtesy of [TC2].

(ORIGINAL IN COLOUR)
underbust girth. The generosity of [TC]$^2$ in providing access to their software has meant that this research could explore the participant’s 3D body scans in detail and define landmarks and measurements specially for larger size, some of which are discussed here.

Once E (mid body point) and E2 (narrowest point of the torso) were established in the manual measuring process, they remained static. Once 3D body scans had been taken however, it became possible to view the mid body point (E) and the narrowest point of the torso (E2) in different visual relationship to each other as described here. The independent waist ‘measurement extraction parameters’ (mep) file that was created by this research from knowledge of larger body size, when compared to a standard ‘mep’ such as that used in SizeUSA (as included in the [TC]$^2$ NX16 software), demonstrates remarkable differences which are caused by the following conditions.

All the files discussed here placed the centre back focal point at the small of the back as designated by the scanner. SizeUSA positioned the centre front point at exactly the same level as the centre back point, thereby keeping the waist horizontal. The ASTMSizeUSA mep permits the centre back point to be located 1.27cm above or below the small of the back. Once the centre back point is established, the centre front point of the waist can be located between 1.27cm above the centre back point and 7.62cm below, which allows the waist line to be slanted and higher at front than back. The waist shown on this research’s waist mep file generated for Portia was given the same back allowance of 1.27cm above to 1.27cm below, but as Portia’s E2 manual landmark was 9cm above her mid-body marker E (the equivalent of the centre front point) a limiter of 9cm above to 4cm below was imposed within which to locate the centre front point, thus allowing a more slanting waist. An illustration of the resulting
different placements of the waist based on the ASTMSizeUSA, and SizeUSA parameters, plus two sets from the research and one combination of these has been included to demonstrate the variations. (Figure 4.)

In this research, waist positioning was important for the reasons discussed so far. However, the bust girth and that found to be located just below the underbust but above mid body position, together with the location and girth at furthest frontal and posterior prominences proved to provide better information from body scans for applying 3D shaping to knitwear for the lower torso in larger sizes. As well as a lower body dimension that reflected a distinction between the underbust indentation, it was also desirable to keep a mid body ‘waist’ position for relational measurement purposes. As demonstrated in Figure 4, this did not necessarily have to be level with the small of the back, but was set as such because the knitwear to be developed from the research measurements was not required to fit closely at the waist.

3.2.6 Landmarks and measurements affected by waist position in manual and 3D body scanning of larger body shapes for knitwear

Dimensions that were critical to this research were the narrowest girth of the torso (named ‘abdomen’ in the research body scan data file Vikkiknit1.mep to differentiate from the ‘waist’ which generated as the mid-body point), the stomach and the hip. The stomach in the body scan data was the equivalent of what had been termed the tummy point in this research’s manual measuring (greatest prominence in front below bust). It was possible to set the hip dimension in the body scan data to measure either the greatest girth, the largest side to side, or largest front to back width between upper and lower limits. For body scanning measurement this was changed from the manual designation of widest from the front to the largest girth.
Figure 4. Five variations in waist placement on Portia. This illustrates the difference between standard body measurement and clothing sizing waist position compared to that worked with in this research for upper body knitwear. As can be seen, on this larger body shape the narrowest point of the torso is higher and not horizontal. Image courtesy of [TC]2. (ORIGINAL IN COLOUR)
The seat landmark in body scans locates the greatest prominence at the back of the body below the waist and is the equivalent of the thigh in manual measuring for this research. Establishing the vertical relationships between the heights of these landmarks is vitally important to correctly locate the provision of additional fabric for bodily prominences when developing knitwear for larger size. Any number of distances could have been generated but after consideration a simplified number of vertical relational measurements were chosen. As well as the heights of all the landmarks, these included: stomach to shoulder, stomach to neck, stomach to abdomen, stomach to hip, abdomen to hip and hip to seat. (see Appendix C for landmark details)

3.2.7 Establishing upper torso landmarks

The underarm level can be calculated from the shoulder point as a perpendicular measurement down to the point at which a ruler held horizontally tight up into the armpit meets this line. Whilst useful for other dimensions, the underarm level is not suitable for the shoulder slope measurements. These cross diagonally from the shoulder, traditionally ending at the waist at centre front and back, and measure the contours of the front and back chest. A lower marker is still needed to which this diagonal measurement, which originates at the shoulder point, can be taken. This could be the widest hip measurement, but this will be in a variable position among the participants. It was decided that the skeletal landmarks of the vertebrae in combination with the rib to pelvis relationship were the best choice as a ‘mid way’ marker on the torso that would be definable across body types and shapes. This would not however be used to establish the natural waist position. Vertical measurements need to terminate at a recognised point on a horizontal line that bisects the body; on the front shoulder slope this ensures that the tape does not lie in the valley between the breasts,
but travels diagonally over the breast prominence. A recognised definition of mid
body marker to which the front and back shoulder slope can be measured is half way
between the lower rib and the crest of the front pelvis in line with the fifth vertebrae,
therefore a line drawn around the body horizontal to the floor became the mid-body
marker E.

This line became the destination for measurements originating from other
landmarks to the mid-body point. A diagram was created with the research
measurement lines in relationship with the landmarks developed for larger body size.
(Figure 5) (Also see Appendix A)

At the shoulder Pheasant lists two breadth measurements; bideltoid, encompassing
tissue of the upper arm and biacromial, stretching between the bony points of the
shoulder bones. These are quite different, but both useful. The skeletal referencing
of the biacromial points which uses the acromia or bony shoulder points is relevant to
clothing that wraps around the body underarm, for example in a set-in sleeve style
which has to allow movement of the arm, but must fit at the shoulder. The shoulder
point can be tricky to locate, and Righetti, in Sweater Design in Plain English,
described a useful and effective method of doing this involving gentle palpation of the
shoulder area but also recommended lifting the arm to locate the dimple that occurs at
the rear of the shoulder - which is approximately level with the shoulder point.

The bideltoid measurement may aid the fit of sleeve heads because the bicep
circumference alone could be insufficient to develop the sleeve head. A calliper
measurement taken between the outer limits of the upper arms (bideltoid), when

342 Pheasant. 37.
Figure 5. Diagram of measurement lines for larger sized female bodies showing relationships to landmarks. Pilot study version, 2004. (ORIGINAL IN COLOUR)

Body Dimensions
See Measurement sheet for location of landmarks and method.
viewed in relationship to that between the shoulder points (biacromial), will provide information for sleeve head development. Bust depth measurement was taken by Pheasant from a vertical plane behind the body to the fullest forward extent of the chest, which assumes that the back connects with the vertical plane at a level with the bust/chest. This is not always the case, with some physiological conditions, notably hyperkyphosis (‘dowager’s hump’) in older women, an abnormal curvature of the thoracic spine occurs in the upper back. It was decided beforehand that if this was encountered extra measurements would need to be considered.

As this research is looking not only at the body surface, but also at the space it occupies, chest depth was taken with callipers to define the concave spaces of the spine and between the breasts. An upper chest measurement at underarm contributes to defining the bust shape and records the back shoulder padding that often occurs in larger women. This measurement is not horizontal, as the front outward chest angle and any convexity of the back shoulder shape at this point forces the tape into a shallow curve upwards at the front. Acceptability of this method of measurement can be seen in the Japanese National Institute of Technology Measurement Method for Body Size where the photograph and diagram quite clearly show a slightly slanted path.

Pheasant’s description of the spine and vertebrae, whilst primarily for product design, has contributed to this research’s definition of individual landmarks on the body. Using knowledge of measuring larger body size gained through the

Figure 6. Diagram of the measurement network for larger sized female bodies, showing relationships to landmarks - frontal view. Main study version, October 2006. (ORIGINAL IN COLOUR)
Figure 7. Diagram of the measurement network for larger sized female bodies, showing relationships to landmarks - anterior view. Main study version, October 2006. (ORIGINAL IN COLOUR)
experience of the pilot study, the measurement diagrams were revised for the main study. (Figure 6) (Figure 7)

3.2.8 Cloning body shape to aid the design process

As has been briefly discussed earlier, the original intention was to make clones of each participant’s body shapes following each measuring session. This was however revised following the decision to include 3D body scanning to gather body shape data for the research. This section therefore only applies to the clones made for Juliet during the pilot study and Desdemona, the first participant in the main study.

During research planning it had been decided that a life-size ‘body clone’ torso of each participant should be made with the aim of capturing unique body shape rather than just linear measurements. This would facilitate testing of prototypes as recommended by both Aldrich in Metric Pattern Cutting, and Deckert in Sewing for Plus Sizes, and had been tested during the planning stages and proved viable. A number of possible methods had been investigated, and it must be remembered that at the start of the research 3D body scanning was not used, therefore digital methods were not an option. Casting from body moulds was investigated, but it was felt that this was over complicated for this component of the research, required additional skills to be learned by the researcher and would impose on the participants more than was acceptable. Therefore less complicated and invasive manual methods were adapted to make them suitable to this research. These included those described by Coffin in Threads magazine for making a ‘fitting assistant’, and Leah Crain’s 1999, Duct Tape Double. The process involved the participant wearing an old tee shirt over the same underwear as had been chosen by them for measuring. Layers of duct

tape were then wrapped over the tee shirt following a careful pattern to capture the body shape as accurately as possible. It was necessary to tension the tape carefully to avoid binding the softer parts of the body too tightly thus altering the shape, and at the same time not to constrict the participant. Once the wrapping was complete, the ‘shell’ was cut off the participant complete with the tee shirt and then padded to match both measurements and shape - which was referenced from photographs. (Figure 8) Clone building sessions were organised in a similar manner to those for measuring, and with the same level of sensitivity to participants’ needs.

The cloning method had been tested during research planning and particular consideration was given to the claustrophobic effect of the wrapping process. The measurements and photographs taken during both sessions informed the construction process for cloning both Juliet and Desdemona later on in the main study. (Figure 9)

Clone making proved valuable, providing an intimate understanding of Juliet’s occupation of space and her body surface convolutions. In particular it demonstrated the relationships between the swell of her stomach and buttocks, the shape of her body at natural waist (E2) as opposed to her mid body (E), and how these are caused by the concavity of her spine, the high convexity of her stomach and a slight forward-leaning posture. (Figure 10) Similar visual and spatial familiarities were achieved through creating Desdemona’s clone in the main study. Further details of the body clone construction method can be seen in the accompanying exhibition.

### 3.3 Increments and tolerances

When measuring the body, 2.5mm increments where used, but it proved impossible to work with this level of accuracy on the clones, the making of which has been described in the preceding section of this chapter. In view of this, the smallest increment for measuring was set at 2.5mm, with an additional allowance on the clone
Figure 8. Clone building. On the left, Juliet is still inside the wrapped clone and on the right she is holding the 'shell' once it has been cut off. Pilot study, October 2004. (ORIGINAL IN COLOUR)
Figure 9. A series of images showing the clone building process for Desdemona. Main study, November 2006. (ORIGINAL IN COLOUR)
Figure 10. Juliet full size body clone. Main landmarks are marked. Pilot study, April 2005.

(ORIGINAL IN COLOUR)
of 5mm. This 7.5mm tolerance was found to achieve an acceptable accuracy, whilst
remaining realistic.

3.4  The practical application of the measurement system developed
for larger body size: measuring Juliet for the pilot study

As already briefly outlined, the research had two clear stages, a pilot study with
one participant (Juliet) to test methods, and a main study with two participants
(Desdemona and Portia) employing the initially refined methods and further
improving these as found necessary. Results from both were used in the research and
discussed in this text with the relevant stage indicated. The first two hour measuring
session was arranged with Juliet, for which she was asked to wear her favourite
foundation garments, preferably a bra and pants. Because it was the pilot session, and
although Juliet had been made aware of the intimacy of the process, some confusion
about suitability of clothing occurred. In order to respect her wishes she was measured
with her lower garments on. After advice from the University of Brighton Ethics
Committee, and following my own concerns over this, both participant and researcher
were better prepared for the measuring sessions in the main study. The intimacy of the
process and clothing requirements were more clearly explained to all future
participants. The need to wear few clothes and be immobile for lengths of time meant
that a warm, private room with comfortable flooring was needed, preferably
somewhere the participant felt at ease. At all times during measuring sessions the
participant’s comfort and wellbeing was monitored.

Equipment selected for measuring included two non-stretch fibreglass measuring
tapes. A small spirit level was attached to one to keep it horizontal. Other equipment
included a plastic ruler for marking the underarm level, a steel ruler and a plumb line
for finding the perpendicular. In addition to these, a length of elastic was
Figure 11. Equipment used when measuring Juliet. Pilot study, October 2004. (ORIGINAL IN COLOUR)
used to settle on the natural waistline. Landmarks were plotted with a skin-safe felt pen. A simple pair of anthropometric callipers was devised for the pilot study; once their usefulness was established through application, an anthropometer, (measuring callipers that are large enough to bracket the body) was purchased to complete the research. (Figure 11) Identifying the body’s landmarks in practice instead of theory proved lengthy and exacting, but as these are fundamental to the measuring process this time was well spent. Once the landmarks were marked, significant connections were drawn on the skin (e.g. shoulder point to underarm, shoulder point to neck point) to ‘wireframe’ the body for measuring.\textsuperscript{349} (Figure 12) and (Figure 13)

Methods of measuring and choices of linear body measurements to capture 3D body shape were based in this research on texts already discussed in Chapter Two section 2.4.4. These included Beazley’s \textit{Procedures in undertaking a survey of body measurements}, Simmons’s \textit{Body Measurement Techniques}, Emodi in \textit{Threads} magazine, and Tatara’s guidance in the \textit{Pattern Master Boutique Instruction Manual}.\textsuperscript{350} As with landmarking, measuring Juliet for the pilot study was a vital step in testing whether these chosen measurements were the most appropriate ones. In practice, the initial measuring chart was found to be inadequate. For example, right and left side measurements had not been allowed for, and the upper chest measurement was lacking. Taking depths and widths of the body with callipers, particularly depth of the upper chest between the breasts and the mid body point E as described earlier, proved valuable information for body shape. Revisions to the measurement charts were made following the pilot study and used for the main study.

\textsuperscript{349} Simmons:20.
Figure 12. Measuring Juliet, two views. Top: the natural waist as found by allowing a loose elastic band to find the narrowest part of the torso and the bust girth being measured. Bottom: defining underarm height using a ruler that is horizontal to the floor being placed high into the axilla.

Pilot study, October 2004. (ORIGINAL IN COLOUR)
Figure 13. Measuring Juliet, two side views. Top: the back armscye line marked on the body. Bottom: the neck and shoulder points marked on the body, the front neck point is just visible on the right of the image. Pilot study. October 2004. (ORIGINAL IN COLOUR)
Bye reminded us that, “Securing accurate physical measurements is crucial to achieving successful fit”.\(^{351}\) As single-handed measuring for the pilot study proved difficult it was possible that some results might have been inaccurate. Therefore with the participants’ permission a second person was recruited to check and record data for the main study measuring sessions. However, even with two people, the truth of Bye’s observation led to an eventual decision to incorporate 3D body scanning into this research to achieve more accurate and timely results. The suitability of 3D body scanning became clearer as the research progressed, and was informed by the literature review outlined in Chapter Two. Further details have been discussed earlier in this chapter and attention will be given to the practical application of this technology within this research in Chapter Five. Yu’s 3D \textit{body scanning}, and Simmons’ comparison of manual and 3D body scanning measurement methods in her 2001 doctoral thesis, \textit{Body Measurement Techniques}, were particularly useful in making this decision.\(^{352}\)

It was found to be necessary for the researcher to independently relate the existing research landmarks to those obtainable through 3D body scans. After this the landmarks had to be redefine in the scanner software to match the measurement descriptors as identified by this research for larger body size and shape. This happened because the scans are generated in proprietary software, and then converted at the London College of Fashion (where the scans took place) into 3D data files and electronic tape measure charts in portable document format. It was not until the scan data was analysed that the landmarks and the linear measurement generated by the


technician during the scanning process were found to be unsuitable for larger body size, despite lengthy discussions beforehand. This developmental process was made possible through the generous support of [TC]^2, (The Textile Clothing Technology Corporation) of America, who donated their proprietary software to the research project, and the knowledgeable advice of Jeni Bougourd.

The pilot study thus enabled successful development of specific landmarking and measuring. Furthermore, it was fundamental to the later requirement to generate customised digital landmarks, specific to larger sized knitwear, for the NX12 bodyscanning software.

3.5 3D knitting methods

3D ‘reciprocated’ pouch heel or toe short row shaping has been in use in commercial circular hosiery production for many years. Orton in *Knitting Together* considers that the earliest circular machine able to turn pouch heels with short rows was Griswold’s 1871 ‘Little Rapid’, and it is clear that this had become a common method by 1903 as demonstrated by the instructions for knitting socks found in the *Instruction Book for ordinary and patent compound Automatic Knitting Machines.*\(^{353}\) (Figure 14)

In flèchage knitting, short rows of stitches are worked in a gradually narrowing knitting field, so that the resting needles ‘hold’ their stitches, and an arrowhead pattern is created where the reducing rows of stitches run into each other (fleche is the French word for ‘arrow’). If just one side of the knitting field is worked, a less 3D effect is achieved. If both sides of the knitting field are worked concurrently in the

Figure 14. The instructions for turning a stocking heel which involves short row knitting. Selected needles are lifted up out of action to prevent them making stitches when the carriage passes around the dial and in this way more rows are built up to create a 3D pouch for the heel shaping.


Author's collection. (ORIGINAL IN COLOUR)
‘reciprocal’ form this, knitting method creates a 3D point. The reciprocal method emulates the 3D shape created after both edges of a piece of knitting are decreased and then increased and then these edges sewn together.

Another knitting technique which was found to have been used to create 3D shaping was wale shaping, also called wale transfer fashioning. In this method of knitting, groups of stitches (wales) are transferred laterally across the knitting field of stitches. This either increases or decreases the number of stitches. Most importantly to this research, the addition or reduction of stitches takes place mid-field, and if this is repeated in the same needle position, over a series of courses, it causes both the horizontal courses and the vertical wales of the knitting to slant. In extreme cases, this technique can create a 3D cone effect with its apex at the position of the first wale transfer.

### 3.5.1 3D shaping in mass produced knitwear

Although used in circular knitted hosiery, it was not historically a common practise in flat bed commercial knitwear to create mid-row flèchage shaping. Although some evidence of what was probably 3D wale fashioning of underwear was found by this research in museum collections, it is clear that the fit of knitwear over the 3D body and its contours has traditionally relied on, and is generally still dependent upon, what Brackenbury terms the ‘elastic deformation of the fabric’.\(^{354}\) This dependence has been discussed in Chapter One section 1.2.1.

Fashioned shaping of knitwear is laborious with the risk of dropped stitches, as individual needles have to be selected and transferred laterally. Automatic shaping requires needle selection and transfer mechanisms, both of which have been available

for many of years on flat knitting frames, enabling fully-fashioned, generally single
bed garments. Such mechanisms were however not truly industrially viable until
automatic electronic needle selection was developed between 1975 and 1990.
Following this, and in combination with the presser foot, V-bed machines could
finally produce automatically patterned and shaped flat garments, and as Brackenbury
predicted, have since largely replaced all other specialist manufacturing methods.

Flèchage (short row knitting) still however presented some problems to
commercial V-bed machinery due to ‘take-down’ issues. When working short row
shaping on hand operated machinery, to prevent the non-working ‘held’ stitches from
jumping off the needles whilst knitting the short rows, strategic weights are added
below the working needles. These weights are then constantly moved to maintain
downwards tension or ‘take-down’ on the stitches. The same principles of selected
‘holding’ and strategic ‘take-down’ must be observed in industrial machine knitting,
and highly sophisticated mechanisms to achieve this have been developed in recent
years, particularly in complete garment machinery. This description outlines the
technical knitting process that partly governed participant selection criteria discussed
in Chapter Two, section 2.4.2.1.

Brackenbury, as discussed earlier, foresaw the potential of the newly developed
industrial integral knitting machinery which was capable of flèchage, and directs the
reader to Michael Pearson’s Traditional Knitting of the British Isles, (in which
Pearson in turn was quoting from the Shetland knitting tradition) advising, “Never,
ever sew when you can knit”. This sentence epitomises the underlying driver of
the complete garment method of manufacture; that of saving labour and material

---

With the advent of complete garment technology, the potential for improved comfort and fit through technological precision was profoundly increased. At the same time, the more traditional V-bed machines are benefitting capability wise from the complete garment research and development through software updates and engineering design. Based on these technological advances, this research therefore incorporated 3D shaping into V-bed knitwear in specific areas, thereby taking advantage of the principles embodied in Pearson’s advice. It has moreover, deliberately applied these principles where possible to widely available industrial knitting equipment in a strategic manner to suit larger body size. This was in direct response to the underlying premise of this research, that there was an opportunity to improve the fit of traditionally mass manufactured knitwear for the UK high street apart from, and as well as, that made by the complete garment method.

### 3.5.2 Knitting 3D shape with flechage

During the literature search regarding knit shaping methods, little reference can be found to the use of flèchage knitting (otherwise known as ‘short rowing’ or ‘holding’) in commercial knitwear. It is however likely that the technique was developed in the stocking and hosiery industry in the late 1800s. Continuing use can be found in commercial socks, stockings and specialist beret production as described by Brackenbury, as well as hand knitting.\(^{357}\) The technique did not however feature heavily in knitwear until the 1970s and 80s when it was adopted, predominantly by the domestic machine knitting community, for knitting A line skirts.\(^{358}\) One such skirt, by 1980s designer Lois Franklin, featured by Kinder and reproduced courtesy of

---

\(^{357}\) Brackenbury. 79-80.

Knitting International, was clearly knitted with this flèchage technique.\(^{359}\) (Figure 15)

Subsequently flèchage was exploited in the industrial process of integral knitting of pockets and other details, and most recently has been seen in complete garment knitting.

3.5.3 Fitting knitting to 3D larger body shape

In domestic hand knitting, the possibilities for shaping knitwear for larger size, has long been discussed. Short row shaping was recommended by Tillotson in 1940 in, The Complete Knitting Book, and termed as ‘Lengthening One Edge Only’ and ‘Lengthening the Centre of Fabric’; a description of the effect rather than the cause.\(^{360}\)

Also in 1940, Hints for the Outsize Knitter suggests short row darts to add, “…extra fullness over the bust”.\(^{361}\) Similarly in a 1948 Stitchcraft larger sizes supplement bust darts are created with short rows.\(^{362}\)

Using short rows slightly differently, in Knitting from the Top of 1996, Walker suggested short rows to add 3D shape to shoulders and sleeveheads. Recent interest in accommodating larger body shape had been shown by authors Moreno and Singer, who in Big Girl Knits of 2006 also suggested short row bust shaping.\(^{363}\)

In cut and tailored apparel, 3D shape is added to the garment using a technique termed ‘suppression’. This technique involves retaining the full required width or length of the garment piece at the widest or longest dimension of the body whilst smoothly and three dimensionally shaping the garment to the narrowest of shortest

---

\(^{359}\) Kinder.80.
Figure 15. A 1980s sideways knitted suit using flechage technique by Lois Franklin. These were knitted on Dubied industrial machinery with presser feet. From page 80, Kathleen Kinder, The Technique of Knitweave, originally in Knitting International.
dimension. For example at the bust this would be achieved by folding the fabric horizontally at the

side seam and letting the fold narrow to nothing by the time it reaches the furthest bust prominence – the bust point. This forms a ‘bust dart’. To complete the dart, the apex is positioned approximately 2cm outside the bust point, and the excess fabric is stitched flat and sometimes cut away. The dart is then sewn into the side seam. Both of these options leave a residual irregularity in the surface, density and handle of the garment, creating a visual clue to its manufacture.

In a similar manner, but by using flèchéage as outlined earlier in section 1.5, integral horizontal darts as described here can be created whilst a garment is being knitted. It was found that if the number of stitches knitted in a row were gradually reduced, so that incomplete rows built up into a wedge with its point at the at the furthest bust prominence, the fabric at the apex of the dart had more rows and was therefore longer. (Figure 16) When two darts opposed each other, as on a symmetrical bust shaping, the fabric was forced to take 3D shape. By altering the position of the apex points and the length of the short rows, different shapes could be made. This was the underlying principle that was adopted for shaping the bust area in this research.

Horizontal darts are not the only shaping required to fit the 3D body, in tailoring, vertical darts may be used elsewhere, for example at the waist (where they are termed ‘waist suppression’), and at the back shoulder to shape the garment to the 3D body contours. A styling technique in cut and tailored clothing termed ‘godets’ or ‘gores’, may

---

365 Rasband and Liechty.16.;Aldrich.25 and 42.
Figure 16. Demonstration of the effect of flèchage. The 'held' stitches are gradually brought back to knit from the right edge inwards, creating a longer fabric at the apex on the left. The black lines follow every 15th row of knitting, and show the way in which the knitting becomes angled to create the shape. Flèchage test series, October 2006. (ORIGINAL IN COLOUR)
sometimes be used to gradually add width towards the hem. The simplest form of these are equilateral triangles of fabric inserted into vertical slits in the garment which increase the width at the bottom of the opening, whilst retaining the original, narrower width at the top.\footnote{The Vogue Book of Sewing, 4\textsuperscript{th} Ed.(Butterick, NY, 1975). 239-240.} Pleats or gathers may also be used in tailoring, but are not discussed here as are not relevant to the purpose of this research. In this research, flèchage was not the only answer to all the challenges of 3D body shapes, and so variations of 3D wale fashioning as described in section 1.5, were found to be the best solution for incorporating vertical darting, gores or godets to accommodate changing body girth and to shape the shoulders.

Fully-fashioned shaping is created when individual or groups of stitches are transferred inwards or outwards at the edges of a field of knitting. Needles that are left without a stitch (in the case of widening) are filled either by splitting the stitch when it is transferred, so that part of a loop remains on the empty needles, or by making a new stitch with the yarn on the next knitting traverse of the carriage. In the case of narrowing, the stitch on the inside edge of the narrowing field is transferred to the adjacent needle so that this needles has two loops in its hook. These loops are then knitted together in the next knitting traverse of the carriage. 3D wale fashioning or shaping however, usually requires the complete field of stitches outside the designated fashioning position to move inwards or outwards as well. Unlike flèchage this actively changes the width of the fabric, whilst similarly but less dramatically than flèchage, it may add slight lateral and vertical convexity to the fabric. If a complete sequence is followed by another of the opposite action, i.e. narrowing after widening, this is considerably emphasised, so that this technique can also create 3D pouches. However, this was not the intention in this research. Rather it was used instead, as will be
explained in Chapters Four and Five, to accommodate girth variations and shape the
knitwear at the back shoulder.

3.6 Fabric development

3.6.1 Developing a knitted fabric with potential for evaluating stretch on
the body

In knitwear manufacture, as in that of other clothing, body measurements were
found to be translated by various methods into a style pattern. Although CAD
(computer aided design) largely now replaces manual methods and as discussed in
Chapter Two, knitwear can now be shaped on electronic systems, any manual process
of drafting 2D garment patterns was seen to be aided by the evenly gridded increments
of ‘dot and cross’ paper. The use of surface grids as responsive visual indicators of
stretch were described by Watkins in 1995, in Clothing, the Portable Environment, in
which she wrote about Kirk and Ibrahim’s ‘anthropometric kinematic’ investigation
into localised skin strain and methods of testing stretch clothing.367 In a similar
manner, Illian in Bodymapping, in 1999 suggested using evenly squared gingham
fabric to ‘wrap and map’ the body when creating dress patterns for individual body
shape.368 The examples discussed here, which suggested imposing geometric
divisions onto the body and/or the garment, inspired the concept of an embedded grid
to aid design and mapping of 3D garment shape which has been used in this research.

Knitting’s inherent stretch suggested that this could, at the same time, become a
dynamic grid, thus creating a topological evaluation tool by which to assess the
research garments in their relationship to the body surface. In 2004, Black in her paper
Surface and Form, discussed Leitzmann’s example of knitting as a surface made from
a meshing continuous thread which has an interdependence integrity (i.e. the whole

367 Susan Watkins, Clothing, The Portable Environment (Ames: Iowa State University Press,
will unravel if the end thread is pulled).\textsuperscript{369} Indeed it is this meshing which enables knitting to stretch. This inherent extensibility of knitting made it critical for this research to be able to gauge its behaviour over a 3D shape. At the same time, this extension of individual units gives knitting the topological quality that, no matter how much or in which directions a pre-defined number of stitches and rows are stretched, the number of stitches and rows remains the same. Therefore the grid design, in whatever stitch structure it was finally knitted, had to meet the following criteria:

- Map the underlying body shape
- Highlight extension of stitches, wales and courses
- Permanently delineate a precise number of stitches and rows
- Not compromise wearer comfort
- Not compromise the quality of the fabric
- Be aesthetically pleasing

3.6.2 Developing a knitted structure with an embedded grid to evaluate stretch

Initially a double bed jacquard construction was considered. This structure allows two or more clear colours on the face of the fabric, it can display a precise stitch-based grid and as an industrial standard for flat-bed weft knitting of imagery its programming is streamlined. It was however concluded that when compared to other knitting structures that of double bed jacquard was less bendable and could affect the drape of the fabric, thus compromising assessment of the sensitive relationships between knitting and the form beneath. The researcher’s experience of knitted

structures, and an evaluation of existing fabrics, in combination with Kenkare’s 2006 discussion on the evaluation of drape characteristics, sufficed to eliminate double bed jacquard.370

Single bed jacquard, which is the face side of double bed jacquard but without the backing stitches, was considered next. This structure, similarly to double bed jacquard, allows two or more colours in a row on the face and can be knitted as efficiently. However, single bed jacquard was rejected because the floats on the reverse can allow slippage and robbing between stitches along courses, which could confuse evaluation of stretch.

Intarsia, the next potential technique, is a single bed knit in which different yarns are knitted on separate groups of needles across one colour pattern row; each field having its own yarn supply. With this technique a grid could be knitted in two colours as required. As a single knit the fabric would show deformation clearly and provide visual, technically simple stitch-to-row ratios to aid evaluation because there are no floats or backing stitches to thicken the fabric as in single and double bed jacquard. Although intarsia presented as an ideal fabric, technical limitations of the Shima Seiki SES 102ff knitting machine available for this research (an inadequate number of feeders), rendered it impossible to knit a repeating grid over a large area. It was recognised in this research that the latest Shima Seiki SIG and NewSIG machines can knit many more intarsia fields and therefore would be capable of producing intarsia fabric of the intricacy required for the proposed research grid.

Structures involving tuck stitch were considered impractical as the tuck action, as

---

described by Spencer, would distort the fabric laterally.  

Following re-assessment of the purpose of the fabric, the decision was made to work with the needle selection and multi-directional transfer capabilities that, as discussed in Chapter One, had made V-bed knitting machines an industrial standard for producing shaped knitwear. A grid that was fundamental to the structure of the fabric would not be subject to the robbing of floats as single bed jacquard, nor was it created with the zig-zag yarn path and layering of colours that caused double bed jacquard to be unbending. It was further decided that combinations of double and single bed knit with stitch transfers between would have the potential to affect the evaluation of stretch. Therefore, of all the potential structural effects, a single knit fabric was found to be preferable.

However in order to completely fulfil these, in particular the last two, a suitable density of wales and courses that formed a two centimetre grid had to be established. Loop density has been discussed in more detail in Chapter Two, section 2.3.9. As validity of the experiments depended on consistency of the knitting structure, all knitting trials were documented. A satisfactory loop density of 65 wales to 82 courses in 10cm of fabric was established in sample b10bin.000. This meant that in one centimetre there were 13 wales and 17 courses, (to include one vertical and one horizontal reverse stitch) creating a 2cm repeating grid. (Figure 17) (Also see Appendix B, page from Research Diary 5th January 2005, and exhibition)

Whilst early sampling was in various 2/28nm and 2/30nm yarn, following sampling and finishing that satisfied the research criteria, Zegna Baruffa 2/30nm Cashwool was used for all subsequent knitting. After working with Cashwool alone in a number of samples, tests were carried out plating (see Glossary of Terms) a low

---

Figure 17. Representation of the research grid of 14 wales x 18 courses. Based on Shima Seiki colour designations, red represents front bed stitches, green represents back bed stitches. Top left shows one repeat, at top right is a visualisation of the stitch effect and at bottom the grid is in repeat. Created with Designaknit 8 Pro, courtesy of Softbyte. (ORIGINAL IN COLOUR)
power stretch yarn (Bilorex 7034, 30dtex 17.7% Lycra, 82.3% Polyamide from Wykes International of Leicester), with the Cashwool at the original stitch tension to improve the compactness (or covering effect) and recovery of the fabric. Spencer explores the technical aspects of the covering effect of knitting as defined by Munden, which apart from his comparison of the compactness of stitches of different loop length and yarn weights largely falls outside the scope of this text.\(^{372}\) A simple explanation of the cover factor in knitting as it relates to this research is however included in Chapter Two, section 2.4.6.2.

The resulting fabric was adopted for all future samples and can be seen to have an emergent appearance that has increased opacity with the vertical grid lines more clearly defined, see Figure 17. A scarcity of literature around plated elastane yarn led, as observed by Abdessalem and Blake, to experience and practice governing yarn choice and machine settings for this development.\(^{373}\) As the plated Bilorex affected width, length and weight as well as elasticity of the fabric, the grid required re-calibration for all sampling thereafter. This had to take account of a slight change in the resultant loop size reflected in the 14 wales and 18 courses that now composed a 2cm square. Wykes International generously donated the Bilorex used in this research project.

### 3.6.3 Fabric design, technical and aesthetic considerations

As explained, Bilorex stretch yarn was plated with the main Cashwool yarn to improve the aesthetic appearance of the finished garment. The inclusion of stretch yarn increased the opacity of the fabric, and at the same time improved the recovery of

\(^{372}\) Munden in Spencer.281.

the stitch shape and therefore that of the finished garment. This is a common practice in knitting manufacture, as it can give the appearance of a finer gauge of knit alongside the properties described here. Bilorex was developed by Wykes to be transparently plated throughout a garment (stretch yarn was formerly only used in cuffs and welts) for the reasons discussed here. Holmes, writing in *Knitting International* in 2005, highlighted the rapid take-up of elastane yarns by the knitting industry when he reported that, ‘...35%-40% of all clothing in developed markets’, contained some stretch filament. Therefore, the decision to include a stretch yarn in order to improve fabric consistency, colour opacity, fabric handle and recovery power was in line with recognised industrial practises as described by Blake.

### 3.6.4 Rationale for final structure selection

Finally a single knit, knit and purl stitch (links-links) structure became the focus of the fabric, and grid delineators were tested. (Figure 18) In such a fabric, a grid embedded into interlinked stitches could map routes to the source of distortion, creating an accurate and rigorous stretch-evaluation tool. Thus a type of ‘rubber sheet geometry’, as Bruckheimer describes it in Leitzmann’s *Visual Topology*, was created to map the wales and courses of the knitting as they followed 3D body shape. This extensible geometry is made possible by the meshing of the knit loops, the legs of which allow vertical stretch, whilst lateral stretch is restrained by the top loop of the stitch directly below, through which the legs pass. The starting length of the loop, in combination with the yarn’s stretch properties, governs the amount of potential extension. Spencer, when discussing both these properties in *Knitting Technology*

---

374 Blake. 4  
376 Blake. 4  
Figure 18. Three grid delineation experiments. All are on a single knit, face fabric base. The top two samples are knitted in 2/30s acrylic yarn. The grids are created by the following structures. Top: one face and one reverse stitch both horizontally and vertically. Middle: one face and one reverse stitch vertically and one complete reverse stitch row horizontally. Bottom: as middle grid, knitted in 2/30s Merino Cashwool. October 2004. (ORIGINAL IN COLOUR)
considered loop length to affect fabric drape, and Brackenbury took a similar view, further associating drape with the aesthetics of the fabric. Both connected drape with satisfactory handle. Furthermore Lam’s 2011 study of knitted fabric handle demonstrated that single knit fabrics have better draping (and by association handle) qualities than double bed fabrics, which further supported the choice of a single knit fabric.

3.6.5 Incorporating a visual evaluation tool

Knitwear manufacturing tolerances recognise that overall dimensions may be inaccurate due to the stretch characteristics of the fabric. McDevitt in the *Complete Guide to Size Specification* recommends tolerances of between ¼” (7mm) and 3/8” (10mm) in knitted clothing specifications. To counteract this effect, the integral knitted grid in this research has been specifically developed to enable a degree of accuracy for calculating finished sizes in knitted pieces and for making comparisons. This is in line with Watkins description of applying grids to test skin stretch and clothing pressure on the body discussed in Chapter Two, section 2.3.6.

3.7 Conclusion

The first step in manual measuring was to establish landmarks and take measurements using traditional methods. To this end a measurement protocol was developed for manually measuring larger body shape was developed for the research based on the literature. Despite this protocol, measuring larger body shape proved complex and it was difficult to achieve consistent results. It was found that employing a second person and refining the recording methods improved the practical process. However

---

378 Spencer.281;Brackenbury.158.
380 Myers McDevitt.6. From electronic Appendix.
381 Watkins.240 and 258.
the accuracy was still hard to maintain as larger body shapes were found so un-linear as to be impossible to define with measurements alone. It was necessary to take body depths to establish the shape of a girth and then relate these to height from the floor. To place these depths at their correct levels in vertical and lateral relationship with each other, they then had to be thought of as if the body girths were floating in space around a central vertical core. This ‘three dimensional’ concept of the body proved difficult to capture with measurements alone.

When the decision was made to include 3D body scanning in the research process, comparisons were made between the established manual landmarks, and those that would be required in 3D body scanning for the purpose of developing knitwear for larger body shape. Important landmarks established with visual reference to the body shape rather than linear measurements during manual measuring were still found to be the natural waist (E2) and the point of furthest frontal prominence of the stomach.

Identical ‘clones’ for checking knitting and body shape requirements were helpful but time consuming to make. Consequent to both these issues, 3D body scanning was incorporated into the research design to provide more accurate measurements and provide a method of viewing the body shape from different angles without the participant being there. It was found during the practice that in order to develop successful knitwear for larger body shape a combination of digital and manual measurements, the ‘cloned’ real body shape and the virtual 3D body images was required.

The development of the integral, embedded topological marker (the grid) was established to be a considerable aid to the assessment of the behaviour of the knitting. Provided it was knitted using the loop density and cover factor established to be the most effective for this research, every future piece of knitting produced by the
research that included this topological grid would clearly display and distortion. This embedded topology proved, during evaluation of the toiles, to be a valuable tool which enabled investigation of knitwear in its relationship to body shape.

The criteria for the fabric structure and surface design was identified as a structurally integrated, permanent, incremental measuring system, allowing for ease of evaluation, satisfactory drape, and a pleasing aesthetic. In response to these first five criteria, and as described in this chapter, a single knit structure fabric was designed to use as a base from which to develop knitwear prototypes for larger body shape.

Therefore original tools for gathering specific larger size female body shape data were tested, revised and put in place and innovative ways of applying knitting methods for translating these shapes into 3D knitwear were developed, assessed and established. Finally a novel method with which to evaluate the stretch and behaviours knitting and the fit of the finished knitwear was developed and applied to all the knitwear that followed throughout the research project.

To offer improved fit in knitwear for larger body shape, both traditional edge shaping and 3D shaping were found to be useful. Suppression was introduced into the knitwear by developing darts that worked in the same manner as sewn godets and gores in tailoring. These were unique to knitting as they fitted the body smoothly with no excess fabric or stitching required to create the 3D shape. Thus a practical method of measuring larger body shape, translating this information into knitting and introducing 3D shape into knitwear to improve the fit for larger sizes began to take shape.
4 Application of the practice based research framework to developing innovative 3D shaped knitwear for larger body shapes

4.1 Introduction

When planning this research, detailed development consideration was given to its organisation, management and execution. As discussed earlier, the pilot study provided early opportunities to establish and develop specific knitting methods and design measurement and evaluation protocols.

Selected illustrations have been included in this text. More details are however contained in Appendices B and D, and the complete collection of template schemata, images and videos will be made available in the accompanying exhibition.

The challenges faced by the researcher in measuring the body, and the solutions and methods developed in response to these have been described and discussed in Chapter Three. The progression of the empirical research in the form of knitting and garment developed in response to these challenges are presented in this chapter. Selection of the three participants has been discussed in Chapter Two 2.4.2.1. As described, the participants represented the two body shapes most commonly reported in the research survey, with variations occurring within these. Each of these body shapes required different solutions for improving garment fit. (Figure 1)

Whilst working with the participants it was found that creating knitwear to fit their body shapes required not only edge shaping, but also shaping within the knitting field. This method was found to accommodate body protrusions by altering the space between the knitwear and the body at the exact radial position it was required. Some of the knitted effects resembled that of godets or goring, as described in Chapter Three, section 3.5.3, but as these are inserted into the fabric, whilst those in the
Figure 1. Photographs of the three participants; Juliet, Desdemona and Portia, during their respective measuring sessions. (ORIGINAL IN COLOUR)
research were integrally constructed, the term ‘darting’ was used in this research. The problems encountered in achieving 3D shape, solutions developed and the principles and methods employed are explained here.

4.2 Technical design processes developed to enable knitting 3D garment shape for larger body shape

Preceding the knitting of any garments, the fabric structure had to be tested to meet the research demands as discussed earlier. There were issues of visual clarity, knitting consistency control and the inclusion of an evaluation tool as has been discussed in the preceding chapters. It was however, considered desirable to develop a design process that remained close to commercial methods as the research outcomes have always been intentionally aimed at commercial, mass manufactured knitwear.

The knitwear design and sampling process was investigated by Eckert in 1997. When compared with that described in April 2011 by Anna Koski, (girls’ knits designer at American Eagle), it was clear this process had not significantly altered since Eckert’s study. According to Eckert, fabric and garment shape were usually developed separately, only being integrated once the knitted fabric had been approved. Fabric sampling by technicians was informed by designers using garments, ‘tears’ from magazines, or sometimes, (but according to Eckert much less likely), a knit structure diagram of some type. Koski also described purchasing swatches from third party designers at this stage. Garment shape was then finalised by the design team into a specification drawing, which then passed to the production unit for sampling. Although modern digital systems have simplified input, calculation and output methods, these remain the fundamental underlying processes. It was considered

384 Frances Tobin, (2011), Interview about knitwear for larger sizes, 13th June: n.pag.
385 Eckert:67.
to be valuable to this research to determine whether digital communication alone was used for prototyped knitwear production. Koski reported that American Eagle’s women’s wear knit designers still travelled overseas to check their samples because it was, ‘easier and faster rather than communicating through emails’. In contrast, during a 2011 interview, the German plus size designer, Anna Scholtz, explained that she no longer travelled overseas as it was too time-consuming, preferring to use e-mail to control the sampling and production of knitwear. This may have been due to the difference in scale of the two businesses, American Eagle being far larger concern than Scholz’s independent label. Scholz also indicated that she would prefer to work with European manufacturers, and that she found Far Eastern demands for large quantities unsuitable to her needs. Both these views of commercial knitwear design and manufacturing provided validity to the base concept of developing templates that are digitally transmittable and understandable in different global locations, and the research idea that larger sized knitwear has potential as a smaller niche market product. Because of the combined knitwear design and technical experience of the researcher and the size of the project, the processes described here varied slightly in this research. (Figure 2)

4.3 Developing knitting templates for larger body shape on the Shima Seiki SDS®-ONE system

Before commencing this section, it is necessary to explain what the term ‘template’ meant as used in this research. On the Shima Seiki SDS®-ONE system used for developing the research templates, as with other flat V bed knitting CAD/CAM systems at time of writing, the knitted structure including shaping was drawn in stitches and rows as a 2D image on the screen. This 2D digital image could be cut

386 Anna Scholz, (2011), Interview about the design process for larger sizes, 17th May: n.pag.
387 Scholz: n.pag.
Figure 2. Process map designed through developing the pilot study research garments. 2005-2006. (ORIGINAL IN COLOUR)
and pasted in a similar way to any image. Therefore the research templates were actually digital files made and saved in a proprietary Shima Seiki format. Because in flat bed knitting technology colour is used as an international language to represent knitting structures, any knitting technician opening one of the research templates on a Shima Seiki system would be able to visually read the structure and understand what the knitting instructions meant. This was tested and proved successful as can be seen in the description of Shima Seiki Europe’s production one of the prototypes garments for this research in Chapter Five, section 5.3.

Because the templates were digital files, conversion to other visual formats was possible. Once they were turned into digital image files as shown in this text and in the Appendices, they became visual schemata. Therefore, and because knit systems were developed with the same colours generally continuing to be used to represent basic structures, it would be possible for a technician familiar with a different system to read a significant amount of information from the research template schemata. If additionally provided with the ‘key’ to the more complex structure colours as designated by Shima Seiki, a skilled knitting technician would be able to fully understand the research template schemata from either digital files or printouts.

The significant difference between a standard garment shape as generated by the automatic processes which are discussed next and the research templates was that the templates had the relevant knitting structure information drawn into the image at the strategic points as governed by the body shape for which it is intended. Because of the image-like nature of the 2D knitting structure files, parts of templates, (for example bust dart shaping), were cut and pasted between different participant templates where similar body shape features occurred. (Figure 3)

As described in Chapter Two, section 2.4.5., the Shima Seiki SDS®-ONE system
includes three proprietary software packages, *Paint* (design), *PGM* (garment pattern making) and *Knitpaint* (technical translation). These may be used alone or in sequence to design knitted fabric or knitwear, but only *Knitpaint* can be used independently of the others to manufacture knitting as it contains the software that communicates with the knitting machine. Secondly, it must be noted that this research relied on software training and updating of the knitting system that this was provided mainly through the generosity of Shima Seiki Europe Ltd. This resulted in software capabilities, which industrially might have been exploited from inception, only gradually being made available to this research. Finally it was highly significant to this research’s aims, objectives and outcomes that the researcher was also the technician for this research and carried out all fabric sampling, programming and garment production. In doing this, four key roles were incorporated into one; researcher, designer, fabric technician and shape technician, all of which, as highlighted by Eckert, Gray and Cuden, might have conflicted as independent specialists.388

In September 2007, training was provided by Shima Seiki Europe Ltd., which included the SDS®-ONE *SPaint Integrate* menu (version A54). This significantly affected the research practice. Although these updates resolved many of the technical aspects of programming and shaping (which formerly had been complex and time consuming), in order to take advantage of this the research’s base template schemata had to be re-programmed. In July 2009 the software was once again updated, to version A61.

Figure 3. The template for the bil2a development of the early prototype garments. The bust dart is shown in the process of being cut and pasted from the flechbil2 developmental template. In this template the standard colours for digital representation of knitting structures can be seen. Red represents front bed needles as single knit structure, green is back bed as single knit and yellow is double bed with both beds knitting together. (ORIGINAL IN COLOUR)
This research primarily used Knitpaint, with some garment shapes being developed through PGM, (notably Portia’s which required asymmetrical shoulder shaping). Initial experiments with Knitpaint’s integrated garment shape generator, Easy Shaping, proved to be too inflexible to meet the requirements of the research. A new method was designed therefore using SPaint pattern blocks to generate the initial body blank (SPaint is a sub-package within Knitpaint that facilitates garment shape development). Although the measurements required by SPaint are different from those needed for Easy Shaping, this was still insufficiently flexible for final customisation. The garment development table in SPaint had to be completed with dimensions obtained through the research methods of measuring larger body size. To aid this purpose, a system was designed specific to this research, so that data acquired in this way or via 3D body scans of larger sizes could be input to generate the template from which a garment could be knitted. (Figure 4) Therefore the garment template ‘blanks’ were extracted from SPaint without completing the automatic process, and treated as independently drawn ‘blanks’ for developing into templates. This was followed by the inclusion of shaping and any additional customisation to meet the participant’s measurements and body shape. (See Appendix C) Although the SPaint pattern blocks include set-in and raglan sleeved garment shapes, this research concentrated on the set-in sleeve garment shape with sloping shoulders. This being a classic style that follows the upper torso contours and enabled the creation of knitted toiles or ‘fitting shells’ which have potential for development into fashion garments. Ease issues and the application of ease to the research garments

In SPaint the finished size of the garment, not the bodily dimensions, were used, therefore an ease allowance had to be considered. Ease in general was described by
**Figure 4. Visual representation of the system designed in this research so that dimensions of larger body size are correctly input into the SPaint garment development table. (ORIGINAL IN COLOUR)**

<table>
<thead>
<tr>
<th>SPaint 'Size Input' fields</th>
<th>Recommendations for larger sizes and 3D shape</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body length</td>
<td>To above welt</td>
</tr>
<tr>
<td>Chest width</td>
<td>Bust width (manual measuring and body scanning) of front panel</td>
</tr>
<tr>
<td>Shoulder width</td>
<td>Of garment, based on body measurement shoulder point to point</td>
</tr>
<tr>
<td>Front (back) bust width</td>
<td>Chest/back width in manual and body scanning measurements</td>
</tr>
<tr>
<td>Shoulder drop</td>
<td>Better set-in sleeve fit if drop maintained from measurements</td>
</tr>
<tr>
<td>Neck widths</td>
<td>Neck widths - very little adjustment required from standard sized</td>
</tr>
<tr>
<td>Armholes as either 'straight' (diagonal length) of by height</td>
<td></td>
</tr>
<tr>
<td>If armhole by height, then apply curve by height. If 'straight', then apply a ratio for curve</td>
<td></td>
</tr>
<tr>
<td>Bind off width - longer than standard sizes</td>
<td></td>
</tr>
<tr>
<td>Waist width - E2</td>
<td>Larger bra cup - better with a shorter curve</td>
</tr>
<tr>
<td>Waist position from top</td>
<td>Front chest width - (shoulder width + curve height) / 2</td>
</tr>
<tr>
<td></td>
<td>Use same method on back</td>
</tr>
<tr>
<td></td>
<td>To establish where shaping for lower section will finish</td>
</tr>
<tr>
<td></td>
<td>Neck point to E2 (waist)</td>
</tr>
<tr>
<td>Hip width</td>
<td>Widest girth of lower torso to be covered by garment. 'Thigh girth' in manual measurements, 'seal' in body scanner software</td>
</tr>
<tr>
<td>Hip height</td>
<td>This requires the distance from hem to hip as established above. When using body scanning measurements this is garment length less neck point-to-seat measurement</td>
</tr>
<tr>
<td>Difference of body length (B&gt;F)</td>
<td>A minus value here generates a shorter back panel, (and can therefore be used to make the front longer to enable inserting filing/rows later on). Adjustment will be required as the armhole depth is affected</td>
</tr>
<tr>
<td>Difference of body width (F&gt;B)</td>
<td>Larger sizes may benefit from a wider front panel, this allows for a better 3D shape on a larger bra cup size as deeper filing/rows possible</td>
</tr>
<tr>
<td>Straight sections to suit design</td>
<td>Use sleeve expand width to allow for larger biceps</td>
</tr>
<tr>
<td>Sleeve length and width as standard method</td>
<td>The sleeve cap and height and width will differ from standard to fit the longer bind off at underarm</td>
</tr>
<tr>
<td>Sleeve cap flat width and height</td>
<td></td>
</tr>
</tbody>
</table>
Gill in 2009 as, ‘...the difference between the pattern and bodily dimensions’.

Chen,
in 2008 when seeking a new method for setting ease allowances, refined this
description by defining three types of ease; standard, dynamic, and fabric ease,
although two are more generally accepted. Rasband, Branson and Yu described
these as ‘wearing ease’ which is added to allow the body to move inside a garment,
and ‘design ease’ which is added (or subtracted) from dimensions to achieve a style of
fit, and is generally influenced by culture and fashion trends. In 2008, Petrova and
Ashdown observed that there was as yet no industry standard for ease, and that the
allowance ‘...relies on experience and common practice’. Likewise, in 2009, Gill
reported that expert texts on pattern construction recommendations for ease differed as
much as 5.6cm at back bust, and 5.7cm in armhole depth.

Ease in stretch garments is even more variable, being dependent on the
extensibility and recovery of the fabric. Branson argued that it was wrong to assume
knit will in every case, ‘...fit in all the right places and provide ease of movement’,
and referred to Watkins, who in 2000 sub-categorised stretch clothing as: form fitting
(does not compress the body), action fitting (supports the body) and power fitting

---

389 Simeon Gill and Nicola Chadwick, "Determination of ease allowances included in pattern
construction methods", *International Journal of Fashion, Design, Technology and Education* 2.1
12/1/2009.
391 Judith Rasband and Elizabeth Liechty, *Fabulous Fit*, Second ed. (New York: Fairchild, 2006).36-
38; D.H. Branson and J. Nam, "Materials and sizing", *Sizing in Clothing*, ed. S Ashdown. (Cambridge:
392 Adriana Petrova and Susan P. Ashdown, "Three-Dimensional Body Scan Data Analysis: Body Size
and Shape Dependence of Ease Values for Pants' Fit", *Clothing and Textiles Research Journal* 26.3
393 Gill and Chadwick:7
This research however was concerned only with looser rather than form fitting clothing. Additionally it was concerned to apply what Wang terms ‘radial ease’, meaning that which is spread out around a cross-section of the body rather than added solely at the side seams. However the amount of ease allowance that would be suitable for larger sized knitwear was not at first clear.

Petrova and Ashdown suggested increasing ease values for larger sizes and larger measurement, but offered no practical or numerical examples. Their method appeared however to mirror the traditional concept of grading up sizes, which is not based on real body shape. At the minimal end of the ease scale, Branson reported that action fit or sportswear clothing is often made with ‘negative ease’, a practise that might suit clothing intended to display body shape, but was not suitable for larger sized knitwear, therefore neither of these types of ease matched the intended outcomes of this research.

Expert opinion therefore offered varying advice on ease in general and there was a noted lack of information on applying ease in knitwear. It was known however through the researcher’s experience in knitwear manufacturing that ease would be necessary. As the intended garments were not primarily for fashion purposes, this study is predicated on the fact that whatever ease was found to be necessary would be wearing ease, not design ease. The aesthetic intention to compliment body shape indicated that strategically placed radial ease would be desirable in the garments, though in the first stages of the pilot study no ease was added as it was intended that the knitwear should match the body dimensions closely for clear evaluation.

---

394 Branson and Nam.269.; Watkins, P. “Analysis of stretch garments”, 80th World Conference of the Textile Institute, Manchester, (2000). 1-17. in Branson and Nam.269.
396 Petrova and Ashdown:227 and 231
397 Branson and Nam.272.
However, by the time the Desdemona 3 garment was commenced, it was clear that enough was understood about designing for larger body shape to include the type of wearing ease discussed here. Rasband defined the average wearing ease as between 1” and 2” (2.5-5cm) at bust and hip girth, but as her recommendation was for woven fabrics without stretch, only 4cm (1 ½”) was added at the bust and hip (not at the waist as will be explained in sections 4.6 and 4.8.1.), and 3cm (1 ¼”) on the sleeve width.  

4.4 Shaping the shoulder and body

Rasband considered that if a garment fits at the shoulders, it has a good foundation to drape well on the rest of the body. This premise was used in the following discussions, and in evaluations the garments were assessed accordingly, from the shoulders downwards. The challenge of capturing the 3D-ness of body shape in knitting was heavily influenced by technical knitting rules, but tempered by the desire to create an equally positive aesthetic in fabric and garment. When designing the garment, body dimensions and proportional relationships were considered, starting with the relationship of shoulder width to that of the upper chest/back and bust girth at underarm height.

For example, Desdemona’s manual measuring results showed a front shoulder width (B-B on research measuring diagram, see Chapter Four, Figure 3) of 34cm, chest of 38cm, front bust arc of 57cm and a total bust girth of 102.5cm. These measurements were compared to the nearest standard measurements from Aldrich’s *Metric Pattern Cutting for Women’s Wear* of a size 20, (104 cm bust, 37.2 upper

---

398 Rasband and Liechty.60.
399 Rasband and Liechty.60.
chest, shoulder length 13.7cm) which comply with BS EN 13402-3.\textsuperscript{400} To calculate the shoulder width, which was not indicated, the shoulder length (13.7cm) was doubled, and in accordance with Aldrich’s method of calculating the back neck width, $2/5$ of the total neck measurement of 41cm (16.4cm) was added to this, giving a total shoulder width of 43.8cm; clearly wider than Desdemona’s.\textsuperscript{401} The method used to calculate the front bust arc for this comparison is shown in the following table. The difference between these measurements indicated that the garment had to narrow by 23cm (11.5cm each side) between the front bust at underarm and the shoulder point, instead of the standard 17.5cm (8.75cm each side), a total of 2.75cm more each side.

(Table 1)

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Desdemona (manual measurements)</th>
<th>Standard size 20 (Aldrich)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total bust</td>
<td>102.5</td>
<td>104</td>
</tr>
<tr>
<td>Chest</td>
<td>38</td>
<td>37.2</td>
</tr>
<tr>
<td>Sh-Sh</td>
<td>34</td>
<td>43.8</td>
</tr>
<tr>
<td>Fr bust arc</td>
<td>57</td>
<td>61.25*</td>
</tr>
<tr>
<td>Difference bust-shoulder</td>
<td>23 (11.5 each side)</td>
<td>17.5 (8.75 each side)</td>
</tr>
</tbody>
</table>

*If the front bust arc is taken as the same percentage of the total bust measurement as Desdemona’s (58.9%), the standard size front bust arc = 61.25cm.

Table 1. Comparison of Desdemona's measurements to those of a standard size 20 from Aldrich, Metric Pattern Cutting for Women's Wear, (2008).

Two methods of edge-narrowing a set-in sleeve body could achieve this; firstly by extending the underarm bind off or secondly by increasing the number of narrowings in the armhole, both of which may lead to an enlarged armhole. These methods were


tested, and ultimately the front panel of Desdemona 2 was knitted slightly wider than the back. This was partly due to the perceived need to move the side seam further back on the sagittal plane of the body to achieve a better fit on the bust and stomach. The probability of the side seam moving further back on larger-busted women is noted by Ashdown in her 2008 article, *Automated side-seam placement from 3D body scan data.* Although Desdemona did not have a large bust, the balance of her body was towards the front, as her stomach protruded almost as far as her bust apex. (Figure 5) Ashdown stated that, ‘There is little guidance for the appropriate location of the side seam in common practice’, and in this case a longer bind off at underarm was combined with narrowing and a vertical dart at the shoulder (as will be discussed later), to achieve the narrower width across the shoulders in combination with a wider front body piece. In the Desdemona 2 garment this vertical dart was angled slightly outwards from the above the bust point. This prevented it interfering with the neckline. Depending on the differences between the shoulder, upper chest and bust arc width, darting on the front chest and shoulder can increase or decrease width in the middle of the knitting field. This method can accommodate larger differences than normally possible with edge-shaping, without compromising the shape and size of the armhole. These darts, knitted with 3D wale shaping, also create a slight 3D curve within the fabric, which in combination with horizontal flèchage darts, develop 3D form for the bust.

On the back shoulder, shaping had to allow for any fullness on the curve of the upper back. Desdemona’s upper back curve reached its full prominence 15cm below the neck point (C). However, in order to prevent strain of the stitches, and to maintain

---

403 Ashdown, *et al.*:201
Figure 5. Photograph of Desdemona during measuring. The vertical line to the right of the image illustrates the prominence of her stomach in relationship to her bust. Note the forward balance of her body. 29th June 2006. (ORIGINAL IN COLOUR)
the fullness of the dart over the apex of the curve it was evident that the dart should not start until 2cm above the most prominent point. This positioning was based on a similar principle to that of the horizontal bust dart, and started at least 2cm outside the bust apex. Therefore the dart was 13cm long, and narrowed according to requirements of the body shape (1cm in the case of Desdemona’s upper back).

Vertical darting contributed to the narrowing required between upper back width and shoulder, which presented a similar problem to that already discussed. As front and back shoulder seam measurements have to be the same to create a smooth shoulder seam, dart length and shaping frequency (which may be affected by physical impracticalities) were critical influences on the finished garment. The front of Desdemona 2 did not have a lower torso dart, as when seen from the anterior plane, her body shape varied little in width from hip to bust. It had been considered that by varying the width between front and back panel and putting darting on the back as on Juliet the front panel would only require the bust and upper darts to sculpt the 3D shape. Evaluation and the considerations as discussed next led to some alterations.

Desdemona’s tummy circumference exceeded that of her hip or thigh, and this was observed to cause distortion of the grid on the front panel. A solution was developed so that if the lower hip and thigh girths are smaller than that at the tummy point (point of most prominence to the front), and in order to avoid an unflattering tightness of the fabric over the bulge of the buttocks and or the stomach, the hip girth has to be considered to be the same as that at the tummy. Consequent to this there may be excess fabric to drape at the hem. This solution had been applied to the back as it had been found to improve the fit of the Juliet series of garments, but for the reasons just discussed it was felt to be unnecessary on the front panel of Desdemona 2. However, following the evaluation of Desdemona 2 and detailed analysis of the results, and
conjunction with the newly available body scan measurements, the front and back panels of Desdemona 3a were altered. In this case, the vertical dart would start to narrow the garment after the tummy point was passed, and as with the upper darts, the inward curvature should be gentle. Therefore on Desdemona 3 the dart started 2 cm after the most prominent tummy point, and narrowed according to the measurements via the waist (E2) towards the underbust level. If a lower vertical back dart is to be included on the back panel, as it was for both Desdemona 2 and 3, it may be necessary to add a horizontal, back underarm dart (as on the Juliet 4 garment) to shape the back area and equalise the length of the side seams

4.5 Shaping the bust with flèchage

The interactions between vertical 3D wale shaping and horizontal flèchage darting were fundamental to introducing 3D shape to the research garments, and successful execution of a balanced result was dependent on understanding the effect of bra cup size on the knitting methods. Juliet’s bra cup size was larger than had previously been tested; requiring fifty-four rows of flèchage as opposed to fourteen, and this presented some technical problems due to machine capabilities. A successful method, involving waste knitting, tucking the end flèchage point and localised erasure of the grid, was designed with the help of Phil Baines of Shima Seiki Europe.404 (Figure 6) (Appendix B)

Placement of the bust darts proved challenging. In the Juliet1 garment, they had been 3cm too high, and in the first evaluation of Desdemona 2 they were 2cm too high. The resolution to this was to over-compensate downwards by 2cm when placing the darts, which improved the placement; however the flèchage method was re-considered during the main study. This re-designing was prompted by questioning

Figure 6. On the left is a photograph of the SDS®-ONE screen whilst working on mini9phil2.dat schematic. The bottom shows the flèchage waste (the zig-zags in pale colours), the bust flèchage areas are the dark triangles mid-way up, followed by the underarm bind off and armhole narrowings. The vertical shoulder darts can be seen at the top. The localised grid erasure has not yet been done. On the right is the mini9phil2 sample knitted up. The brown at the bottom is the flèchage waste which facilitated the knitting of the bust darts further up the piece. 29th September 2005. (ORIGINAL IN COLOUR)
whether horizontal courses of knitting above or below a diagonally converging series of courses would be more flattering to the bust shape than the mitre method used so far. Therefore with reference to Lewis, who in *A Machine Knitter's Guide to Creating Fabrics* wrote extensively about short row techniques, a method was designed that would also, according to Lewis, give a smoother dart. The samples from these experiments, Spiral A and Spiral B demonstrated quite clear differences between the original mitre and each other. (See Appendix B)

These differences were both visual and physical. In the mitre method, short rows before and after the apex of the dart knit created the classic ‘arrowhead’ effect of flèchage with rows symmetrically flowing backwards from the apex. The new version Spiral A knitted short rows only before the apex, and Spiral B only after. (Figure 7) It was mooted that Spiral B, with diagonal courses converging downwards at the sides of bust, would follow the upper chest diagonal curve as the mitre did, but be influenced to lie closer to the body by the uninterrupted complete courses below and the resulting perpendicular fall of the lower fabric. It was considered that these horizontal rows could prevent concavity of the garment under the bust and any resulting ‘cling’ to the abdomen area. Spiral A was anticipated to demonstrate an opposite effect, with the diagonal courses curving upwards around the under sides of the bust tucking the fabric into the body, thereby emphasising any tummy bulges. It was also expected that the straight courses above the bust line would not follow the upper chest curve as closely as spiral B. The grid aided assessment of these samples, as it clearly showed the paths of wales and courses. However it also caused some conflict where it visually over-emphasised the effect of the short rows. Both spirals forced the dart to slope, which compounded the problem of bust dart positioning, but

---

Figure 7. On the left is a diagram of the short rows involved in knitting the three different flèchage darts, and on the right is the emergent appearance created by the flèchage. The 3D effect cannot be shown here, but is visible in the photographs of the techniques. Top: Mitre. Middle: Spiral A. Bottom: Spiral B.
when tested on full sized front pieces overwhelmingly positive behaviours were
noticed. Of the first set of samples, Spiral B seemed the more effective of the two,
giving shape and form to the upper chest, but the dart appeared to slant downwards.
Spiral A, in contrast to expectations, fitted the bust shape well without overtly
tucking-in underneath. Further samples of both spirals were knitted in the research
fabric and evaluated by two female colleagues on Desdemona’s clone, as neither
participant was available. One comment they agreed on was, “If you’re older you
don’t want lines on boobs that point downwards, gravity does this anyway.”406
(Figure 8) This was a significant visual aesthetic consideration and as both spirals
offered equal positive behavioural properties, the comment influenced the decision to
develop Spiral A in future garments. One consequence of Spiral A’s upwards slope
was that on the schemata they would appear to start too low on the side seam, and
although their apex would originate level with the bust point as before, they would
also now finish at this height. (Figure 9)

Later in the development of the pilot study garments, flèchage darts were also
introduced under the armholes on the back body piece, to prevent ‘drooping’ at the
side seam and to equalise the side-seam lengths whilst maintaining centre back length.

4.6 Fitting the garment to the lower torso

Once bust shaping was in place, the lower garment had to accommodate the lower
torso shape. The frontal stomach prominence on Desdemona and Portia was clearly to
be seen in their 3D body scans. (See Appendix C) In the pilot study this landmark
was not designated, although body depth at F (underarm) plus body depth and width at
E (body mid-point) and H (hip) was recorded. Therefore the processes discussed here
largely refer to the prototypes developed in the main study. Juliet 2 was however

Figure 8. Spiral A and B bust dart flèchage samples knitted on the SES102ff machine and evaluated for fit. November 9th 2006. (ORIGINAL IN COLOUR)
Figure 9. Graphical representation demonstrating the effect of Spiral A flèchage. The white dotted line shows the position of the apex of a flèchage mitre dart. This has been superimposed on a schematic of a Spiral A flèchage dart. The Spiral A dart places the bust point higher than the Mitre, therefore to match the same bust point as the Mitre the whole dart would need to be moved downwards on the schema. (ORIGINAL IN COLOUR)
developed, alongside the ‘conference’ sample presented at Knitting 2005: Global Challenges Innovative Solutions and the ‘Australia’ garment (exhibited at Blurring the Boundaries, 2006 and discussed in Chapter Five, section 5.2.2.1) with lower vertical darts on the back to accommodate the width of her upper back in comparison to her buttocks and hips. (See Appendix D for evaluation photographs) This process served to inform the technique for future front darts.

Frontal stomach prominence was found to disrupt how a garment drapes below the bust, and could also affect the fall to hip, or garment hem. Protruding buttocks similarly affected the fall of the lower back of the garment. It should be noted that body girth at this prominence was not necessarily larger than that at hip, waist or bust. In order to prevent this disruption to the garment’s drape, it was found that 3D shape could be introduced at the point of greatest prominence but not (knitting rules providing), affect the girth at bust and E2. If necessary the garment could also be adjusted radially at hip width to accommodate wider hip girth. As the research garments were knitted from the hem upwards, the hem was the same width as the largest lower torso girth. To prevent the garment pulling in below this it was found best that it should narrow above the curve of the buttock prominence at the back and the stomach at the front. Vertical darting inside the knitting field, created by 3D wale shaping was chosen in preference to edge shaping for this. Edge shaping created shape only in a 2D plane, so that the garment panel remained flat and any bulges on the surface of the body disturb the smooth plane of the fabric. Introducing narrowing darts in the fabric field above a prominence created a gentle curve in the fabric that smoothly accommodated the bulge instead of emphasising it. Desdemona had quite a prominent stomach without any pronounced ‘midriff bulge’ above or below the navel, so this technique was tested in Desdemona 3a, the evaluation of which is discussed
fully in section 1.8 of this chapter.

The start and finish height of front darts was dependent on the height of thigh, hip, E2, and bust, and their vertical relationship to the tummy prominence. Lateral placement of the front darts was found to depend on the relationships between front bust arc, E2, front hip and thigh measurements, as well as the position of the tummy prominence.

4.7  Shaping the armhole and fitting the sleevehead

As discussed earlier, the front panels of the first Desdemona garment (Desdemona 2) was knitted wider than the back up to the underarm. One consequence of this was that the underarm bind off, already lengthened to compensate for an increased difference between shoulder width and front bust arc, became still longer. Consequently an equal number of stitches had to be reflected in the corresponding bind off at back and front of the sleeve underarm shaping.

Between Desdemona 2 and 3 there was considerable alteration to the sleeves. (Figure 10) The sleeve head was shortened and widened, whilst the sleeveheads became markedly asymmetrical in order to fit around Desdemona’s quite full biceps but still, when being worn, follow the armseye (armhole) line down from the shoulder point to underarm as recommended by Rasband.407 Although the sleeves were narrowed, in line with Rasband’s recommendation 3.8cm was retained as wearing ease.408

4.8  An example of the research design development process: re–designing the Desdemona 2 garment as Desdemona 3a

The adjustments and alterations discussed in this section are those made following two evaluation sessions of the Desdemona 2 garment, the first on the clone and second

407 Rasband and Liechty.62.
408 Rasband and Liechty.62.
Figure 10. The revised right hand sleeve template schemata for Desdemona 3. On the right is the original Desdemona 2 sleeve, and on the left is the revised Desdemona 3 sleeve. The new sleeve clearly illustrates the shape required to accommodate Desdemona's fuller bicep without being too loose below the elbow. It also shows the lowered and flattened sleeve head. (ORIGINAL IN COLOUR)
on Desdemona herself. This process has been included in detail as an example of the research design development and the exploration of larger body shape in relationship to knitwear.

The Desdemona 2 garment was composed of the following knitted pieces listed in the table below and shown in the following figure. (Table 2)(Figure 11)

<table>
<thead>
<tr>
<th>Garment piece</th>
<th>Template file name:</th>
<th>Knitting file name:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Front body</td>
<td>Desdemona_2frontdev.dat</td>
<td>des2f.000</td>
</tr>
<tr>
<td>Back body</td>
<td>Desdemona_2backdev.dat</td>
<td>des2b.000</td>
</tr>
<tr>
<td>Left sleeve</td>
<td>LHSleeve_shapeddevfinal.dat</td>
<td>des2sl.000</td>
</tr>
<tr>
<td>Right sleeve</td>
<td>RHsleeveshaped_devfinal.dat</td>
<td>des2sr.000</td>
</tr>
</tbody>
</table>

Table 2. Table of the knitted pieces for the Desdemona 2 garment with template file name and knitting file name.

The garment was programmed and knitted from manual measurements prior to 3D body scanning being adopted. (Selected photographs from garment evaluations are contained in Appendix D and the resulting marked-up garment can be seen in the exhibition.)

4.8.1 Design process

A major revision following analysis of the evaluation of the Desdemona 2 garment was to remove 2cm on each side of the front panel and add 2cm on each side of the back panel to bring them to an equal width at the hem. The panels had been drafted of unequal width for Desdemona 2, as discussed earlier, partly in order to assess the effect a wider front body panel which moved the side seams towards the back of the sagittal plane of the body had on the drape and fit over the bust. It had been proposed that a wider front might allow a longer horizontal bust dart which if knitted as
Figure 11. The four template schemata of the Desdemona 2 pieces. From top right: Desdemona_2front.dat (des2f.000), Desdemona_2back.dat (des2b.000), LHSleeve_shaped.dat (des2sl.000), and RHSleeveshapedl.dat (des2sr.000). These are shown before they were divided and developed with knitting instructions as discussed in the section on the design process. (ORIGINAL IN COLOUR)
mirrored, mitred flèchage may have permitted the front and back darts to be knitted in one. This was however found to be impractical on the available machinery, being more suited to at a machine with sinkers or complete garment knitting and so was discontinued as a development for this project, but has potential to be explored in future developments of the findings.

When re-designing the width of the front and back panels it was obvious that if fabric was added or subtracted arbitrarily throughout the length of both panels whilst keeping the neck width and underarm bind off the original length, the shoulder lines would be affected. Therefore to keep the shoulder lines the correct length and equal with each other front and back, width must be varied solely below the underarm bind off. On the back, this was to be achieved by inserting 2cm into each of the two vertical lower back darts and to gradually remove this width throughout the length of the lower part of the garment, so that the back bust and back width remained the original measurement.

It was observed during both professional evaluations that on the front of Desdemona 2 the grid distorted laterally slightly on the ninth grid up from the hem and that the centre front hem peaked. It had been learned through the experiences with the Juliet series that this peaking could be affected by adjusting the flèchage. In this case it was caused by less rows of flèchage being knitted for a smaller bra cup size (Desdemona had an A cup and Juliet a B cup), therefore the centre front length was not as significantly different to the side seam length as had been the case in the Juliet garments, and consequently there was a less pronounced curvature of the hem. Three solutions were proposed to this; to knit the front slightly longer than the back, to include front vertical narrowing darts, or to knit additional symmetrical flèchage ‘wedges’ at each side immediately after the welt to increase the length at centre front.
and curve the hem even more. (Figure 12)

The first solution was rejected as this was found to produce side seams of different length to the back. In the second proposed solution, if the darts finished at the seventeenth grid from the hem they could at the same time address the slight tightness observed on the upper side front. Positioning the darts directly below the apex of the bust would place them on the central front of the stomach, but if they were offset to under the apex of the flèchage darts they would augment the curve of the hem, thus alleviating the peaking at centre front. The front dart requirement was assessed on the participant, during which it was found that the hem needed to be widened by 6cm, however the prominence at front did not occur until the ninth grid from the hem, therefore the extra fabric should remain constant until that level. This would create drape at the hem underneath the frontal prominence. To commence with a narrower hem and increase for the prominence would be unflattering, particularly from the side view, as the fabric would pull in under the prominence, drawing undesirable attention to it. Professional evaluation by the research of the garment on the participant led to the dart being assessed as slightly shorter than that defined on the clone, which meant that the dart would now narrow smoothly from 3cm wide at the end of the ninth grid to nothing by the end of the fifteenth grid. (Figure 13) The darts were achieved on the stomach area to by symmetric mid course 3D wale shaping. The third solution was reserved in the event that even more curvature would be required on the front hem. At the body hem, the participant expressed a preference for a similar depth to that at the cuff, and it was decided that this revision would not only meet the needs of the participant, but also add weight to the hem, encouraging the lower garment to drape well. Evaluation on the clone had shown the back neck to be quite low, but this was based on her preference for collars to lie below or away from the quite pronounced
Figure 12. Evaluation photographs of Desdemona 2 on the clone and Desdemona herself. This side view on the clone illustrates the smooth fall of the fabric over the upper back, the peaking at centre front hem and the position up to which the proposed darts will contribute extra fabric. The latter two alterations can clearly be seen to be necessary in the right hand photograph of the garment worn by the participant. (ORIGINAL IN COLOUR)
Figure 13. Evaluation photographs of frontal views of Desdemona 2 on the clone and on Desdemona herself. On the left: the garment on the clone, with the proposed darts and the new bust dart positions indicated. On the right: the garment on the participant. When worn the garment displays some distortion of the grid on the right stomach area. (ORIGINAL IN COLOUR)
curve at upper spine/lower neck. This was left for further evaluation pending the
participant’s assessment. When asked about the neck, she observed that when she
leaned forward the front neck was too high and she felt constrained by this however
the neck width and the back neck depth were assessed by her as, “just right”. The
neckline on Desdemona 3 was accordingly dropped by one grid during the re-making
of the garment. (Figure 14)

The bust area also required adjustment. The researcher had observed during
professional evaluation on both the clone and the participant that the darts were too
high. (Figure 15) Their position was assessed and the darts were dropped by the
resulting 3 grids (6cm) on Desdemona 3, making them 30cm from the side neck point.
Although the bust point remained consistently placed, the bust darts were shortened to
compensate for the overall narrowing of the front piece. Desdemona had a small bra
cup, and the darts had been constructed accordingly, however more 3D shape was
desirable. Therefore in order to accentuate the hem curve, as discussed earlier, by
providing 2cm (¼”) more length at centre front, as well as additional 3D shape at the
bust, it was calculated that it was necessary to add 2cm) in the form of 18 course depth
to the horizontal darts.

The back armhole on each side displayed a fold of fabric under the arm indicating that
there was too much fabric gathering at this point. Rasband’s advice is that loose
diagonal wrinkles, as were displayed here, indicate that a garment is, ‘too long and too
wide for the body contour above it’.409 (Figure 16) When re-drafting the Desdemona
3 schemata, the horizontal underarm back dart was increased in depth by 1cm, and its
length was adjusted to 18cm on the newly widened back panel. The folds also
suggested that some width could be removed from the upper back, and as there was no

409 Rasband and Liechty.62-63.
Figure 14. Evaluation photograph of Desdemona 2 on the clone, illustrating the deep back neck drop preferred by the participant. (ORIGINAL IN COLOUR)
Figure 15. Evaluation photograph of the right bust dart on Desdemona 2 worn by the participant. The top image illustrates the bust dart with the incorrect apex circled, and the corrected position indicated. The bottom image shows the proposed deepened bust dart continuing into the back underarm dart. (ORIGINAL IN COLOUR)
Figure 16. Evaluation photographs of Desdemona 2 on Desdemona. The top image shows the back at underarms displaying the diagonal fold which indicated that the garment was too loose and wide below the curve of the upper back. The bottom image shows the same view after half a centimetre had been removed from the sides of the upper back section, and the sleeve head had been shortened. The mild diagonal wrinkles still visible below the underarm would be addressed by increasing the depth of the underarm back darts. (ORIGINAL IN COLOUR)
distortion of the grid on the upper back, it was decided that 0.5cm (¼”), could be
removed at each side by edge shaping to continue the dart’s affect further up the back
armhole. It has been noted elsewhere that no adjustment could be made in isolation,
and this alteration had to be viewed in conjunction with those proposed to the shoulder
line and sleeves, as are now to be discussed. The shoulder line had been narrowed
with stitch transfer rather than being bound off. The narrowing created a tight
shoulder line which in turn drew the sleeve head into an inverted ‘V’, distorting its
shape. (Figure 17)

This effect was most prominent on the right shoulder but visible on both, therefore
on Desdemona 3 this was altered so that the shoulder seams were bound off. With
suitable machinery with sinker capabilities, it was recognised that using flèchage
shaping followed by binding off across all stitches, a smoother and more discreet seam
could have been created. However the shoulder angle was found to be too steep for the
machinery available to this research to knit successfully in this manner.

When evaluating the sleeves, a number of points of ill-fit were observed. These were
that the sleeves were both too long, there was stitch extension and grid distortion
across the sleeve head and chest when the arm was raised, and the sleeves were too
wide overall. (Figure 18)

Desdemona’s preferred sleeve length was to her watch strap (60cm) whereas the
standard sleeve length as defined by Rasband is taken to the wrist bone, (63cm), it was
considered probable however that once the sleeve was narrowed it would shorten
slightly in wear.410 The method of evaluation of sleeve head fit was that suggested by
Myers Mc Devitt of lifting the arm and checking for pulling on upper arm and chest,
and the observed stitch extension and grid distortion demonstrated that the sleeve head

410 Rasband and Liechty.70.
Figure 17. Evaluation photograph of Desdemona 2 worn by the participant. This shows the inverted 'V' created on the sleeve head by the tight shoulder seam. (ORIGINAL IN COLOUR)
Figure 18. Evaluation photograph of the left sleeve of Desdemona 2 worn by the participant. The two top images demonstrate the wrinkles and pulls causing grid deformation that indicate that the sleeve head is too high and narrow. They also show the excess width in the sleeve below the underarm. Both bottom views show the effect of shortening the sleevehead in conjunction with re-shaping the upper chest and back. (ORIGINAL IN COLOUR)
was too long, and too narrow. Therefore, based on the alteration requirements recorded during the evaluation, the sleeve head on Desdemona 3 was shortened by one grid (2cm) and widened to 5 grids (10cm) at its maximum width. Overall the sleeve length was reduced by 5cm below the underarm, and the width was reduced by 2cm above (to allow for her fuller biceps) and 6cm below the elbow. This was based on evaluation and on the allowance of a small amount of ease as suggested by Myers McDevitt. The cuff was adjusted to match the new hem depth.

Whilst re-working the right hand sleeve of the Desdemona 3 garment, (file name: desdemona3asleevegridded.dat and machine file: ds3ars.000) an example of the clash of knitting rules versus the aesthetics of the garment shape and design was encountered. This occurred when, in response to the evaluation of Desdemona 2, and in order to shape the sleeve head to follow the body contour as it curved from the front of the shoulder point over the shoulder point to the back shoulder, a new shape had to be drawn and calculated for the sleeve head which required abrupt shaping.

Narrowing the fabric when knitting is generally carried out in even sequences, indeed most processes in knitting are best kept to even sequences due to the reciprocating movement of the yarn and cam box. The solution chosen to improve the fit of the sleeve head had been, as described earlier, to widen and shorten the sleeve head and create a more rounded shape, maintaining width further up the sleeve head, particularly at the front. This however caused the diagonals and curves to be more complex, following a gentle ‘S’ shape, which in turn had an impact on the knitting processes as described here.

In order to knit this ‘S’ curve, it was necessary to narrow the lower curves in an

---

412 Myers McDevitt.243.
irregular sequence, and at the top to bind-off along the sleeve head in a series of small steps. This was because in order to maintain safe knitting the maximum narrow is two stitches every two rows and at the top the shaping was too abrupt to be achievable by this sequence of narrowing alone and required larger blocks of stitches to be bound off every two rows.

These adjustments contributed to the refined fit of the Desdemona 3 garment, which was evaluated on the participant and the clone, and is discussed in detail in Chapter Five.

4.9 Conclusion

Through the application of the practical research framework, developed from the research idea and its themes and practice, a technical design process for the development of knitwear for larger body shape, which ran parallel with that of industrial practice, was created.

Development of the design process followed the identification and recruitment of participants of suitable body shapes as discussed in Chapter Two. Working closely with these body shape examples and the individual features found in these body shapes, the design process enabled the development of digital template schemata of the processes of applying 3D shaping within the proprietary software of the knitting system. The common visual technical knit language of knit structures in which these templates were developed made them highly transferable, with potential for commercial development.

Contributory to developing the templates was the exploration of the application of ease both within the digital design methods and on the body.

The investigation of which knitting methods were best used to create 3D shape
within a garment in order to match 3D larger body shape was part of the design process. Based on the tailoring concept of godets and gores (termed darting in this research and discussed in detail in Chapter Three, section 3.5.3) these knitting methods were established to be flèchage for bust, back and hem shaping, and wale transfer for shoulder darting and lower torso shaping.

The body area that was identified by other experts to most influence satisfactory fit was the shoulder area therefore this was selected as the starting point for developing knitting methods. Early relationships between body measurements, body shape and knitting in this area showed discrepancies existed between standard sizes and those of the participant’s body shapes. The main discrepancy found was that standard sizes assumed a smaller difference between shoulder width and front bust arc or total bust girth. A garment made to the standard measurements would have fallen off the shoulder point of the participant. This resulted in the development of a new armhole shape for larger sized knitwear and the narrowing was augmented by wale shaping between bust and shoulder. Horizontal reciprocating flèchage darts particularly suitable for the larger body shape were developed which added 3D shape to the bust area and if necessary could do the same at the upper back.

These two main knitting methods, themselves variable, offered a flexible fit to accommodate larger differences between bust girth and shoulder width than is normally assumed in sizing for standard body shape. At the same time the combination of these knitting methods gave 3D shape to the upper chest and back shoulder area which accommodated the rounded shoulders and stooped posture found in the participants body shapes.

Frontal stomach prominence was the second key area for developing 3D shaping for improved fit. Larger body shape in this research was defined to include a rounded
stomach. To prevent the knitting stretching over this area, 3D shape was developed through suppression darts that narrowed towards the natural waist (E2). These release fabric where it was required but defined the narrowest point of the torso (E2), giving shape and fit without fabric-body collision.

A positive effect of the combination of wale shaping and horizontal bust darts was found to be a curved hem, which gave additional length to travel over the front stomach prominence, whilst shortening the side seam to prevent drooping.

Through anticipating and resolving the issues described and discussed in this chapter this research developed prototype garments which challenged the poor quality of existing fit of commercial knitwear for larger sized women.
5 Evaluation of fit of knitwear designed for larger female body shapes through the innovative application of 3D shaping

5.1 Introduction

On average it took four major re-iterations of partial and completed garments to achieve a successful outcome for each participant. The Juliet and Desdemona series of garments were evaluated three times each respectively. The final assessment of the Desdemona 3 garment was carried out solely on the clone, due to weight loss of the participant during the period of the research project.

5.2 Evaluation of the research garments

Each re-iteration of the knitwear made for the participants’ larger body shape was assessed by the participant as wearer, with the exceptions of the Desdemona 3 (see section 5.2.3.2. and Portia 5 (see section 5.3) garments, and all were professionally evaluated by the researcher. All evaluations were recorded in still photographs and those involving the participants were also filmed. Participants were requested to complete evaluation forms and encouraged to give verbal feedback, primarily about the garment’s comfort and fit. (See Appendix E for example evaluation form)

5.2.1 Drape characteristics are influenced by complex interactions

When evaluating the garments, as discussed earlier, visual methods predominated. These observations considered the complex interactions of varying factors that affected the drape of the fabric as well as the garment’s overall fit. The drape and appearance of the knitting could be affected by individual stitch behaviours and stitch and row interactions such as slippage and extension and also by the overall weight, thickness and bending of the fabric as a whole. Because the knitting was consistent in yarn weight, colour, stitch quality and structure, many of the problems associated with assessing drape across different fabrics (as discussed by experts including Kenkare
and Griffiths), who explored visual evaluation of fabric, were not even encountered.  

Branson described fabric drape as its, ‘...ability to hang freely in graceful folds when some areas of it is supported over a surface and the rest is unsupported’.  

Drape may also be evaluated mathematically as described by Kenkare, but its visual evaluation, as used in this research, observed whether the knitting hung freely and folded gently rather than extending and distorting the stitches and rows when it passed over a protuberance.

In order to evaluate drape, stretch, fabric-to-body collision, grid distortion and satisfactory elements in the garments, a procedural list was created based on sources including Myers Mc Devitt Davis and Rasband.  

5.2.2 Juliet – the pilot study

Juliet was selected as a participant with a Type C-D body shape as discussed in Chapter Two, section 2.4.2.1. A Type C-D body shape category had been defined in this research as ‘wide hips and round tummy’ together with narrower shoulders. (See Appendix E, survey images) Her comments that, ‘All my family have large waists’, and, ‘...my waist is very high...but my bust is small’, made during interview (see video in exhibition) contributed to this classification. Juliet’s posture had been established to be Type P2 with a rounded stomach and a mild kyphotic curve in the upper back, but also with a tendency for her upper body to lean backwards (posture type P3).

The first evaluation of the Juliet series of knitwear was of a garment piece testing

---

technical flèchage issues on Juliet’s clone knitted from the machine file: min93.000, which was found to be too wide on the chest and shoulders. This was re-designed as the first front panel (template: bil2dev22a.dat, machine file: bil22.000), and re-evaluated on the clone, which demonstrated that the bust darts were too high by 2cm and the shoulders possible still too wide. To accurately assess this, the piece was joined at the shoulder seam to the first back piece (machine file: back1.000), which highlighted that the lower body was too wide. It was also demonstrated that the back hem ‘peaked’ outwards.

In order to fully evaluate these pieces, and before revising the templates and machine files and re-knitting them, the neck was cut to shape and the right sleeve was knitted and linked into the armhole, then the part completed garment was re-evaluated. Following this procedure, it was considered that the inclusion of underarm darts on the back panel would shorten the side seams and prevent them drooping and forcing the centre back upwards, thus reducing the peaking of the hem, whilst both body panels required narrowing by 1cm each side all the way down to the hem. On the shoulders the right hand sleeve head was too high, and had to be re-set in to fit correctly. However, when done symmetrically this stretched the grid over the upper back. Therefore it was decided that the back sleeve would require asymmetrical shaping to alleviate this in the next iteration. The shoulder seams were re-shaped into a sharper angle, which together with the underarm dart improved the set of the sleeve, and the fit of the shoulder and front chest. (Figure 1) (See Appendix D photographs and exhibition).

Revisions from the evaluation included: two grids should be added to the length so
Figure 1. Photographs of early evaluations leading to Juliet 1 garment. Top left to right: on left - detail of revised armhole/upper chest shape, on right - shoulder line alteration. Bottom left to right: on left - front and back showing underarm back dart and revised front dart, on right - sleeve inserted, the body hangs straighter and bust darts lie horizontal. November 2005-January 2006. (ORIGINAL IN COLOUR)
that it finished lower (not on the most prominent posterior point), the body would
be narrowed, the bust darts were to be raised by 2cm, and the shoulder points dropped
by half a grid (1cm), which meant that the shoulder line would need to be adjusted
accordingly. The sleeve head would be revised as discussed.

These revisions resulted in the Juliet 2 garment, knitted from templates bil22.dat
and bil2dev22astrp12.dat (machine file names: 10206f.000 1026b.000 and
1026slv.000 respectively). (See Appendix B for bil2dev22astrp12 template)

5.2.2.1 Evaluation of Juliet 2

Juliet 2 was evaluated on Juliet’s clone. It was noted that the bust darts were well
positioned; the point of the bust dart lay just outside the bust point and released fabric
to smoothly match the curve of the bust, without stretching the stitches. At underarm,
the removal of excess fabric through flèchage allowed the armhole to settle into the
negative space of the axilla (armpit). This in turn (and in conjunction with the length
removed by the back dart flèchage), affected the side seam, which fell to the same
level as the centre front and did not droop.

The upper front chest curve was moulded smoothly by the top vertical darts and the
bust darts. This effect was noticed in both the horizontal and vertical planes of the
chest area. In conjunction with the flèchage on the bust, and the extended underarm
bind off, the vertical darts effectively create the complex 3D shape that occurs where
the upper bust, lower chest and underarm of the body converge. It was also clear that
the fullness of the fabric at the apex of the bust, retained strategically in this position
by both sets of upper vertical and bust darts, was referred down the front fall of the
garment, and draped across the under bust/upper stomach ‘padding’ on Juliet’s torso
without clinging. (Figure 2)
Figure 2. The evaluation of Juliet 2. Top left: the complex 3D shape achieved with bust and shoulder darts in combination with long extended underarm bind offs. Right: the side seams hang level with the centre front length. Bottom left: the rolling hem and cling of the knitting on the stomach. Right: the back underarm and vertical darts fit the garment to the back width and shoulder without excess fabric gathering at underarm. (ORIGINAL IN COLOUR)
The hem was however, still not lying flat, and although not peaking as before, it was rolling up, and clearly required revision. It was also observed that the front collided with the body around the tummy point. To eliminate this it was decided to insert a short vertical inverted dart, narrowing from the hem to just before the apex of the protruding curve. It was considered this would also encourage the back hem to fall without cupping the buttocks. A note was made that front darts might need to be incorporated in the main study garments. It was mooted that adding length overall to the garment could provide enough weight to the fabric so that it would drape over the tummy prominence rather than curling under it and terminating at an unflattering position. This would present a less time consuming solution, whilst also being one which would positively translate into industrial situations. On the back, the vertical lower body darts in combination with the back underarm flèchage dart eliminated excess fabric width under the arms. It was observed however that the back was not draping well overall and that the horizontal grid lines were distorted into an ‘M’ across the upper back. This was because the mild kyphotic curve of Juliet’s thoracic spine not only disturbed the vertical plane but also contributed to a lateral convex curve in the same area. In order to address this 3D shape in the upper back, the distortion of the grid clearly demonstrated that length must be added in the centre of the fabric field in some way.

Fitting solutions for these observed problem areas included creating a sharper angled back shoulder line by dropping the shoulder point and raising the neck point up to a total of 4cm overall. Another solution was to shorten the shoulder darts, reducing them from 10cm to 6cm which would retain width higher up the upper back. In addition the back neck could be lowered by 1cm, which would allow the neckline to lie under the back neck/upper back curve rather than ride over it. The final solution
was to insert two lower front darts as described earlier. The ability to not only recognise the possible solutions, but to put them into practice, relied on the combination of skills as researcher, designer and knitting technologist that were core to the practical success of this research.

These revisions were incorporated into a new drafting of the back shape, and this revised back was incorporated into a striped and styled version of Juliet 2 which was knitted for exhibition in Australia. (Figure 3) The garment (‘Australia’) was evaluated on the participant before sending, and her feedback, the video of which can be seen in full in the accompanying exhibition, included:

“Its loose on the body”

“Its too tight on the sleeves, the cuffs are tight, but it might be the ribbing?”

“I would wear this jumper, its soft on my skin”.

“I like looser clothes, but this is comfortable”.

“It feels like I haven’t got in on, almost”.

“There’s plenty of room everywhere, it doesn’t pull anywhere” (when asked to raise and move her arms).

“Make me one please”.

The professional evaluation of the striped garment concluded that there was some gathering on the sleeve head and a slight distortion of the stripes at the underarm when she moved, but these were not apparent in repose. Disappointingly the bust darts were still too high, and would need to be dropped by another 3cm. The upper back ‘M’ distortion of the grid had been resolved, (the back panel had been revised and re-knitted as discussed beforehand for this iteration of the garment). There was
Figure 3. Coloured striped fully fashioned garment that does not rely on stretch to fit. Knitted using the original research size and shape template from the pilot study. Exhibited in 'Blurring the Boundaries', Sydney, Australia, June-September 2005. (ORIGINAL IN COLOUR)
no obvious distortion of the stripes or grid through collision with the body shape underneath. This evaluation contributed to the revised Juliet 3 garment as is discussed next.

### 5.2.2.2 Evaluation of Juliet 3

Juliet 3 was evaluated on the clone and then on, and by, the participant, which is the assessment discussed here. (See Appendix D for evaluation photographs). Juliet found the new cuff and sleeve comfortable, although the sleeves were slightly too short. This was attributed to be an effect of the combination of the new shoulder line and the re-shaping of the sleeve head. She also thought that the left hand sleeve head felt a bit bulky, this was found to be due the construction technique on this side, and it was later reset in the armhole with a more satisfactory result.

The bust darts were once again too high and would need to be lowered by 3.5cm. Although they had been lowered for this garment, this was before the upper chest was shortened and the compensation had been lost whilst shortening the upper chest. The effect of these revisions had been overlooked and the bust darts were not subsequently re-positioned accordingly. This example clearly demonstrates how even minor adjustments can have a domino effect throughout the garment due to the inter-relationships of bodily dimensions.

Juliet’s assessment of the hemline was, “it curls up at bottom, not sure if I like this”, and, “it makes it look cheap.” Clearly the rib needed further revision, and a tubular welt was considered a better future option in order to keep the hem narrow. A deeper rib would not roll, but deep ribs are not aesthetically desirable under a prominent stomach as they draw in and emphasise this prominence.

Her observation about the underarm fit was that, “it doesn’t pull at all even with
my arm full extended upwards”. Unfortunately she found the sleeve and cuff to be an, 
“...irritating length on both sides. If it [sleeve] was longer it would fit fine on the 
wrists, but the cuff is fine.” When measured, the sleeves were found to be 6cm higher 
than her wrist bone when her arm was bent, (this is the method recommended by 
Rasband for measuring sleeve length).416

It was clear that Juliet’s evaluation, especially of fit during movement, provided 
positive feedback that the garment was already offering improved fit and comfort. It 
was considered that after the revisions highlighted in this section, the garment could 
offer significantly enhanced fit to Juliet.

5.2.2.3 Evaluation of Juliet 4
This took place at Juliet’s home as she was very busy at the time, but this was 
however viewed as an opportunity for her to experience the garment during everyday 
activities. 

Juliet 4 was worked with revised tubular welts rather than ribbing at the hem, 6cm 
longer sleeves and lowered bust darts as discussed earlier. This evaluation was not 
filmed due to technical problems.

Juliet’s assessment was that the bust darts were now in the right place. The sleeve 
head was smooth on the shoulders and the longer length meant that the wrist was 
comfortable. She preferred the new hem, and liked the fact that it didn’t curl up.

Overall she found the fit and comfort improvement commensurate with the points she 
had noted during previous evaluations. (See Appendix D for evaluation photographs)

Professional evaluation found the bust darts to be in the correct position and the 
sleeves to now be a satisfactory length and no fabric-to-body collision or distortion of

416 Rasband and Liechty.61.
the grid was visible. The tubular welt hem presented a successful solution to the hemline, which now lay flat and straight. At the neck there was no binding or pulling at the front during movement and the back did not ride up. Wrinkles that were apparent during movement relaxed back into acceptable wearing wrinkles and did not present as fitting problems.

The researcher’s growing understandings of larger body shape and the developments of knitting techniques and methods that had been achieved whilst working with Juliet throughout the pilot study were employed in the main study garments which are discussed next.

5.2.3 Desdemona

5.2.3.1 Evaluation of Desdemona 2

Desdemona’s body shape fell between the D and E types as shown in the research survey images. (See Appendix E) A Type D body shape had a wide waist and a round tummy, but as Desdemona also had no clearly defined waist shape this indicated a tendency towards a Type E. Posturally, Desdemona had an upright stance, with a tendency to lordosis and with a significant protrusion at the top of her spine.

The evaluation of this garment has been discussed thoroughly in Chapter Four, section 4.8., as an example of the research design practice and process, and to demonstrate the researcher’s growing understanding of larger body shape in relationship to knitwear design. This initial garment of the Desdemona series had some knitting imperfections, but as these were cosmetic and did not affect the behaviour of the garment, they were not rectified before this evaluation. Primary evaluation was supplemented by a secondary visual and discursive assessment with a second person experienced in knitwear construction. Evaluation and resulting revisions have already been discussed, however is should be noted that during the
evaluation the grid highlighted how the knitted courses curved evenly over the convexity of the upper back without stretch, fitting smoothly into the rear of the armhole, thus demonstrating the 3D shape being created by the vertical darting on the shoulders working in combination with the underarm flèchage.

Similarly, observations of the slight distortion of front abdomen grids concluded that this effect may have been referring from the back panel. This conclusion was based on how, when the garment was repeatedly and randomly extended and released to relax into the fabric’s natural position, it draped in a fuller, (but still not totally satisfactory) manner over the abdomen, whilst the back ‘bound’ on the buttocks. To rectify this effect, the back width was adjusted as described earlier to allow the front to drape in its natural inclination.

Sleeve evaluation on the clones of both Juliet and Desdemona had proved repeatedly to be unsatisfactory and were found to be far more effective on the participant.

5.2.3.2 Evaluation of Desdemona 3

Between the body scan, the preceding evaluation and this session, Desdemona lost thirty two pounds in weight, thus making evaluation on the participant unreliable. However it was decided to use this session mainly to refine the sleeve head but to otherwise continue to work with Desdemona’s body scan measurements and clone. Future lower body revisions were based on evaluations on the clone.

On the clone the garment was successful on the torso at stomach, hips and buttocks. The hem at front and back lay horizontal whilst the horizontal underarm darts prevented drooping at the underarm and the resultant horizontal folds that had been occurring here on Desdemona 2. By fitting to the curve of the upper back, as
noted earlier on Desdemona 2, the upper vertical darts led the upper back smoothly into the shoulder line, whilst narrowing of the upper shoulder area. This meant that the body panel did not hang over the shoulder point onto the upper arm.

The shoulder seam matched the horizontal length of the shoulder line and lay at the corresponding angle. There was no visible stretching or waving of the seam line and it did not extend past the shoulder point.

At the front of the sleeve head, ‘peaking’ was observed at the top of the narrowing and the back sleeve head displayed puckering and vertical and horizontal folds. The right hand sleeve also appeared too small for the armhole, but once re-set in, with the centre point of the sleeve head being taken as the centre of the flat part of the sleeve head and married to the shoulder seam, the sleeve fitted smoothly into the armhole. (Figure 4) This in turn led to the underarm easing into the curve of the armhole neatly. The sleeve was then reviewed on the participant because as already noted, sleeves are difficult to evaluate on the clones. During this subsequent evaluation, the sleeve was still found to ‘peak’, but this now occurred slightly lower down the armhole. To resolve this it was decided to edge-shape a slight inward curve into the body panel at this strategic point and to add the same amount onto the sleeve head width in compensation.

The front bust dart was observed to now lie slightly low. It had been too high on Desdemona 2 and had been lowered by 2cm, which should have brought it to 30cm down from the side neck point, however in reality this measured 33cm. It was found, on reviewing the technical notes that this had been caused by a miscalculation in the garment drafting and was rectified in Desdemona 4 as discussed below. (See Appendix D, research diary page)
Figure 4. Desdemona 3 sleevehead evaluation. On the left is the sleeve before aligning the centre of the flat sleevehead with the shoulder seam. On the right is the re-set sleeve. (ORIGINAL IN COLOUR)
This evaluation was primarily to assess the revisions prompted by the evaluation of Desdemona 3 on both the clone and the participant. Due to Desdemona’s weight loss, as discussed earlier the main revisions were to the sleeve head and armhole shape, and a shortened test sleeve was knitted to evaluate the sleeve head. The new sleeve head and armhole were observed to follow the curve of the armscye more closely, thus eliminating the puckering and folds at the side.

It was considered that the Desdemona 4 garment successfully displayed a deepening of the understanding of larger body shape and its relationship to the fit of knitwear. The inclusion of 3D wale shaped vertical darts on both front and back provided radial ease to accommodate a high, rounded stomach without stretching, and without ‘oversizing’ the garment at the bust or shoulders. Carefully balanced length, depth and placement of both horizontal flèchage and vertical 3D wale shaped shoulder darts in combination with refined armhole shaping created a complex 3D shape in the underarm convergence of upper chest, upper back and axilla, which followed the body shape without stretch or distortion of the knitting. Hem revisions produced a satisfactory welt without compression suitable for larger sizes.

Updates in the knitting software, as discussed earlier, had caused some re-working of schemata but benefited the research process long-term. During the development of this series of garments a method for designing and producing larger sized knitwear using the Shima Seiki SDS®-ONE automatic system was established, which also incorporated specialised methods at significant points in the process. The Desdemona series had been developed using mainly manual measurements, although body scanning was adopted during this time and Desdemona 3 and 4 were to some extent informed by this.
5.2.4 Portia

Portia was the third and final participant. Her body shape category as defined in this research was a Type C, with wide hips and a rounded stomach, whilst her posture was classified as Type P2. This classification indicated that she had significantly rounded shoulders with her head held in front of her body. In particular contrast to the other two participants, Portia had a larger bra cup size than Desdemona and a more defined waist than either Juliet or Desdemona. Portia also had a lower stomach prominence than Desdemona, as can be particularly seen in the following figure. (Figure 5)

5.2.4.1 Uneven shoulders

A feature of body shape which became important when developing the Portia series of garments was the participant’s uneven shoulder line. This imbalance can be seen in her body scan and is reflected in the electronic measurements taken from this and was discussed in evaluations as will be shown later on. (Figure 6) Her right shoulder between neck point and shoulder point was shown to be 1.33cm longer than her left, and her right shoulder point was 1.25cm lower relative to the floor. This was also demonstrated in the shoulder point to waist measurement. (Table 1)

<table>
<thead>
<tr>
<th>Portia’s shoulder related body scan measurements in centimetres</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Shoulder slope left</td>
<td>3.53</td>
<td>Shoulder slope right</td>
</tr>
<tr>
<td>Shoulder height left</td>
<td>141.89</td>
<td>Shoulder height right</td>
</tr>
<tr>
<td>Shoulder length left</td>
<td>13.51</td>
<td>Shoulder length right</td>
</tr>
<tr>
<td>Shoulder to waist front left</td>
<td>48.97</td>
<td>Shoulder to waist front right</td>
</tr>
<tr>
<td>Shoulder to waist back left</td>
<td>46.28</td>
<td>Shoulder to waist back right</td>
</tr>
</tbody>
</table>

Table 1. Table of shoulder related measurements generated with the research mep file from Portia’s body scan. The differences between left and right shoulder can clearly be seen and are coloured to correspond to those marking Portia’s shoulder line in the preceding figure. (ORIGINAL IN COLOUR)
Figure 5. The three participants: Portia, Desdemona and Juliet, these photographs show the differences in their body shapes. Portia has a lower stomach and bust line, but a larger bra cup than Desdemona. Juliet has a distinct kyphotic rounding of the upper back, but less of a lordotic curve than Desdemona. Portia's upper back although not rounded vertically has a distinct forward thrust of her shoulders creating a lateral curve across her upper back and causing her stance to be slightly forward, which in turn causes her buttocks to jut out slightly. Juliet has a less prominent upper stomach and more of an indented waist than either of the other two when viewed from the side. Desdemona has a pronounced prominence to the rear which is higher on her body than that of Portia, and Juliet has flatter buttocks, but her stance is such that she carries her hips forwards and leans back slightly. (ORIGINAL IN COLOUR)
Figure 6. Frontal plane 'skinned' image of the data generated from Portia's 3D body scan. The lines have been added to highlight her asymmetrical shoulder line and postural lean to her right. The colours correspond to those used in the table of Portia's shoulder related measurements. (ORIGINAL IN COLOUR)
5.2.4.2 Portia 4a; a refined development process

In order to capture this asymmetry in the garment, and also to evaluate a different method of developing shapes for larger sizes, a new method was developed for the Portia garment. This was to draft a 2D base pattern in the Shima Seiki PGM (pattern making) software, and to then bring this base shape into SPaint for further development through the same process as that described earlier. (Figure 7)

This was the final evaluation of a research garment with a participant. The methods and solutions developed during designing, making and evaluating the first two garment series, Juliet and Desdemona, were tested in this garment and its evaluation would be the final piece of empirical research. The evaluation session took place over six months after completion of the garment for the following reasons: a break in study due to personal issues and the busy lifestyle of the participant in combination with her new circumstances. During the period between 3D body scanned and final evaluation, the participant reported weight loss of approximately a stone (6.5kg) and an overall toning of her body shape, so it was possible the garment would be too large for her on evaluation, however it still required assessment. The original intention had been to design Portia’s garment solely from body scan measurements and point cloud images, and only to use manual measurements where the body scan could not provide this information. For example the armscye and chest measurements are difficult as the arms can obscure the underarm area of the body, in which case manual measuring can give a more accurate result. Because the original plan had been to test the success of this process, a re-iteration of the garment following the evaluation was not envisaged. This was however revised due to a combination of the problems associated with evaluation once Portia’s body shape had changed and Shima Seiki Europe’s generous agreement to knit a ‘proof of concept’
Figure 7. Screenshot of the base pattern drafted in PGM which was developed into the Portia 4a garment. This front panel of the garment at an early stage, prior to template development, shows Portia's uneven shoulders and the adjustments made to the garment shape to accommodate this feature of her body shape. (ORIGINAL IN COLOUR)
garment for the research, which is described in sections 5.3, and 5.4 of this chapter.

5.2.4.3 Evaluation of Portia 4a

On first impressions it was obvious that the participant had lost weight and toned her shape. She stated that she had been lightest about a year before and was putting some weight back on now, but considered herself a similar overall shape apart from her tummy, which had shrunk.

On donning the garment her first reaction was, “It feels very nice”, followed by, “I’ve lost weight on my tummy, but not up here”, indicating her bust and chest. As in the other evaluation sessions there was no mirror in the room, but Portia wanted to visually assess the garment as she found it hard to do so without seeing herself. Her initial reaction was that the garment was fitting comfortably and to her visual satisfaction,

“…on balance it works really well, its been a bit thrown because I’ve lost weight, but the bit that works really well is the top bit here (gestures across front chest and bust), its really comfortable all around the neck and bust and that really works well”.

She continued, “The sleeves are good, they’re very comfortable, they’re just too long”. (Figure 8)

Portia had quite pronounced asymmetrical shoulders, as discussed earlier, and she commented on this during the evaluation, saying, “I am slightly lopsided…necklaces always roll to one side on me”. This was taken into account in the garment construction, and she expressed particular satisfaction with the fit on the shoulders because of her problems with this in standard sized garments.

The professional evaluation was that the right hand sleeve fitted better than the left. The left displayed diagonally radiating wrinkles from the upper armhole down over the bicep, which indicated that there was too much fabric in the upper sleeve. From
Figure 8. Portia 4a, the sleeves were too long. This image is marked with the proposed revised sleeve length which is 1.5 grids plus the welt (5cm) shorter. (ORIGINAL IN COLOUR)
the back, these folds were not so apparent, which in turn indicated that the excess fabric was in the front of the sleeve. This was recognised as being caused by the shoulder seam being too long in combination with the single angle, diagonal shaping of the sleeve, which resulted in the upper sleeve being wider than necessary. Portia's biceps were not large in relation to her lower arm, for example her left bicep was only 3.68cm larger than her forearm, whereas Desdemona’s was 4.68cm larger. Split shaping, above and below the elbow, would have resulted in a closer fit of the upper sleeve. In the Shima Seiki SPaint garment software, upper and lower sleeve width can be varied along with the distance from the wrist at which this occurs. Because this was not the way in which this garment was programmed, it was not utilised as an automated construction option in this garment.

From the posterior view, when the arms were raised, the sleeve head travelled with the armhole without catching on the upper arm and the back armhole displayed no stretch or distortion of the grid, stitches or rows. Meanwhile the upper back area did not bind into the bra crease or strain the grid across the shoulders. It could be seen that the underarm area responded well to movement, the long bind off under the arm allowing the arms to rise without unduly straining the body or sleeve fabric. (Figure 9)

The neck and front upper chest were satisfactory to Portia; in fact she found them very comfortable and complimentary to her shape. The upper chest vertical 3D wale shaped darts and horizontal flèchage bust darts followed the body shape thereby eliminating excess fabric that causes convexity and wrinkling on the chest when the shoulders are held forward. Portia commented on this during the evaluation, saying, “It fits around the bust and it looks nice…That’s the most difficult part I think with jumpers…” She expanded this observation with, “…either they’re going to gape
Figure 9. Still image from Portia 4a evaluation. This shows how the upper back area develops movement wrinkles but does not distort the grid at the armholes. They move with the garment without undue wrinkles at the sleevehead. (ORIGINAL IN COLOUR)
when you lean forward, or there’s that sort of ‘tight’ thing”.

The professional evaluation concluded that the front bust moulded to the convex curve of the bust, but that the darts were low and missed the bust point by a vertical depth of one and a half grid squares (3cm). Although Portia had lost weight it was unlikely that her bust point had changed so drastically, therefore it was decided that they should be raised by 3cm. The decision was supported by the observation that the length and depth of the darts remained satisfactory despite Portia’s weight loss and that the bust area was working successfully with the body shape beneath. Moving the bust darts up would not add or remove length from the side seam, but merely transfer the equivalent dart rows to a new position 3cm further up underneath the arm.

Both shoulder seams were over-long and extended past the shoulder point by 4cm. The right hand sleeve head follows the curve of the arm hole, whilst the left one falls off the shoulder. Both shoulder shaping and sleeve heads had been altered to adapt to Portia’s uneven shoulder line, and this seemed to have been more successful on the right hand shoulder than on the left. Excess body panel fabric extended over the left shoulder point, which in turn caused the sleeve to lie incorrectly and drop down the arm at the shoulder point, causing folds as already discussed that radiated out from the shoulder point into the sleeve. In a tailored garment the sleeve head should sit on the shoulder point, however Portia found this comfortable. The relaxed quality of knitwear and the fact that she prefers looser clothing made this acceptable to her. However as the garment was now to be revised, this was noted as an alteration.

On the back of Portia’s right hand shoulder, the garment followed the curve of the armscye, whilst on the left hand side back wrinkling was observed close to the armhole. On the right hand side, vertical wrinkling started approximately on the scapula, and extended diagonally down the back, curving out over the right hand hip,
causing a slight flare in the hem, but not an actual fold. After analysis this was attributed to the lower back body panel being too wide. The vertical darting on the right hand shoulder was successfully controlling excess width in the shoulder area, but because the lower back panel was too wide and the back armhole bind off insufficiently long, excess fabric width was being referred upwards and outwards into a fold reaching to the beginning of the shoulder dart. This dart was equally successful in creating 3D shape on the shoulder, where it was clearly observed to contributing to improving the moulding of the right shoulder seam to the shoulder and upper back. (Figure 10)

Overall Portia found that the garment was too wide below the armhole. Folds were observed during the professional evaluation to run diagonally from bust to hip, which according to Rasband and Liechty signify that, “...a garment is both too long and too wide for the body contour above it”. These folds may have been partly caused by excess fabric present because of Portia’s weight loss, which as she noted, and had been observed by the researcher, was most noticeably in the stomach and abdomen area of the body. This proposed cause of the vertical folds and wrinkles was supported by the level of comfort experienced by the participant around the chest and bust and the lack of wrinkling around this area. When Portia moved around, movement wrinkles appeared in the body and sleeves, although the bust, shoulder and upper back remained consistently smooth. The majority of these upper movement wrinkles disappeared when she became still, whereas the lower sides of the garment fell back into the same pattern of droopy folds described above, signifying that they were fitting, not movement wrinkles. (Figure 11)

---

417 Rasband and Liechty.63.
Figure 10. Portia 4a, back view. The right shoulder fits the 3D body shape, but further down the back a fold developed at the level of the shoulder blade and extended down to the right hip.

(ORIGINAL IN COLOUR)
Figure 11. Still photographs extracted from the evaluation video. These illustrate the manner in which the bust area develops movement wrinkles, but returns to a smooth, 3D form-fitting shape. (ORIGINAL IN COLOUR)
Despite Portia’s weight loss, the lower front vertical darting was discreetly fitting the garment, making a softer and more flattering shape that allowed movement without binding and wrinkling. (Figure 12) These darts extended from above the stomach prominence to the negative space under the bust, successfully shaping the front, whilst releasing fabric further up the body to provide the fullness required at the apex of the bust darts. Because the shaping occurred above the most prominent point to front and back and shaping was applied radially (instead of being referred around to the side seam as with edge shaping), the darts simultaneously added gentle waist definition whilst preventing drooping at the side hems. Similarly, the back darts referred fabric to cover the swell of the buttocks in situ on the posterior of the body. No distortion of the grid through fabric-body collision was visible on or below the darts at the front and back prominences.

The hem line appeared to slope to one side in reality and in both video and still images. It was not however crooked when measured, and may have been affected by Portia’s posture. As discussed earlier, the body scan showed that Portia’s shoulders are not only lop sided but incline slightly to her right in comparison to her feet and her right hip has a slight inclination to the left, in other words she has a slight right sided lean to her frontal stance. The hem also ‘peaked’ at centre front, which was caused by the excess fabric as discussed earlier that referred from further up, particularly that under the arm at the side seam which was draping aggressively in an vertical line and forcing the extra fabric to move towards the centre front and back. In images extracted from the video, in which Portia had her arms raised, the hem lies straight which supports this theory, as the excess drooping fabric was being pulled up when she raised her arms. (Figure 13) Viewed from the side the garment fell smoothly over the abdomen and stomach, and did not collide with the body curves, or pull in
Figure 12. Still images from Portia 4a evaluation. On the right is the garment in stasis, and on the left in motion. Although Portia is smoothing the front down, this accentuates the shape achieved by the 3D wale shaped darts on the lower body of the garment which can be clearly seen at the sides. (ORIGINAL IN COLOUR)
Figure 13. Still image from the evaluation video of Portia 4a. This sideview shows how the hem lies straight when the arms were raised, which means there is excess fabric under the arm as if the hem was straight this movement would raise it in comparison to the centre front and back levels. (ORIGINAL IN COLOUR)
underneath. The grid was not distorted by the body shape beneath the knitting. Similarly on the buttocks, the garment draped over the curve and across the negative space under the buttocks without stretching, binding or colliding. In some of the evaluation movements, the garment caught in loose folds across the small of the back at the top of the buttock curve. This was attributed, in line with Rasband’s advice, to there being excess width, therefore reducing width would be the solution to this fitting problem.418 (Figure 14)

Overall a full evaluation proved difficult because of Portia’s weight loss, but a focused approach led to the following conclusions. Portia’s satisfaction with fit was largely based on the significant comfort she experienced on the shoulders, chest and bust, which she found a problem area in standard shaped garments because of her uneven shoulders. Visually she was pleased with the garment, but found the sleeves to be too long, and the lower body too wide, although both were comfortable. Obviously there was too much fabric in the lower body, but it was not clear whether this was totally due to reduced body size. After professional evaluation and as the upper garment provided satisfactory fit, it was concluded that any major revisions should be in the width of the lower body and sleeves as the fundamental shape of the upper garment conformed to Portia’s body shape.

5.3 Portia 5 – the proof of concept garment

As a result of the design development process of the Juliet and Desdemona series of garments the decision was made to test how successful it would be to translate 3D body scan data directly into knitwear using the templates developed through the research. Therefore no body clone was made of Portia and the first Portia garment was evaluated with no interim stages on or by the participant.

418 Rasband and Liechty.62-63.
Figure 14. Still images from the evaluation video of Portia 4a. On the left the fabric catches above the buttocks during movement and remains there until adjusted. Once freed on the right, the garment skims the buttocks smoothly without catching. This was attributed to there being excess width in the lower garment. (ORIGINAL IN COLOUR)
Portia 5, the final garment in the Portia series was designed using the refined research methods resulting from both the pilot study of Juliet, and that of Desdemona in the first main study. Following continuing interest and support throughout the research project, Shima Seiki Europe Ltd., generously offered to knit a ‘proof of concept’ garment on a 12 gauge SES/SSG type knitting machine at their UK headquarters in Castle Donington. This is discussed further in section 5.4 of this chapter. Therefore Portia 5, the concluding garment of the study, was knitted by Shima Seiki Europe Ltd., in ecru Cashwool 2/30s from the original research templates and machine files. In order to test the design further, they also produced a second identical garment in deep red Cashwool 2/30s yarn. (Figure 15)

This concluding garment, Portia 5, was not evaluated on the participant as her change in body shape through weight loss rendered this impossible. However, an exact replica body clone had been CNC milled from blown foam using her original 3D body scan data (translated via Solidworks software) on which the effect of the revised bust dart technique and fitting issues as discussed in section 5.2.4.3 can be seen. (Figure 16) (See also Appendix D)

A positive effect of the bust darting, particularly when applied in combination with vertical darting, was to shorten the side seams by the equivalent number of rows incorporated in the flèchage. Larger sized knitwear which accommodates lower body girths greater than that at the bust, and that did not have 3D bust shaping, had been observed to droop at the side seams. This was also seen to occur in knitwear in which the shoulder width exceeded that of the wearer. An example of a combination of
Figure 15. The Portia 5 proof-of-concept garment knitted by Shima Seiki Europe Ltd., in deep red Cashwool 2/30s and Bilorex stretch yarn. (ORIGINAL IN COLOUR)
Figure 16. Four views of the proof of concept garment knitted by Shima Seiki Europe Ltd., in July 2010. Shown on the Portia clone that was CNC milled from the participant's 3D body scan data. The garment exhibits an overall highly satisfactory fit, particularly in the drape achieved over the lower stomach. At the same time the bust and shoulder area demonstrate 3D shape, and the hem lies horizontal with no peaking at front or back. (ORIGINAL IN COLOUR)
These conditions is shown in the following figure. (Figure 17) It was of significance to this study that the accumulative effect of the 3D body shaping darting developed in this research eliminated such an effect by shortening the side seams whilst maintaining length at the centre front to pass over a prominent stomach. This ensured that the garment hung level at the hem. A recommendation for future development of this shaping, for more extreme differences in girths, was the inclusion of additional horizontal flèchage darts immediately above the hem welt. This would enable additional adjustments to the curve of the hem, and length of the side seams, without disturbing the bust shaping.

5.4 Conclusions about knitting for larger body shape based on the research knitwear toiles

The bust darting moulded the front vertical drop around the bust and there was no distortion to the grid, so although low, the bust darting was successful. Likewise the upper back and chest dart which accommodated Portia’s uneven shoulders has allowed the garment to drape evenly at the bust line and neck, thereby preventing the sideways shift Portia discussed experiencing with standard garment shoulders and necklines.

The right hand shoulder-dart shaping and asymmetrical shoulder lines moulded the shoulder area fabric to the body shape so that there was no strain on the grid. A method to develop garments for this imbalance was a significant finding of this garment, only made possible by the use of body scan data for measurement and shape information. that both the body shapes (Type C-D and D-E respectively) exhibited a narrower shoulder width than would be considered ‘standard’ for the full bust girth measurement as shown in Table 2 of Chapter Four, (section 4.4). This meant that the shoulder line was not only shortened, but rose at a steeper angle from the shoulder.
Figure 17. Marks & Spencer classic, round neck, set-in sleeve jumper in a size 20, knitted without side seam shaping and shown here on Desdemona's clone. Desdemona's bust girth was 102.5cm and the circumference at the most prominent forward point of her stomach (tummy point) was 116cm. Her largest girth below this was 112.5cm. Marks & Spencer size 20-22 knitwear was, according to their website, designed for a 107-118cm bust and 115-126cm hip girth, and would therefore have fitted her tummy girth as intended and can be seen to do so. Size 16-18 fitted hips 105-114cm and would therefore have been tight at her 'tummy point' girth. It was noticeable that the bust girth had too much fabric as indicated by the diagonal folds, and the shoulder seams dropped off the shoulders, creating excess fabric at underarm. Both these conditions contributed to a drooped side seam. <http://www.marksandspencer.com/General-Womenswear-Size-Guides-Product-Information-Help/b/47647031> Accessed 11/5/2011. (ORIGINAL IN COLOUR)
Whilst developing the Juliet and Desdemona series of garments, it had been found point to the neck point than would have been the case if the shoulder width was ‘standard’ and therefore wider. To visualise this scenario, it was helpful to see the shoulder line as the third, longest side of a ‘virtual’ triangle above the shoulder line. This triangle traced a line horizontal along shoulder width from neck point to shoulder point, fell perpendicular down the shoulder drop depth to the shoulder point, and was then completed by the shoulder line angling up to connect with the apex at the neck point. As the research was advised by experts that the shoulder drop at shoulder point remained relatively constant across different body shapes, the effect of the shoulder line shortening (as shoulder width narrowed) was to create a more acutely angled shoulder line. This shorter, steeper shoulder line was found to be unsuitable for narrowing as this method gathered the seam and was aesthetically unpleasing, (see Chapter Four, section 4.8). Shoulder lines were therefore subsequently bound off. It was considered however that with suitable machinery a satisfactory solution would have been to use a fléchage shaping followed complete row bind off.

Integral vertical darts can reduce fabric at points on the body where excess fabric would occur due to the fabric requirement above or below. If taken to the garment edge, they can also curve the fabric three dimensionally, emulating the body curve; for example around the back upper shoulder area. Integral horizontal darts remove length in areas where the body is shorter, whilst retaining length in neighbouring areas where more rows of knitting are required to follow the body’s longer profile. Neither of these need be at the side seams. This versatility means they can be positioned where the fullness is needed. In order to place these darts to channel the fullness to the strategic areas that require it, specific information relating to larger body shape and size is vital. Therefore to make a successful, well fitting knitted garment for larger body size, both
manual and 3D body scan measurements must be tailored to larger size. In this research it was found that body scanning is insufficient on its own and that some manual measurements are also clearly necessary.

Areas that have been found to have particular importance for the aesthetic and visual satisfaction of the wearer are the fit of the neck and bust region. The fit of these areas was based on shoulder width, front bust arc, upper and back chest measurements and body depth measurements, but also and most importantly, informed by the body shape. For example, measurements alone do not describe the rounded shape of both Juliet and Portia’s upper back shoulder shape. Neither of these were the same, as Portia held her shoulders more forward than Juliet, but Juliet had more ‘padding’ on her upper back.

Overall it was found that comfort satisfaction of the wearer was mainly dictated by the fit of the shoulders and sleeves, particularly during kinetic assessment. This satisfaction factor was consistently displayed across the participants, and had been found to be a problem with fit amongst survey respondents. Therefore a major new understanding of how knitwear for larger sized women should fit their larger body shape to provide minimum satisfaction has been established by this research.

5.5 Transferable methods

In designing and knitting the final Portia4a garment, the knowledge and understandings of knitting for larger body shape gained through Juliet and Desdemona's construction and analysis were utilised to create a garment with enhanced fitting values. This meant that the process was a longer one for a number of reasons, the initial one being familiarisation with Portia's body shape and 3D bodyscan measurements without the use of a clone. A secondary factor was the upgrading of the SDS®-ONE software, which is discussed in Chapter Two section
2.4.5., and the third was the constant reviewing of earlier methods and results to see which technique could be applied most successfully. There followed, as before, a series of knitted samples, to establish 3D results and technical knitability. (See exhibition) Because of the limitations of the SES machine, (which has a small memory) some technical issues became apparent at this stage which would not occur on a machine with sinkers and a larger memory, for example a later version SSG or SIG machine.

It was acknowledged from the start of this research that the knitting machine and programmer was core to the production of viable samples, but that the SDS®-ONE and the SES102ff machine were at the simpler end of production ability and therefore there would be technical limitations. It was however one of the premises of the research that it is possible to add 3D shape to knitwear to compliment the body shape of larger women without resorting to the more complex and expensive complete garment technology. At the same time the results remained transferable and added to the currently limited knowledge about larger body shape in relationship to 3D knitting, in particular the placement of 3D shaping to best compliment different body shapes, and which technique to apply at strategic body surface positions. This is particularly apposite in view of the call for novel responses and fresh sizing information required by complete garment production, as found by researchers at Manchester Metropolitan University, and reported in *Knitting International* of April 2011.\(^{419}\)

The methods used in this research have indeed proved novel, fresh and transferable. When the templates and machine files were sent electronically to Shima Seiki Europe Ltd. in Castle Donington for knitting the ‘proof of concept’ garment, (as

also discussed in section 5.3. of this chapter), the Shima Seiki knitting technologist Jeff Hill, knitted from the templates with no additional information from the researcher. He had not needed to adjust the templates, and had only needed to complete an automatic re-process for the SSG 122 machine instead of the SES 102ff as used in the research. During discussions about the principles of the methods developed in this research, he professed confidence in the programming and knitting methods, and (after a short explanation), expressed an understanding and recognition of the effectiveness of the darting and fléchage. (See Appendix C for photographs)

This successful collaboration of designer (the researcher) and technician echoes that discussed by Eckert and more recently explored in a more positive light by Cuden. During sampling and production of the garment, our conversations seemed to be in a common language. There is a possibility however, that as my knowledge and skills are based in technical knitting and programming as well as design, this may have facilitated the conversation beyond that of conventional designer/technician dialogue. Indeed one of the comments made by Hill was that, “We are working from the same page”, meaning that we shared a common language and could therefore work together without misunderstandings. He added that this was not always the case when designers came to the workshops to develop garments. These salient points of ease of transfer of design to another machine, recognition of simple but effective shaping techniques and their relationship to body shape all demonstrate the transferability of this research to other knitting systems, and garments styles knitted in single bed fabric.

The methods developed by this research have been proven by empirical evidence,

as discussed in this text, to be fully transferable. Furthermore, by exploring knitwear
design for larger sizes within the context of digitally enabled knitting, this study also
contributes to the discussion around the collaboration between knitwear designer and
technician, their self perceived professional differences and those that may be
influenced by industrial traditions.

5.6 Outcomes that may lead to future developments

5.6.1 Differences between garments developed from manual measurements and those from 3D body scan measurements.

If the research had used 3D body scanning for gathering measurement data from its
inception, although an understanding of the advantages of body scanning for analysing
body shape and taking measurements may have been realised earlier, it is considered
unlikely that the knitwear outcomes would be very different. Even in large, national
size measurement surveys such as SizeUK, some manual measurements were
necessary to accurately capture body size and shape for apparel purposes, and this
became the hybrid method used in the final research garments. The early recognition
of the need for the equivalent of ‘fit mannequins’ such as those described by
Bougourd and manufactured by Sizemic, led to the creation of the clones which in
turn aided the understanding of body shape through the empirical act of creation.421
Indeed it is significant that without the original cloned bodies to work with much of
the early knitting could not have been evaluated. The scan data introduced unforeseen
added value as it enabled a third party co-operation with an expert in CNC milling to
create an exact body clone of Portia’s torso. In view of Portia’s and Desdemona’s
weight loss, the clones, both manually and CAD/CAM created, proved to be valuable
tools to the research.

(Cambridge: Woodhead, 2007).133; Andrew Crawford, "Fashion Technology, Size and Fit Solutions",
Whichever method of measurement was used, the progression in the development of the garments relied heavily on a growing understanding of larger body shape, in particular the spatial relationships between salient points on the body. Significant knitting developments were based on the interactions and interdependences found to occur following small adjustments in strategic areas.

5.7 Conclusion

It can be seen through review of the research design process and discussion, that the inter-relationships of bodily dimensions in larger sized knitwear were crucial to fitting success.

The use of integral 3D shaping in its various forms proved successful in achieving a more aesthetically pleasing and comfortable fit for the wearer. Underarm bagging, side seam drooping and neck slippage were all reduced. The latter was particularly informed by 3D body scanning which was found to considerably enable the harvesting of measurements of larger body size and those required for larger sized knitwear that were hard to ascertain manually. However, it is recognised that in line with other research findings, some measurements still had to be manually taken.

Findings from this research have shown that darts on the upper chest, front and back shoulder and a deeper armhole shape compensate for a narrow shoulder width, particularly when found in combination with larger bust. This is a factor that standard sizing generally fails to cater for, assuming that larger girth equates with an increase in skeleton size, which other research discussed in Chapter Two, section 2.3.1, and anecdotal evidence gathered by this study and discussed in Chapter One section 1.1.4.3, has proved to be a false assumption. Mitred bust darts, which initially appeared the better choice, proved to be aesthetically unsatisfactory. Alternative bust darting as developed by this research was most acceptable to the wearer when its
emergent appearance was upward sloping. As the apex can be positioned on the bust point, this enables more accurate dart placement and is also a simpler method of both programming and knitting. Darting, which was achieved by adjusting the wales and courses within the fabric field through both flèchage and 3D wale shaping, was used in combination with extended bind offs at underarm and judiciously applied edge shaping to match the frontal silhouette, to give the garments 3D form. Participants reported the improved fit of the shoulder area and front chest of the research knitwear, achieved with strategically placed 3D shaping, to be particularly important to their garment satisfaction.

The inclusion of 3D body scanning was carefully considered and tested before it was incorporated into this research process. Without the ability to interrogate the body shape with the proprietary software, its use would have been limited to the landmarks and dimensions used by the scan technician, which were not developed for this research but were arbitrarily imposed. Through obtaining and learning the use of the software, a wealth of understanding about larger female body shape was made possible, although it should be noted that licensing issues meant that the software was not consistently available to the researcher and there was no formal training given. It would be correct to stress here that an understanding of the value and intricacies of 3D body scans and the attendant software in its application to knitwear was one of the research’s unintentional outcomes. This outcome has led to the researcher’s involvement in a wider scoped research project requiring this knowledge.422

In the knitwear design and manufacturing industry, as described by Anna Koski, (see Appendix E), two to three fittings were required to achieve a final garment for production. Therefore the average of three evaluations of each piece of knitwear, not

422 ‘Design for Ageing Well’, New Dynamics of Ageing,
all of which have been discussed in this text, placed the research knitwear within a
normal industrial design process range. Once it is recognised that the researcher fulfils
multiple roles within the research, it can be seen that the design process ran in parallel
with those of commercial knitwear design and prototype manufacture.

It must be re-iterated that the aim of project was to produce original and innovative
prototype garments which resolved fitting problems larger sized women were found to
encounter with knitwear. The original pieces of knitwear which emerged through this
research are the conclusions of iterations of knitting with a control fabric using a
carefully pre-selected set of 3D knitted shaping. As such they are not fashion garments
*per se*, instead they represent a basis for future fashion developments, the beginnings
of which was seen in the 2005 pilot study garment, discussed in section 5.2.2.1 which
was exhibited in Australia in ‘Blurring the Boundaries between Knitting and Fashion’,
Sydney.

Overall the evaluations described here proved that the methods developed in this
research could, with minimal and acceptable design development reiterations provide
an improved fit in knitwear for women with larger body shapes.
6 Findings, outcomes and conclusions of the research into improving the fit of knitwear for larger female body shape produced through the innovative application of 3D shaping

6.1 Overview of findings

Analysis of the research survey results and participant interviews clearly demonstrated, as indicated by the literature search conducted at the start of the research, that there was dissatisfaction and even despair amongst larger sized female consumers over the lack of commercial clothing in suitable sizes. They further demonstrate that the fit of what is available is unsuitable and unacceptable to these consumers. This has partly been attributed to the finding that there is considerable variation between upper and lower body sizes as self-reported by larger sized women.

It was found by this research that 23% of women with Type A, and 64% of those with Type D and Type E body shapes reported this disparity between upper and lower body size. This was considered to be compounded by the obvious misunderstanding of larger body shape within the high street fashion industry, that has been demonstrated by the fact that the majority of replies to the survey were unhappy with large sized clothing fit, style and availability.

Although this research has focused on larger size, without particular reference to age, it must be noted that a number of the issues encountered in larger size are also, as demonstrated already by other research discussed in Chapters One and Two, relevant to an ageing body shape. Notably these include larger waist girth in both sexes, and increased upper body circumferences in women. This particular body shape feature became a focus of this research, which in the light of a growing market for fashionable clothing to fit older body shape, enhances the significance of the outcomes by widening the possibilities of their application.
6.2 Findings

Since its inception, this research has addressed design, technology, manufacturing and consumption issues around the central core of larger body size of women and its translation into digitally enabled knitwear that was well fitting, comfortable and satisfactory to the end user. Methods specific to larger size were designed, tested and honed. The empirical evidence of many of these processes formed the practice component of this research, whilst the critical discussion and analysis of these empirical outcomes have been addressed in this text. As such they are mutually dependent, as was evidenced in the accompanying exhibition, although this text too includes numerous images illustrating the processes and outcomes.

This research has revealed seven major significant new findings. Firstly it established that knitwear does not have to rely on the inherent stretch of knitting to accommodate larger 3D body shape. This is a new approach to commercial knitwear design, where traditionally the inherent natural stretch properties of knitting have been used to accommodate body shape differences. It further showed that knitting techniques can be strategically and subtly applied in an innovative manner to add 3D shaping to improve the fit of fully-fashioned knitwear for larger sized women.

The second finding was that it was possible to produce knitwear with an improved fit for larger body shape, using a combination of 3D knit shaping methods on digital knitting machinery, and following an industrially accepted design process including three iterations of fit testing.

The knitting methods and templates developed through this research constituted the third finding and a practical and transferable outcome. These templates have considerable potential for commercial development and are significantly and deliberately compatible with current flat V-bed knitting technology. The transferable
nature of the templates is discussed in detail in Chapter Four, section 4.3 but in essence they can be cut and pasted as any image file, and can be readily understood and used by skilled knitting technicians.

The fourth finding was the development of an embedded topological tool to aid the visual and technical evaluation of the extension of knitting and the stretch and fit of knitwear. Whilst other research had used grids for evaluating clothing and skin stretch, by embedding the evaluation tool into the fabric this developed a new and effective technique for evaluating stretch in knitwear on the body, which is particularly suited to working with larger body shape. This method is applicable to preliminary fit testing of single knit garment shapes in manufacturing situations.

The fifth finding was that measuring larger body shape specifically for knitwear benefited from using new technologies, but significantly again that the fundamental methods developed through this research, that is the landmarks and dimensions found to be important for developing knitwear for larger sized women, remained the same. These landmarks developed for larger sized body shape were developed specifically for knitwear. When translating these into 3D body scan landmarks keeping these contextualised specifically to knitwear was extremely important, as there were so many more variables available through the digital scanning method. Further information as required could be gathered by interrogating the body shape virtually with different landmark and measurement parameters. However, it was found that the key landmarks, levels and dimensions continued, for the development of 3D shaped knitting on the shoulders, chest upper back and bust, to be:

- Shoulder width
- Bust girth
• Front and back bust arcs
• Upper back
• Upper chest
• Body depth at underarm

Plus the relationship between shoulder width and to bust girth which was critical to shaping positioning.

Those that were critical to knitting 3D shape into the lower part of the knitwear were:

• Position of frontal stomach prominence
• Front bust arc
• Bust girth
• Hip or thigh girth, whichever was the greater.

Plus the following relationships, which were crucial to the strategic placement of 3D shaping to prevent stretch over prominences, whilst giving a flattering shape to the garment by skimming not clinging to the body shape.

• Girth at frontal stomach prominence in relationship to front bust arc
• Girth at frontal stomach prominence in relationship to front under bust girth
• Girth at frontal stomach prominence in relationship to girth at hip and thigh.

The position of the natural waist (E2) was particularly important along with its relationship with the lower torso measurements bust listed above.

At the back of the body, the furthest backwards prominence of the bottom in relationship with the hip, thigh and back bust girth was necessary (as had also been the case on the front of the body) to create 3D shape for the bottom, and in particular for
the rounded upper back of stooped posture.

The sixth key finding was that 3D shape for larger sized knitwear could be achieved without the need for expensive and complex complete garment technologies.

The final finding was that the underlying knitting principles developed in this research, and their visual representation in the templates could be understood by knitting technologists, as described in Chapter Four section 4.4., because the templates were developed with knowledge of the shared language between designer/researcher and technologist and with deliberate intent to bridge this recognised and problematic divide.

6.3 Discussion on findings

The success of this project was dependent on the development of a specific, unique research framework to design and manage data gathering of information on larger sized women’s body shapes, which included working closely with participants. This in turn necessitated adopting formally recognised ethical approaches, adapting methods of research and implementing these accordingly.

6.3.1 Challenging stretch to fit in knitwear for larger sized body shape

Whilst pursuing its empirical path, the research challenged the belief that although the inherent stretch of knitting makes it suitable for garments that can be sized vaguely and broadly, this practice is detrimental to the resulting wearer’s comfort and aesthetic experience, particularly in the case of larger sized women. Findings have shown that if the knitting is not extended through stretching to cover a body shape, it retains its intended qualities of colour, opacity, texture and handle. By reducing and eliminating the extension of the stitches and rows, and thereby maintaining opacity of fabric as well as wearer comfort, an improved wearer satisfaction has been achieved as discussed in the evaluation of the research garments in Chapter Five sections 5.2.2,
5.2.3. and 5.2.4. This is clearly applicable to all sizes of knitted garments.

6.3.1.1 **3D shaping and its relationships to larger body shape**

To achieve a well fitting piece of knitwear, it was recognised that the main linear measurements of the body had to be found, and that these had to be translated into the garment. This research has however found that the entire torso shape is as equally important as these main linear measurements. Fulfilment of this original research aim and the resulting finding relied partly on successfully establishing a method for measuring larger body size and shape specifically for knitwear and the outcomes of this method, which have been discussed in Chapter Three. Therefore contributing factors from these measuring processes have been included in discussions of the first finding.

Whilst working to eliminate reliance on stretch, it was found necessary to employ methods that contradicted some traditional knitwear manufacturing construction techniques. For example binding off in industry has been found to be a slow and therefore expensive procedure and manufacturers prefer to limit its use. However in order to achieve a well fitting armhole and sleeve head for the body depth of larger body size, it has been considered necessary in this research to include an extended bind off at underarm. Similarly on the shoulder line, where narrowing can be used to create a diagonal edge, it was found preferable in this research to bind off. This was because the shoulder width in larger sizes was found to be narrower in comparison to the full bust girth measurement than in standard sizes, thus creating an angled shoulder line which was not suitable for narrowing. Knitting such an angle requires that narrowing takes place faster, thus causing a tight edge, and the resulting tight shoulder seam was found to compromise the fit of the armhole and sleeve head, further detailed discussion of this can be found in Chapter Four, section 4.8.
The difference between bust and shoulder width, although diminished by the extended bind off was still affected by the body shape above the bust line. On larger bodies ‘padding’ occurs on the front chest and upper back creating a convex body measurement which requires width to be maintained in the garment around the mid armhole height, although this must be reduced before the start of the shoulder shaping. This could be achieved by extending the armhole edge, and indeed this method was used for one garment. The most satisfactory solution found however was to introduce 3D wale shaped darts at mid shoulder line. These darts not only narrowed towards the shoulder, but at the same time created a gentle 3D shape on the front bust and upper back. Participants and survey respondents alike had indicated that too-wide shoulders were a common fitting problem. This solution therefore proved highly successful in two ways. Not only did it technically resolve fit, thereby fulfilling the main requirement of knitwear for larger body size by providing the wearer with an improved fit, but at the same time by offering an improved fit without stretch, it met the participants’ expressed need for confidence in wearing knitwear.

Further down the body, the introduction of 3D shape over the protruding stomach and the wider hip area prevented extension and distortion of the stitches and courses, thereby maintaining fabric opacity and vertical wales. In combination with the flexible waist position this gave 3D shape to the garment, introducing extra fabric where it was required, at the front of the body, rather than at the side seams. The bust darts not only gave 3D shape to the garment to mould around the bust area without stretching, but they also reduced ‘drooping’ at the side seams.

Although placing the bust darts proved challenging, one significant finding was that the type of flèchage used for the bust darts affected their placement. By strategically engineering the vertical sequence of the flèchage, a method was designed
that improved accuracy when positioning the darts.

Overall the most important landmarks and girth levels that effected the application of 3D knit shaping to the stomach area was the height of thigh, hip, E2, and bust and their vertical relationships between each other, but in particular that to the furthest forward projecting point of the stomach. Lateral placement of the 3D shaping across the stomach area was found to depend on the relationships between front bust arc, E2, and front hip and thigh measurements, as well as the position of the furthest forward projection of the stomach. These body landmarks, levels and girths were used to strategically apply the 3D knit shaping methods into the templates, which then resulted in the correct positioning of 3D shape in the knitwear.

6.3.2 Combining 3D body scanning with digital knitting technology to produce knitwear with an improved fit for larger body shape

The second finding was that a combination of 3D body scan data and 3D knit shaping methods could produce knitwear with an improved fit for larger body shape using digital knitting machinery. The use of 3D bodyscanning meant not only that digital measurements could be taken, but also that the body shape could be viewed in a virtual 3D environment which informed the 3D knit shaping positioning and overall final shaping effect. Combining these two technologies was found to have also been a challenge to other parallel projects, as discussed in Chapter Two, 2.3.5, and this had largely been attributed to the complexity of the knitting technology. Therefore, it was the unique combination of experience and skills of the researcher here that made this research not only possible, but successful.

Whilst it would in the future be desirable to continue this research and digitally integrate the data from the 3D body scan into the knitting development process, this would be dependent on the two manufacturer’s, Shima Seiki and [TC]², agreeing to
share proprietary software information, and resolving this was beyond the scope of this research.

### 6.3.3 The research template library

The third finding and a lasting outcome of this research was the creation of digital templates which provided original and useful information for knitwear design and development for larger sized women. These templates were digital files, created and developed specifically to match the body shape of the selected participants, which in turn reflected those most frequently reported during the research survey. This research was unique when conceived because it developed the complete process of knitwear for larger size from measurement to product rather than formulating a theoretical model. The visual nature of the templates meant that specific knitting principles and the strategic way in which these were applied was clearly visible as discussed in Chapter Four 4.3. The templates drafted for knitwear for larger body shape were assembled into a template library in preparation for future work in this field.

The value and importance of the template schemata in understanding the principles behind the research was demonstrated during the researcher’s visit to Shima Seiki Europe in July 2010 as discussed in Chapter Four, section 4.3. Whilst the researcher was working on the screen with a research template, a Shima Seiki knitting technologist examined the template and understood it immediately. Once the full concept had been explained, he made a connection with what he termed ‘wholegarment methods’, and was intrigued at these being explored on a traditional V-bed machine.\(^{423}\) His observation clearly showed how, until this study, compartmentalised thinking has largely confined the investigation and application of 3D knitting techniques in shaped fashion knitwear to complete garment production.

---

\(^{423}\) Personal communication with Cesare Mercurio, Knitting Technologist at Shima Seiki Europe Ltd., July 2010.
As the templates had been deliberately developed to be transferable to other industrial, digital knitting systems, this proved the original concept to be successful.

6.3.3.1 The transferable knitting templates can be exploited commercially for future development

There was a subsidiary outcome which added significantly to the third finding. For this outcome, the research exploited the international visual language of knitting structure recognition, as discussed in Chapter Four 4.3. It had been intended that although the templates were developed on the Shima Seiki SDS®-ONE system in a proprietary format, within the boundaries of knitting rules they would be transferable to other makes of industrial, digital V bed non-complete garment knitting systems. This was because they were easily converted to digital images in which format, as template schemata, they would be understandable by technicians familiar with other knitting systems, for example those of the German machine manufacturer Stoll. This aim was partly achieved in that the templates were proved to be directly transferable to other models of Shima Seiki, digital, non-complete-garment knitting systems, but not tested on other makes of machine.

Although this research specifically focused on larger size, the unique combination of methods developed in this research and discussed in Chapters Four and Five provided information for increased clothing satisfaction across single knit, fully-fashioned knitwear production of all sizes. The templates developed for larger body shape and their underlying principles were designed to contribute to the existing knowledge pool of traditional manufacturing of fully-fashioned knitwear and have indeed done so with new knowledge. It is of significance to the knitwear industry that they also have potential to be applied within the, as yet, fledgling field of mass-customisation of knitwear. In this area the templates have particular value, not only
for larger size women’s knitwear, which has been identified as a sector for further development in mass-customisation, but also for other non standard size knitwear applications, e.g. clothing for the ageing body shape and possibly for the larger man. The research has shown that within mass-customisation, this research’s methods for producing fitting, fully-fashioned knitwear would be less wasteful in raw materials than that of cut-and-sew knitwear as described in the *Knit on Demand* project and that this method also offers a better fitting garment.

### 6.3.4 Issues of the visual evaluation of stretch in knitwear for larger sized body shapes

The fourth key finding of this study relates to measuring the stretch and extension of knitting. This was important to the findings, and various methods were considered, all of which involved placing a marker on the fabric, a tried and tested method in clothing stretch evaluation, as discussed in Chapter Two section 2.3.7. As explained in Chapter Two section 2.4.6.3, this concept was of fundamental importance within the development of better fitting knitwear for larger sizes. The advantage of working with a constructed textile was that unlike in other research, the marker could be embedded into the fabric and could therefore become an absolute in the wales and courses of the piece.

A hierarchy of requirements and desired outcomes, as described throughout Chapter Two section 2.4.6.2, in combination with the researcher’s technical knitting experience, all contributed to the design development of an integrated grid for evaluating stretch. The fact that this grid was fundamentally part of the single knit structure made it a rigorous, visual, topological (meaning that however the grid is stretched, its stitch-to-row relationship is not affected), stretch-mapping evaluation tool. In addition and as intended, the grid’s emergent appearance proved to be
aesthetically pleasing to the participants.

Overall it was found that introducing a low power stretch yarn into the fabric gave stability and density to its resulting behaviour and appearance, and that the fabric retained opacity when it passed over body protrusions. This proved to be a positive benefit, providing this was not used to increase the extensibility and recovery of the knitting for fitting purposes.

It therefore was clear that the final knitted structure developed for this research, of a grid embedded into single knit fabric, presented possibilities for other applications, as it could measure the movement of knitted fabric on a body shape, and highlighted where extension occurred within a knitted garment. The behaviours of the knit structure as described here indicated points of fabric-body collision to aid fit evaluation. Further investigation into the application of this concept in singled knit shaped knitwear was considered to have potential, particularly in the fields of body measurement and mapping body shape.

6.3.4.1 Evaluation methods developed for knitwear for larger body shape

Evaluation methods developed for this research also relied heavily on the knitted grid to aid visual assessment of wrinkle, extension and collision of fabric with the body. Professional evaluation of these incidents in the early prototypes led to revisions of the templates and the series of garments leading up to the final versions. Therefore the methods developed for evaluation of the knitwear contributed fundamentally to the overall findings and outcomes. Professional evaluation was however augmented and sometimes totally reliant (as in the case of comfort) on the individual participant’s subjective assessment. To this end, and with reference to advice on ethical issues about working with participants in intimate situations, as discussed in Chapter Two
section 2.3.7, protocols were developed for evaluation of fit. As well as the issues of privacy and the comfort of the participant, these involved the design of simplified participant evaluation sheets that included images and lay terms.

6.3.5 Measuring larger sized 3D body shape specifically for knitwear

It has been found in this research that when developing knitwear for larger body shape a novel approach to landmarking and measuring the body between these landmarks was required. Measuring the body in the traditional manner provided a set of measurements, but this is not same set of measurements required to programme a knitted garment via the Shima Seiki SDS®-ONE, SPaint garment development software. In response to this, as shown in Chapter Three, sections 3.1.2, large body shape was viewed in an entirely new way that was particular to knitwear design and landmarked accordingly, so that the waist in particular was no longer locked at the mid body level just above the navel, as it is in traditional garment sizing. The focus of the research was always on the three dimensional body and therefore it was important not only to measure linear distances but to place the body within space. This led to including body depths and the positions of the most prominent points of the body in space in the final table of measurements. This table was then used when translating body shape into 3D shaped knitwear for larger size.

This research has therefore highlighted the use of 3D body scanning related to knitwear sizing and shape development for larger female body shape. It became apparent as shown in Chapter Three, section 3.3, that the technology of 3D body scanning required specific knowledge in order to understand the pivotal landmarks.

The successful combination of 3D body scanning and knitting technologies, as demonstrated through the original outcomes of this research, have usefully highlighted the dependence of successful knitwear design and development for larger body shape
on shared languages between researcher, designer, technician and wearer. This finding supplies a quadruple pool of the initial information required for a successful product outcome.

**6.3.6 Improved fit in knitwear for larger sizes can be achieved with widely available knitting technology**

The sixth and seventh outcomes, which make this research widely accessible to the knit industry, were dependent on the choice of knitting technology. It was core to the research that this project maintained compatibility with the most widely available V-bed industrial knitting plant whilst at the same time exploiting the advantages of modern technology. The success of the knitting methods described in Chapter Two section 2.4.6, and Chapter Three section 1.5, and that of the resulting garments discussed throughout Chapter Four and Five, in meeting the objectives of this project, proved the Shima Seiki SES 102ff knitting machine in combination with the SDS®-ONE programming system to be a highly satisfactory and clearly viable choice. This clearly demonstrated that an improved fit could be achieved for larger sized knitwear through strategically applied 3D shaping without resort to complex complete garment technology.

**6.4 Future potential of the findings and outcomes**

The direct and obvious potential for future developments of this research is its commercial application in fashion knitwear for larger sized women. It had been found through apparel related surveys such as SizeUK and SizeUSA that body size was increasing throughout the developed world. At the same time dietary and lifestyle changes have led to body size and shape changes in the populations of developing countries.\(^{424}\) When body size increases this study has shown that shape becomes

---

more complex, requiring closer sizing increments than are currently practiced within knitwear manufacture. The translation of non-standard sizing differentials developed from those that have been discovered in this study from 3D body scanning, into coherent information for knitting technology presents possibilities in the further improvement for methods of developing sizing information for larger and non-standard body shape.

This research into improving the fit of knitwear for larger sized women has provided a theoretical and practical framework for future commercial development. Most importantly the research template schemata have the potential to become part of a mass-customisation method for fully fashioned knitwear similar to that envisaged (but not achieved) by other research projects, and as such will contribute significantly to the development of mass-customisation of fully-fashioned knitwear.\textsuperscript{425} The individual templates constitute the parts of a modular system for a method similar to, but extended and improved beyond, those described by Eckert and developed in cut and sewn knitwear by Peterson and Larsson. The templates offered here have proven to be understandable and useable by a professional third party industrial knit technician, as discussed in Chapter Five section 5.4. As such the templates bridge the gap that was left between the moderate success of Peterson’s cut-and-sew mass customisation methods and future developments into fully-fashioned mass-customisation of knitwear.

The second potential for extending this research exists in the application of the findings of this research to ageing body shape. This has been shown here to be a

particularly important and current area of commercial and design development in view of the increasing ageing but monied population, as discussed in Chapter One, and is a goal that was also concurrently identified by a large scale EU project into mass customisation of clothing.

The third potential for future development of this research is in the area of 3D body scanning combined with digitally controlled knitting as a tool within the development of improved fit for mass produced larger sized knitwear. This combination of technologies presents possibilities which require further investigation, as shown in the valuable findings into the practical relationships between digitally gathered body dimensions and knitwear, discussed throughout Chapter Four. Dr Bruner, from The Textile Clothing Technology Corporation in America, (developers of the [TC]\textsuperscript{2} NX12 3D body scanner used in this research), expressed personal interest in the outcomes. The successful future combinations of these technologies would require the involvement of a digital knitting technology manufacturer, and Shima Seiki Europe were also supportive to this research, displaying a positive interest in its outcomes, the knitwear prototypes, as discussed in Chapter Five, 5.4. Whilst the proprietary nature of the Shima Seiki knitting software presents some barriers to full integration without the co-operation of the parent company, cross-disciplinary solutions could be found in the future with further, more focused investigation into this area of the research findings. When discussing this as a possibility, both Shima Seiki Europe Ltd., and Human Solutions (Vitus body scanner) expressed interest in future contact.\footnote{Telephone interview with Richard Webster, Shima Seiki Europe Ltd., 20/6/2007. Telephone interview with Erica Thiex, Human Solutions, Germany, 24/11/2008.}

Although there is an ongoing study at the London College of Fashion as discussed in Chapter One section 1.5.7, to the knowledge of the author the research project based here at the University of Brighton remains the first to develop and produce a complete
collection of prototype knitted garments for a variety of larger sized body shapes, using electronic V-bed knitting machinery and 3D body scanning technologies in synergy.427

Thus it can be seen that there are a number of viable potential commercial avenues into which this research can be developed. It is envisaged, that depending on funding, this research will be continued, be inter-disciplinary and involve collaboration with other academic and commercial enterprises and will aim at post doctoral level to develop additional and supplementary aspects of knitwear for non-standard body shapes.

6.5 Overall conclusions drawn from the research

As has been shown through oral testimony and the discussion of relevant discourses, a misconception seemed to exist amongst commercial knitwear manufacturers that fashionable clothing should only be made in ‘standard’ sizes for ‘standard’ body shapes. As an initial step towards providing fashionable apparel for more challenging body shape, this research has developed prototype knitwear (toiles) with an improved fit, aimed at fulfilling the missing, but socially important and economically valuable provision of well fitting larger size knitwear to all ages.

It has been shown in Chapter One, section 1.5.1., that sizing in larger women’s clothing in general across the mass fashion industry is variable and that sizing of knitwear is particularly chaotic. It has been established by Brownbridge that flat bed knitwear in general requires fresh sizing input, as existing anthropometric data has been shown to be unable to provide the necessary measurements, and manual measuring has been found to produce inaccuracies. However Brownbridge’s research,

conducted in 2006-2012, was theoretical, with no physical outcomes, whereas this practice based research project has produced prototype knitwear *toiles* which demonstrate the specific body measurement and knitting methods developed here to improve the fit of knitwear for larger sized women. When measuring the body, this study has discussed existing research on this issue which shows that accuracy is dependent on a number of variables. This research has therefore, in response, developed methods for measuring the larger body shape for knitwear that augmented existing measuring methods (which have been demonstrated here to be subjective and often inconsistent), by introducing 3D body scanning for gathering very specifically targeted measurement data. Whilst it has been recognised in this study that there are inconsistencies in body scanning, and that some manual measuring was still necessary to capture all the body measurements required, this research concluded that 3D body scanning gave an increased and invaluable flexibility to the knitting of 3D shape in knitwear for larger body shapes and improved garment outcomes.

Existing industrial examples of combining digital knitting with 3D body scanning as a commercial proposition were researched and described in Chapter Two, 2.3.5, but it was found that within these developments, fully successful outcomes were rare. However, the new and unique methods and processes undertaken in this research have led to successful outcomes being achieved, as discussed earlier in this chapter. These circumstances, as described by Jeff Hill of Shima Seiki Europe Ltd., and discussed in Chapter Five section 1.5., were the result of a combination unique to this researcher, of substantial experience and skills in design, knit programming, knitting technology and knitwear development.

Apart from the obvious technical issues involved in combining digital knitting with 3D body scanning there was also a shared language problem between design,
technical knitting and 3D body scanning technology. Overcoming the attendant problems, as discussed in this text, required the development of knowledge and language encompassing these three main disciplines.

A parallel but even more divisive language problem between knit designer and technician had been identified, and discussed in Chapter One, section 1.5.6. The outcomes of this research have clearly demonstrated that it was possible for the skills gap between knitting technologist and designer to be bridged through cross-disciplinary knowledge.

Even in the light of later initiatives discussed in this thesis, including the collaboration between Shima Seiki and [TC]² and the Knit on Demand and SERVIVE projects, it was clear that the content, findings and outcomes of this research placed it in the forefront of new understandings. Research methods developed for the project have demonstrated that the ability of the combination of 3D body scanning and knitting to physically translate commonly found larger sized female body shapes, into knitwear with an improved fit, was high. This study has properly and satisfactorily applied the unique content and fresh knowledge gained through this research to the sizing needs of flat-bed knitwear manufacture. Despite the fact that this equipment was first developed in the late 1980s, it has remained the most suitable and economically viable type of machinery on which to create contemporary knitting for larger size women. It must also be noted that, as this thesis has shown, this research has provided knowledge to a wider audience in knitwear manufacture in general. This could include amongst others, knitwear for the ageing body shape, the male body shape and possibly even maternity wear.

This research set out to develop prototype knitwear that offered an improved fit for the body shapes of larger sized women as indentified through this project. To realise
this overall goal, the following aims and objectives were established and successfully achieved.

The primary aim was to question the traditional reliance of knitwear manufacturers on the inherent stretch of knitting to make knitwear fit, and to challenge stretch as an successful method of fitting knitwear to larger sized women’s 3D body shape.

In order to achieve this, and as had been planned from the start, a collection of prototype toiles was developed for commercially viable 3D shaped knitwear which fitted the body shapes of a group of women with specially selected larger body shapes over a size 16. A major step was made towards this development when the ‘Australia’ version of the research garment Juliet 2 was designed for Juliet’s Type C-D body shape, as was discussed in Chapter Five section 5.2.2.1. The ‘Australia’ garment and the dark red version of Portia 5, discussed in the introduction to Chapter Five, are both examples of the prototype garment’s potential for design development.

The knitwear toiles, the original and novel practical outcomes of the research, clearly demonstrated, after experimentations, trials and responsive re-iterations, an improved fit of knitwear for large sized women, and exemplified the strategic application of 3D knitting methods to larger female body shape, as developed through this research. As a contribution to new knowledge in knitwear design and manufacture to achieve fit satisfaction, these toiles embodied an entirely new approach to knitwear as they did not rely on stretch to fit larger body shape.

Based on the tailoring concept of godets and gores as discussed in Chapter Three, section 3.5.3, knitting methods had been developed that created suppression darts, which in turn, when applied in the manner of this research, created 3D knitted shapes. The knitting methods of the most importance for creating 3D shape in the knitwear
were identified as being: wale transfer for shoulder darting and lower torso shaping, and flèchage for bust, back and hem shaping.

In order to establish theoretical and practical frameworks for future developments of the research, methodologies were developed that were specific to improving the fit of knitwear for larger size. The outcomes that enabled this framework included: measuring larger body shape specifically for knitwear, the knitted samples that helped developed the 3D knitting methods to fit body shape, and the digital templates created using these 3D shaping methods, from which the knitwear toiles were knitted.

An innovative outcome developed through this research, which has been shown here to improve the fit of knitwear for larger body shape, was the creation of additional body depth through a longer underarm bind-off than that offered as standard. Additional body depth at underarm was found to be required because of the significant difference in larger sized women, between the upper chest and upper back width measurements in comparison to the bust girth measurement. These differences also affected the shoulder seam length, as the shoulder width was found to be proportionally shorter when related to the bust girth, than in standard garments.

It was however the careful combining of all these techniques and their new application in strategic positions to accommodate larger body shapes that brought true innovation to the knitwear and templates developed through this research.

Digital templates developed for the body shapes as discussed in this text, have been shown to be flexible in use between body shapes, understandable by knitting technologists and transferable between different versions of knitting machinery. The research template library formed of these templates, from which the garments were knitted, has contributed significantly to the aim of providing new information for
The intent of the research from its inception was to work with real women whose clothing size was a UK 16 or above. By working with these real women, a three dimensional understanding of their body shapes had been made possible. The interim, and final evaluations of the knitwear were also more effective and useful as they were carried out by both wearer and observer. The aim was to acquire a three dimensional understanding of their body shapes specifically for the development of 3D knitted garments, and to use this contextual understanding to develop knitwear prototypes. Participants were deliberately chosen based on their body shapes being close to those mostly commonly selected through the online research survey, as detailed in Chapter Two. These were Type C, Type C-D, and Type D-E; all of which had rounded stomachs, which caused the narrowest girth of their torsos to be higher than the standard recognised waist position, close to the navel.

A key outcome was that the relationships between body girth levels were seen to be critical to the strategic application of 3D shaping to the knitwear. These vertical relationships determined at which point on the garment to start and finish including or removing stitches and rows, and how many stitches and rows should be adjusted, to produce 3D shaping whether with flèchage or wale shaping methods. The most important of these on the lower torso, was the vertical relationships with that of the level of the furthest forward projecting point of the stomach. In addition, the lateral placement of the 3D shaping across the stomach area was found to depend on the relationships between the girths of front bust arc, natural waist (E2), and front hip and thigh, as well as the position of the furthest forward projection of the stomach. This determined at what point on the garment to include or remove stitches using wale
shaping to accommodate these different girths.

On the upper torso it was the difference between shoulder width, upper front chest and upper back width and front and back bust girth measurements that affected the placement of 3D shaping. In combination with the vertical distances between these girths, this formed the basis for strategic positioning of the 3D shaping in the knitwear. This was based on knowledge of these body measurements and the 3D shape of the intended wearer.

Therefore this in turn demonstrated that it was body depth, critical girths and the outline shape of these girths around the ‘core’ of the body, in conjunction with their relationships vertically throughout the body, that were found to be imperative to measuring body shape and improving the fit of knitwear for larger body shapes.

The final aim was to produce the prototype knitwear using widely available digital knitting technology so that results would be as broadly accessible as possible. Developmental stages, evaluations, images and discussion of the knitwear as outcomes of this objective, have been included in detail in Chapters Four and Five. Images of the research knitwear in this thesis and the accompanying exhibition clearly show that this aim was achieved successfully.

The findings and outcomes from this research, although focused on larger women’s body shape have the potential to deliver improved satisfaction with knitwear to a broader audience. These have been identified as including, amongst others, men and women with age-related body shape changes.

It is important finally to stress the newness and value of the knowledge this research brings to the emerging field of mass-customisation of knitwear, particularly in the context of larger body shape. This research has discovered and discussed
through interview and creative professional practice, the fashion needs of larger sized women consumers for knitwear. It has further shown how the aspirations of larger sized women in regard to knitwear can be satisfied through the design and technology detailed here. Finally this research has demonstrated, through practice, the successful production of 3D shaped knitwear for specific categories of larger women’s body shape that does not stretch to fit their body shape.
Glossary of terms

Back loop  Technical back of a stitch.

Bearded needle  The first machine needle to be invented. Shaped like a shepherd’s crook, it was used on the early knitting frames and latterly Cotton-type flat bar fully fashioned and circular machines. Usually used with a sinker or loop presser device to facilitate formation of successive loops. Also known as a spring needle.

Bind off  Term used to describe the technique of finishing the knitting on the machine so that it does not unravel (cast off).

Binding  When fabric sticks to the body, this is usually caused by the garment being over tight.

Compound needle  Also called a bi-partite needle, this has an open hook and a separate closing element instead of a latch.

Course  A horizontal row of knitted stitches formed from one thread. In plain weft knit these are normally created in one pass of the carriage. However, in more complicated constructions, a number of courses may be required make up a pattern row (e.g. Intarsia and Jacquard).

Course length  Length of single thread of yarn that is required to form one course of weft knitting; i.e. the amount unravelled from one course of knitting. (See exceptions regarding Jacquard and Intarsia under Course).

Cover factor  Level of opacity of fabric, closely related in knitting to loop/stitch density.

Dart  A shaping technique removing a long, thin triangular or diamond shaped area of stitches using multiple widening and narrowings by loop transfer within the knitting field.

Fabric face  Technical front of fabric. In single bed knitting, stitches show on this side of the fabric as Vs.
Face loop  A loop when looking at the intended face of the fabric. The technical face of a stitch in which the legs show, rather than the top loop.

Fair-Isle  Sometimes used to describe single bed jacquard. Fair Isle is a term used in domestic machine and hand knitting to describe two colours knitted in a row in small repeating patterns. Commonly this has ‘floats’ at the back of the knitting. (see Float)

Flèchage  A shaping technique whereby stepped groups of needles, usually grading from an edge, sequentially cease to knit every two courses. These needles retain their stitches, whilst the carriage and yarn turns before the end of the knitting field, knitting a shortened course as it returns across the knitting needles. This technique reduces courses, and therefore vertical height in the flèchage area, and in designed permutations, can add three dimensional shape. The resulting fabric may show an arrow head pattern, hence the name derived from the French word for ‘arrow’.

Float  When the yarn misses individual or multiple knitting needles in a course, the yarn that is not knitted into new stitches forms a strand or float across the reverse side of the knitting. Also called slip, miss or skip. (see Fair Isle and Single Bed Jacquard for coloured versions.)

Fully fashioned  Method of shaping by stitch transfer. In this method, the transfer takes place within the knitting field, not at the edge, making a clear mark on the face of the fabric. Until recently this was a specialized and relatively slow method of shaping on machinery.

Garter stitch  The knitting consists of alternate courses of face and reverse loops. The fabric lies flat. The alternating loops make this fabric knit up shorter than equivalent number of courses in stocking stitch.

Gauge  In V bed and circular machine knitting, gauge is the number of needles per one inch of the machine bed or around the dial.
traditional, fully fashioned production on Cotton-type flat bar machines, gauge is the number of needles in one and a half inches. Hence a 21 gauge fully fashioned machine is equivalent to a 14 gauge V bed machine.

Godet  
A triangular insert (usually vertical), creating fullness or flare to a garment.

Jacquard  
Double or single bed, patterned knitting using a number of colours in a row. In classic double bed jacquard on a V bed machine, each colour knits on all back bed needles on every row of its selected sequence (usually on alternate needles), and only where a colour is to knit the pattern on selected front bed needles does it knit on both front and back beds. In single bed jacquard a colour not required in the pattern floats behind the non-selected needles, lying on the reverse of the fabric. The selected needles are usually programmed by punch card or computer. (see also Fair Isle, and Float)

Latch needle  
The most widely used needle in V bed knitting. It has a hook at one end, which receives new yarn and a hinged latch pivoting from the base of the hook. As the old loop slides up the shaft of the needle it closes the latch and slips of the closed hook making a stitch. The hook is then opened automatically when the needle slides forwards through the loop it has just made, becoming ready to receive new yarn once again.

Links-links  
(see Garter Stitch)

Loop density  
(see Stitch density)

Loop length  
Length of yarn used to form a loop. This is dictated by the distance a needle travels after pulling the new yarn through the old loop. It depends to some extent on the elasticity of the yarn, as those with natural stretch may allow smaller loops. May be electronically or manually controlled depending on the machine.

Loop transfer  
Method of knitting where a selected loop in a knitting field is removed from its needle and moved between beds to an empty, opposing needle, the bed is then shifted laterally across the
desired number of needles for the lateral distance (usually 1-3 needles) and the loop is picked back onto the receiving needle. This creates a slanting loop, some of which may lie across the face of the remainder, forming a decorative effect, depending on direction of transfer.

- **Loop**
  - One stitch.

- **Narrowing**
  - Reducing the number of needles in the knitting field, thereby making the courses shorter and the fabric narrower. Performed by loop transfer, either at the edge or within the fabric field (see Fully Fashioning).

- **Pattern row**
  - The complete horizontal row of loops knitted on adjacent needles across one needle bed (usually viewed as the face of the fabric). In plain weft knitted fabrics this is the same as a course, but Jacquard, and other fabrics that combine structure with colour may require more courses than pattern rows in their construction.

- **Pill (pilling)**

- **Plating**
  - Knitting in which the loops are composed of two yarns, often of different fibre or colour, for technical or aesthetic purposes. Perfect plating is achieved when one yarn lies permanently on the reverse and the other on the face of single bed fabric. Often a special feeder is used that facilitates this positioning.

- **Press off**
  - Term used to describe knocking open stitches off needles, the stitches are not bound off and will unravel.

- **Presser Foot**
  - A device that holds stitches down between the beds of a V-bed knitting machine whilst the carriage passes over them. It facilitates clean formation of new stitches and ‘holding’ of stitches on non-working needles.

- **Reverse loop**
  - A loop seen from the technical reverse of the fabric.

- **Rib**
  - Wales of face and reverse loops forming a stretchy fabric.

- **Rib-loading**
  - Cotton type flat bar machinery did not in general have the capability to knit ribs, so these were knitted on separate machines. The rib stitches were then transferred to a cassette, or
rib bar, from which the rib was then automatically transferred to the flat bar machine needles.

**Seamless**
Garment made without seams.

**Slider needle**
A Shima Seiki needle patent that has a slider sheath which incorporates a transfer point.

**Stitch density**
Number of wales and courses in a measured area multiplied by each other and divided by the square of the area to give a stitch density. Depending on whether one is seeking surface pattern density for sizing of garments as in the case of jacquards, or structural courses this is translated as pattern rows or passes of the carriage. Also called loop density.

**Stitch size**
Size of an individual face stitch within the stitch density.

**Stitch**
Formed of the loop and the sinker loop.

**Tension**
This can be used to describe the number of wales and courses in a measured area, used for calculating garment wales and courses. Courses are usually translated as pattern rows in this instance. It can also refer to the loop length, i.e. a number representing the value of the size of the loops.

**Tubular knitting**
A continuous circle of stitches forming a fabric. Knitted around the dial of a circular machine, or on a V bed machine using an equal numbers of needles on each bed consecutively. Can also be worked hand on multiple or wire needles. Also called circular knitting.

**Tuck stitch**
When a needle rises sufficiently to take the new yarn, but not high enough to make slip the old loop off the needle. The tuck loop is retained in the hook and a new one added each consecutive course until the needle is selected to rise higher and make a new loop, which at the same time catches the tuck loops into the new loop. Tucked stitches are wider than plain stitches. Tucks can be used for patterning and technical purposes.

**V-bed machine**
Knitting machine with two opposing beds which look from the side like an inverted V, with the needle hooks pointing into the apex of the V.
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wale</td>
<td>Another term for a stitch, usually referring to a vertical line of stitches directly above each other which are knitted in consecutive, laterally knitted courses. In weft knitting they are connected to both adjacent wales by the sinker loop.</td>
</tr>
<tr>
<td>Wale</td>
<td>Vertical column of stitches.</td>
</tr>
<tr>
<td>Weft knitting</td>
<td>Method of knitting in which the loops are made by a thread moving laterally across the fabric. Characteristically the weft thread lies at right angles to the direction of the production of the fabric.</td>
</tr>
<tr>
<td>Widening</td>
<td>Increasing the number of needles in the knitting field, thereby making the courses longer and the fabric wider. Can be performed at the edge by adding needles or loop transfer, or within the knitting field, (see Fully Fashioning).</td>
</tr>
</tbody>
</table>
**Bibliography**


Allen, Richard et al. "SizeUK:Average measurements for MEN and WOMEN".

Alvanon-IFTH to release French Body Measurements for apparel industry.
<http://www.fibre2fashion.com/news/association-
Anderson, Judith L. "Breast, hips, and buttocks revisited: Honest fatness for honest
fitness". Ethology and Sociobiology 9.5. (1988): 319-324
review of the socioecology of ideals of female body shape". Ethology and
Anderson, L.J., et al. "Understanding Fitting Preferences of Female Consumers:
Development of an Expert System to Enhance Accurate Sizing Selection"
for mass customization in the apparel market". Journal of Fashion Marketing
and Management 6.3. (2002): 240-258
Apeagyei, Phoebe R., Rose Otieno, and David Tyler. "Ethical practice and
methodological considerations in researching body cathexis for fashion
products". Journal of Fashion Marketing and Management 11.3. (2007): 332-
348. Emerald Web
Arnold, Rebecca. Fashion, Desire and Anxiety, Image and Morality in the 20C.
Ashdown, Susan P. "An investigation of the structure of sizing systems: A comparison
of three multidimensional optimized sizing systems generated from
anthropometric data with the ASTM standard D5585-94". International


------ "An analysis of task related movement of asbestos abatement crews as a basis
for the design of protective coveralls". Cornell University, 1989. Masters
Thesis.
Ashdown, Susan P., and Hyunshin Na. "Comparison of 3-D Body Scan Data to
Quantify Upper-Body Postural Variation in Older and Younger Women".
Ashdown, Susan, Mee Sung Choi, and Eric Milke. "Automated side-seam placement
from 3D body scan data". International Journal of Clothing Science and
Ashdown, S.P., and E.K. O'Connell. "Comparison of test protocols for judging the fit
Ashdown, Susan, and Lucy Dunne. "A Study of Automated Custom Fit: Readiness of
the Technology for the Apparel Industry". Clothing and Textiles Research
Ashdown, Susan P., et al. "USING 3D SCANS FOR FIT ANALYSIS". Journal of
Carolina State University Web


Baines, Phil. Knitting Technologist, Shima Seiki Europe Ltd. Interview. 29th September 2005.


Blackman, Cally. "Hand knitting in Britain 1908-1939, the work of Margery Tillotson". *Textile History* 29.2. (1998): 177-200 Print


Bougourd, Jeni, 15th April 2007, Interview 1.

------- 23rd April 2007, Interview 2.


------- "Size designation of clothes — Part 1: Terms, definitions and body measurement

<http://www.techexchange.com/thelibrary/VirtualFit.html>
Chowdhary, U. "Clothing preferences of older consumers". *Perceptual and Motor Skills* 86.3 PART 1. (1997): 819-826
Chowdhary, U. "Apparel shopping behaviour of elderly men and women". *Perceptual and Motor Skills* 68.3 II. (1989): 1183-1189

8/7/2009.
Colls, R. "Looking alright, feeling alright. Emotions, sizing and the geographies of women's experiences of clothing consumption". *Social and Cultural Geography* 5.4. (2004): 583-596

-333-


David Clayton. "A Hong Kong knitting factory in 1933:its reconstruction from bankruptcy court records". *Journal of Industrial History* 3.2. (2000): 51-69 Print


Davis, L.L. "Perceived somatotype, body-cathexis and attitudes toward clothing among college females". *Perceptual and Motor Skills* 61.3 II. (1985): 1199-1205

-334-


Desdemona (Participant 2), 19th September 2006, Interview 1 - about purchasing clothing and body type.


Devarajan, Priya, and Dr Cynthia Istook. "Validation of Female Figure identification Technique (FFIT) for Apparel Software". *Journal of Textile and Apparel technology and Management* 1.4. (2004): 23. North Carolina State University Print


Duckworth, Andy. "3D body scanners and how to grow edible clothes". guardain.co.uk: guardian.co.uk, 2010.


------- "Managing effective communication in knitwear design.". *The Design Journal* 2.3. (1999): 29-42 Print


Farrer, Dr Joan. "Fashion Textiles+ Sustainability:Communicating People Profit Planet through Clothes". The 'S' Word RMIT, Australia: RMIT, 2009.


Harter, Pascal (pres) "Spain resizes clothes for women". BBC world service. 26th January. Web.


Hunter, Billy. "Shima Seiki collaborates with leading department store on Ordermade


Hwang, J. "Relationships between body-cathexis, clothing benefits sought, and clothing behavior; and effects of importance of meeting the ideal body image and clothing attitude". Unpublished doctoral dissertation, Virginia Polytechnic Institute and State University, Blacksburg., 1997. Doctoral.


*Is the fashion industry catering for the over fifties? Women's Hour.* BBC. 11 June 2007


Istook, Cynthia L. "Enabling mass customization: computer-driven alteration


Koski, Anna, 11th April 2011, Interview about the knitwear design process.


Kwon, Yoon-Hee, and Ellen S. Parham. "Effects of State of Fatness Perception on


"Large Sizes Supplement". *Stitchcraft*. 1948.


Manager, Noa-Noa, April 15th 2008, Larger size availability in retail.


Meng, Yuwei, P. Y. Mok, and Xiaogang Jin. "Interactive virtual try-on clothing design systems". Computer-Aided Design 42.4: 310-321


Press Association. "By 2020, 80% of men will be overweight, study shows". The Guardian 16th February 2010.
Probert, Christina. Swimwear in Vogue since 1926. Thames and Hudson, 1981.
Rawi, Maysa. "Designer Julien Macdonald attacks plus-size models, branding them 'a joke". Mail Online 17th June 2010, sec. Female.
Recueil de Dessins et Points de Fantaisie. Edouard Dubied et Cie, [c.1923].
Redström, Johan. "Towards user design? On the shift from object to user as the subject of design". Design Studies 27.2. (2006): 123-139
Renn, Cristal. "Women as a whole don't separate sizes". The Independent 16th June 2010.
Righetti, Maggie. Sweater Design in Plain English. New York: St Martin's Press,
1990.

Rota, Jayne, Interview, 9th November 2006.
Scholz, Anna, 17th May 2011, Interview about the design process for larger sizes.
Segal, Lynne. "Agewise: Fighting the New Ageism in America". Time Higher
Seid, Roberta. Never too Thin: Why women are at war with their Bodies New York: Prentice Hall, 1989.
Settle, Alison. Repercussions. Unpublished manuscript .Print. Box 3 FGS. Alison Settle Archive, Design Archive, University of Brighton
----- The best examples of British Fashion in 1937. Unpublished manuscript . Print. P3. Alison Settle Archive, Design Archive, University of Brighton


Size Zero Culture - Who's to Blame?. Womens Hour. BBC. 7 February 2007


"Smart Shops are buying in London; Knitted Boleros". Fairchild's International. April 1930: 94.


Talbot, Anne. "Sifting the Collections". Stitchcraft. 1933: 6-7 and 22.


"They Bear The 'Smedley' Tab!". Moderna. October 1934: 18. Teaching Collection, School of Humanities, University of Brighton.


----- Interview: knitwear for larger sizes. 13/6/2011.

Too Fat or Too Thin. BBC. 25th April 2007

Topshop Snubs Beth Ditto. 2008.


"Training requirements not being met". Knitting International. February 2007: 16.


"Trinny and Susannah reveal 12 women's body types - which are you?". Mail Online 18th October 2007, sec. Femail.


Underwood, Jenny. "The Design of 3D Shape Knitted Preforms". PhD Thesis. RMIT,


van derZee, Bibi. "Where to find the perfect fit". The Guardian Saturday October 16 2004.


Wang, Jian Ping. "An approach to predicting bra cup dart quantity in the 3D virtual


Webster, Richard, Sales Director of Shima Seiki Europe Ltd. Interview. 22nd July 2009


Welling, H. "CAD's increasing cost-savings benefits". *Apparel Industry Magazine* 60.2. (1999): 50


"Woolies Can Be So Very Smart!". Modena. 1934. Teaching Collection, School of Humanities, University of Brighton.


World Congress on Mass Customization and Personalization (MCPC’03). Technical University of Munich, Germany, 2003.


Appendices
Appendix A Manual measuring and development of a specific measuring system for larger body shape and size
A 1  Supporting documentation

1.1 Pilot Study Landmarks

BODY LANDMARKS
A - Centre front vee of clavicle.
B - Shoulder points at end of clavicle and top of shoulder ball joint, where flesh 'dimples' as arm goes up and back.
C - Side neck point, directly below hollow behind ear
D - Nape of neck, on protruding cervical vertebrae around C5.
E - Central marker point, mid way between lower rib and top of pelvic bone.
5th lumbar vertebrae at back.
E2 - 'Natural waist': narrowest part of the abdomen.
F - Underarm horizontal; mark front and back for constant.
G - At most protruding point of stomach, level line around body.
H - Widest frontal view hip line, level line around body.
© Vikki Haffenden 2006

(original in colour)
1.2 Page from research diary – preparation for Pilot Study measuring (2 pages)
* ethos I may consider *.
- clear math @ underarm?
- upper arm
- @ a set answer
down.
- "Clear depth between"
- "breast".
- back math @ underarm.

If I want to know how deep
skin is in rel to back
width - what do I need to do?

I want to know
that & their measurements,
are they same - probably
not.
So long put his down from
head. Should + measure
(even good too?) No -
use L measuring rule

like this. So can put
along arm along front of
body + measure off other.

little level that attaches to tape.
Found one! add to yellow
tape. may need frames for
that slide.

John Warren - dry - OV-DVD
phone + array. 3172
Paul Lyman 3171
3170 - Info Service

This week.

DVD-R can be bought £1.30:
Take DV tape. 11.30.
Tape = needles & DVD is the.
1.3 Pilot study measurement table (2 pages)

<table>
<thead>
<tr>
<th>MEASUREMENT CHART</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name or Identity No:</td>
</tr>
<tr>
<td>Date Created:</td>
</tr>
</tbody>
</table>

Before commencing, find and mark:
- A) Centre front vee of clavicle.
- B) Shoulder points at end of clavicle and top of ball joint on shoulder, mark down to underarm to check position (should be a straight line).
- C) Side neck point, directly below hollow behind ear, where neck widens to shoulder.
- D) Neck of neck
- E) Half way between lower rib and top of pelvic bone, and 5th lumbar vertebra and mark a horizontal line. This is your central marker line.
- F) Underarm a horizontal line on front and back body.

<table>
<thead>
<tr>
<th></th>
<th>Participants right side</th>
<th>Participants left side</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Centre Front Length, from A to E:</td>
<td>32cm</td>
<td>—</td>
</tr>
<tr>
<td>II. Front Shoulder Width B to E:</td>
<td>31.25cm</td>
<td>—</td>
</tr>
<tr>
<td>III. Front Shoulder Slope, from B to E:</td>
<td>40cm</td>
<td>40cm</td>
</tr>
<tr>
<td>IV. Shoulder Length C to B:</td>
<td>9.5cm</td>
<td>9cm</td>
</tr>
<tr>
<td>V. Bust Circumference:</td>
<td>103.75cm</td>
<td>—</td>
</tr>
<tr>
<td>VI. Under Bust:</td>
<td>84.5cm</td>
<td>84.5cm</td>
</tr>
<tr>
<td>VII. Shoulder B to Bust Point:</td>
<td>32.5cm</td>
<td>23cm</td>
</tr>
<tr>
<td>VIII. Bust Point to Bust Point:</td>
<td>19cm</td>
<td>—</td>
</tr>
<tr>
<td>IX. Centre Back Length D to E:</td>
<td>38.5cm</td>
<td>—</td>
</tr>
<tr>
<td>X. Back Shoulder Width B to E:</td>
<td>34cm</td>
<td>—</td>
</tr>
<tr>
<td>XI. Back Shoulder Slope B to E:</td>
<td>41.25cm</td>
<td>—</td>
</tr>
<tr>
<td>XII. Neck Circumference:</td>
<td>32cm</td>
<td>—</td>
</tr>
<tr>
<td>XIII. Circumference at E:</td>
<td>88.5cm</td>
<td>88.5cm</td>
</tr>
<tr>
<td>XIV. Upper Chest depth at underarm (millimeters):</td>
<td>42cm</td>
<td>42cm</td>
</tr>
<tr>
<td>XV. Hip Circumference at widest:</td>
<td>104cm</td>
<td>104cm</td>
</tr>
<tr>
<td>XVI. Hip Depth underarm to XV:</td>
<td>35cm</td>
<td>35cm</td>
</tr>
<tr>
<td>XVII. Thigh Circumference:</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>VIII. Thigh Circumference</td>
<td>Depth underarm to XVIII:</td>
<td></td>
</tr>
<tr>
<td>---------------------------</td>
<td>------------------------</td>
<td></td>
</tr>
<tr>
<td>XIX. Shoulder B to Wrist bone:</td>
<td>62.5</td>
<td>62.5</td>
</tr>
<tr>
<td>XX. Eisco Circumference:</td>
<td>31.75</td>
<td>31.75</td>
</tr>
<tr>
<td>XXI. Wrist Circumference:</td>
<td>15.5</td>
<td>15</td>
</tr>
<tr>
<td>XXII. Height:</td>
<td>164.5</td>
<td></td>
</tr>
<tr>
<td>XIII. Shoulder point B to floor at side:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>XXIV. Centre Front A to floor:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>XXV. Centre Back Nape D to Floor:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>XXVI. Shoulder point B to underarm, flat on body:</td>
<td>20.5 F</td>
<td></td>
</tr>
<tr>
<td>XVII. Body depth at B (callipers):</td>
<td>22.75</td>
<td></td>
</tr>
<tr>
<td>VIII. Body depth at XV (callipers):</td>
<td>26.75</td>
<td></td>
</tr>
<tr>
<td>XXIX. Body width at E (callipers):</td>
<td>29.25</td>
<td></td>
</tr>
<tr>
<td>XXX. Body width at XV (callipers):</td>
<td>38</td>
<td></td>
</tr>
<tr>
<td>XXXI. Upper chest circumference at underarm:</td>
<td>96 cm</td>
<td></td>
</tr>
</tbody>
</table>

Notes:  
- 90 cm -E  
- 50 cm -F  

*dimmers applied so tape Ed clear*
1.4 Measurement table revised for the main study (3 pages)

BODY MEASUREMENT CHART - to be used in conjunction with Body Landmarks and Body Dimension Sheets.

<table>
<thead>
<tr>
<th>Name OR IDENTITY NO:</th>
<th>Date Created:</th>
</tr>
</thead>
</table>

Before commencing, find and mark:

A) Centre front vee of clavicle.

B) Shoulder points at end of clavicle and top of ball joint on shoulder, mark down to underarm to check position (should be a perpendicular line).

C) Side neck point, directly below hollow behind ear, where neck widens to shoulder.

D) Nape of neck, on the protruding bone at top of spine. (approximately at C5)

E) Half way between lower rib and top of pelvic bone, and 5th lumbar vertebrae, mark a horizontal line round body. This is your central marker.

E2 is the narrowest contour of the mid torso where a loose circle of elastic settles. Mark this line, which may not be straight. Measure the distance from E to E2 at CF, CB, L, R sides.

F) Underarm, a short horizontal line on front and back body, mark horizontal line around body at CF and CB

G) Tummy- horizontal line around body at most protruding point of stomach.

H) Widest hip circumference from frontal view.

KEY: * these measurements are taken flat on the body surface.

<table>
<thead>
<tr>
<th>Participants right side</th>
<th>Participants left side</th>
</tr>
</thead>
</table>

I. *Centre Front Length, from A to E: |

II. *Front Shoulder Width B to B: |

III. Front Shoulder Slope, from B to CF @ depth E: |

IV. *Shoulder Length C to B: |

V. *Bust Circumference (but not into negative space between breasts): |

VI. *Under Bust: |

VII. *Upper chest |
<p>| VIII. | Bust Point to Bust Point (apex of bust): |
| IX. | *Shoulder B to Bust Point |
| X. | *Centre Back Length D to E: |
| XI. | Back Shoulder Width B to B (goes through back neck point): |
| XII. | Back Shoulder Slope B to E: |
| XIII. | *Shoulder point B to underarm, flat on body: F B F B |
| XIV. | *Circumference at E: |
| XV. | *Thigh Circumference at widest: |
| XVI. | *Depth underarm to thigh circumference XV: F B F B |
| XVII. | Hip Circumference: |
| XVIII. | *Depth underarm to hip circumference XVII: F B F B |
| XIX. | *Shoulder B to Wrist bone: |
| XX. | *Bicep Circumference: |
| XXI. | *Wrist Circumference: |
| XXII. | Overall height: |
| XIII. | Shoulder point B to floor at side: |
| XXIV. | Centre Front A to floor: |
| XXV. | Centre Back Nape D to Floor: |
| XXVI. | *Neck circumference: |
| XXVII. | *Underarm to Tummy line (most protruding point of stomach) - taken at CF, CB and at sides: CF - flat to body CB - straight down CB - flat Right Left |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VIII. Tummy circumference</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>XXIX.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>XXX. Tummy circumference distance to E</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>XXXI. Shoulder B to narrowest part of the body (flat to body and perpendicular)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>XXXII. Underarm to E</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>XXXIII. Upper chest (from where B to underarm line bisects underarm to underarm line)</td>
<td>F</td>
<td></td>
<td>B</td>
</tr>
<tr>
<td>XXXIV. Natural waist circumference E2 distance to E</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>THE FOLLOWING ARE ALL TAKEN WITH CALLIPERS.</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Body depth @ most protruding point of stomach:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Body depth at E:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Body width at E:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Body depth at hip circumference XV:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Body width at hip circumference XV:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Body width at thigh circumference XVII:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Body depth at thigh circumference XVII:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upper Chest depth at underarm (between breasts):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Body width at underarm, including arms:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Measurement Notes:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>May need to take ‘New Bust point’ if bust does not have a clear apex. This is from where the tape and the bra separate at the outer edge of the bust curve to the other side, same position. If this is taken, then B to this point is also needed.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Should angle?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>--------------</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>E to hip depth</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Comments</th>
</tr>
</thead>
</table>
1.5 Participant consent and information sheets

Consent Form

The Innovative Application of Existing Digitally Controlled Flat Bed Weft Knitting to Fashion Knitwear for the Individual Body Shape of Women, Particularly Those Above UK Standard Sizes

PhD research by Vikki Haffenden, University of Brighton

Name of Participant:

I agree that Vikki Haffenden (the Researcher) may use the following information and representations obtained from me in the course of her research entitled

I agree for these to be disclosed anonymously in relevant publications, on the internet and in the public forum of a conference or seminar.

Data Protection

Your personal data which may include all measurements, body scans, images and research data, may be used by the researcher for research purposes. It will be used in development of garment sizes, held in a data base and analysed for research. It may also be shared anonymously with a third party during the development of a cross platform translation filter (scan data to knitting programme) but not used for any commercial purposes.

Confidentiality

At all times your identity will be kept confidential and only known to the researcher, the scanning technician and any one you choose to disclose it to.

Your information is confidential and you may request a copy at any time.

Intellectual Property

All intellectual property rights created by or associated with this research are vested in the Researcher

Photographs
Verbal communications and recordings

Non-verbal communications
Written communication

Questionnaire/survey results
Measurement data

Video footage
Body shape information

3D bodyscan data

Signed

Date
The Innovative Application of Existing Digitally Controlled Flat Bed Weft Knitting to Fashion Knitwear for the Individual Body Shape of Women, Particularly Those Above UK Standard Sizes
PhD research by Vikki Haffenden, University of Brighton.

This PhD project is investigating the fit of custom made knitwear on women of a size 16 or over.

All measuring, cloning and evaluation sessions will be arranged at your convenience in both time and venue (apart from 3D body scanning which is in London). If you have care responsibilities, sessions can be at your home if this is more convenient.

Participation in the Research Process

Initial participation will require you to be manually measured and in a separate session to have a 3D body shape ‘clone’ taken of your torso, neither of which will be judgemental in any way. The project is not about what size you are, but types of body shape. Later on some may be asked if they will have a 3D body scan done.

After this knitted garments will be made and your attendance at one or two evaluation sessions will be required. Feedback from participants is asked for about the garment during these sessions. Photos and video will be taken.

Manual measuring

Participants wear underwear only and are marked with a washable felt pen (or coloured dots or blu tak if you prefer, please let me know if this is your preference in advance). There will be a second woman present to assist me, whose identity I will notify you of in advance. You may know this person so if this happens and you prefer to have someone you don’t know, please tell me beforehand.

- Time per session - between 1 and 1 ½ hours and can be quite tiring as you will need to stand for most of this time, although a seat will be available for rest periods.
- Researcher provides drinking water, wipes for cleaning off markings and a dressing gown in case you need to visit the toilet.
- Sessions will be carried out in a private, lockable room in the Research Centre at the University.
- Wear the underwear in which you feel your ‘best’, as this is the body shape I will be customising to fit. (Please wear the same underwear to the evaluation sessions).
- Sessions will be videoed, recorded and photos taken.
- An informal interview will start the session when you will be asked about clothes shopping and your body shape.

Practise based work is carried out at the Grand Parade site of the University of Brighton.

3D body ‘clone’ making

- If you are claustrophobic or can’t tolerate tight clothing for long, this is not suitable for you as the process requires you to be wrapped quite tightly in tape which is cut off your body at the end of the session.
- Time per session - approximately 2 hours and can be quite tiring as you will need to stand, particularly for the latter part this time, although a seat will be available for rest periods.
- Researcher provides drinking water, tea or coffee and a dressing gown in case you need to visit the toilet.
- Sessions will be carried out in a private, lockable room in the Research Centre at the University.
• Wear the underwear in which you were measured, as this is the body shape I will be customising to fit. (Please wear the same underwear to the evaluation sessions).
• Sessions will be videoed, recorded and photos taken.
• During this session you may be asked about clothes shopping and your body shape.

Evaluation and Feedback

• Two or possibly three sessions of approximately 1 ½ hours.
  Researcher provides drinking water, tea or coffee.
• Sessions will be carried out in a private, lockable room in the Research Centre at the University.
• Wear the underwear in which you were measured, as this is the body shape I will be customising to fit. (Please wear the same underwear to the evaluation sessions).
• Sessions will be videoed, recorded and photos taken.

The project will span about two years in all.

I can’t pay you for your time I’m afraid, but it is a fun thing to do and my first participant found it really interesting.

3D Bodyscanning
I have had one done to try it out as I would anyone to do anything I was unhappy about doing myself. It is a bit disillusioning seeing the results though, there is no escape from what your shape is when you see the image file!
I found the whole thing really interesting although a little weird, the technician is very sensitive and experienced and anticipated my nervousness.

Medical contraindications
If you have an aversion or medical problem with flashing lights then you should not have a scan. People with diabetes, asthma, epilepsy and who use a pacemaker may not be suitable for scanning, please let me know if this is the case and I will make further enquiries.

The process of 3D bodyscanning
• It is not painful or invasive in any way.
• It does not involve lasers or X rays and is not harmful to your health.
• The [TC]² scanner passes horizontal bars of light up and down your body. The manufacturer’s website states the following “…safe white light 3D body scanning White light is considered to be the safest body scanning technology. [TC]² scans are taken at floor level and self-stabilizing hand-holds are provided for the scan subject” and that their system is, “Consumer friendly, accentuating safety and privacy”.
• You stand up for the scan, which takes about 10 seconds.
• You can keep your eyes open all the time as the technology is harmless.
• The scanning is done in a private booth with an adjacent changing cubicle, and all instructions are clearly explained beforehand by a technician and relayed during the process.
• You may need a second or third scan done during the session depending on the accuracy of the first one.
• Processing the data takes about 1-1 ½ hours in the laboratory, but participants do not remain in the scanner for this time, it might be a good idea to bring a magazine to read whilst you wait.

Location
• The scanner at the London College of Fashion near Oxford Circus, London.
• Participants will have to travel to London, with the sessions starting at 11am.
• The scanner is only available all day Monday, and Tuesday and Thursday mornings.
• Travel costs and refreshments for the trip are paid by the Researcher, if it is not possible to do this in advance, please keep all receipts for these and they will be reimbursed on the day.
• The Researcher will accompany you on the trip.

What to wear for a scan
For the scan you need to wear non shiney, light coloured underwear that is quite close fitting, but not over tight.

A simple bra and briefs is ideal, please do not wear:
• Tights
• Basques
• French Knickers
• Sports tops,
• Teddies,
• Slips
• Camisoles,
• Petticoats
• Hair must be fixed up off the neck, with something non metal, like a scrunchy or elastic band.
• Large jewellery like watches, bangles and drop earrings need to be taken off must be taken off (not stud earrings or rings though).

Use and storage of data
• All data gathered is securely stored on a University computer which is password protected.
• Backup data, written forms and video/images are stored in a locked filing cabinet at the Researchers home
• You can have a copy of your 3D bodyscan data if you provide a USB stick on the day or I can supply an electronic version at a later date if you so wish.
• All their own data is available to the individual participants by request to the Researcher.
• Your data will be used in accordance with the Consent Form.

Withdrawal from the project
I really appreciate your volunteering for the project but sometimes circumstances change, and I want to reassure you that you may withdraw from the project at any time. If this happens, I would appreciate you letting me know as soon as you decide to do so, so that I can make other arrangements.
If there is anything else you would like to know, please feel free to ask me.

If you have any concerns about the research please contact my Supervisor, Professor Lou Taylor at the University of Brighton at Grand Parade. There are more details of my project at http://www.knittofit.co.uk and http://www.brighton.ac.uk/arts/research/4_0_rsd/4_3_0_phrds/4_3_33_Haffenden_Vikki.htm.

Vikki Haffenden

01273 883152 or 07905 515159  V.M.Haffenden@brighton.ac.uk
2.2 Measuring Portia 19th July 2006

(ORIGINAL IN COLOUR)
Appendix B Initial yarn selection, development of fabric, knitting techniques and early prototypes
B 1  Supporting documentation

1.1  Knitting data sheet designed for the research

<table>
<thead>
<tr>
<th>VikkiHaffenden PhD Research</th>
<th>SHIMA SEIKI KNITTING DATA</th>
<th>DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAMPLE NO</td>
<td>PATTERN DETAILS</td>
<td>FILE NAME</td>
</tr>
<tr>
<td>PATTERN NAME</td>
<td>DIGITAL STITCH</td>
<td></td>
</tr>
<tr>
<td>YARN</td>
<td>TENSIONS</td>
<td></td>
</tr>
<tr>
<td>STITCH PRESSER</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NEEDLE WIDTH</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TAKEDOWNS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>COLOURS/YARN FEEDER POSITIONS</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
2.1 Initial knitting and shaping sample development. 25th February 2004

- Initial knitting and shaping sample development.
2.2 Reflections on working methods, yarn selection and knitting structures. 1st April 2004.
2.3 Record of yarn test of Baruffa 2/30s Cashwool. 3rd October 2004.

3/10/04
Bar 1.800 Samples
Bar 2.000 Samples
Kitted as per. file bar 1.500 an
Shiva Seeku.

Functed - see Baruffa recommended 8the:

Samples = 6g each x 5 = 30g total.

Washed in 30°C water
with 2% by weight in hard
liquid wash (Adda) 1 minute
then 2% by weight 10% ac
conditioner (Adda) (1 g of Adda).
T. Dried @ Low for 30 min.
2.4 Development of first grid designs. 14th October 2004
2.5 Definition of the original grid for evaluation of garment and fabric behaviour on the body. 5th January 2005.

Knit large piece shaping + 0's

Definite tension = 745 -
12.5st = 2cm
16st = 2cm

5 sqs must be

Because if they are then laid over the body each segment is 2cm and is inevitably so - if I allow the pull row to 'float' it will not be accurate enough.

Width wise it needs as the rib will stretch if extended. But when static it does not.

14 x 18 Red + 1 line of green

510bu 000
10cm = 4 x 10 + 6
= 82mm
= 10cm
10cm = 4 x 15 + 5
= 65cm
2.6 Original flèchage method for Juliet. A larger bra cup was causing problems with missed stitches and gathering.
2.7 New flèchage method for bust darts, developed with the help of Phil Baines, Shima Seiki Europe Ltd. 29th September 2005.
B 3  Knitting samples and developments

3.1  Schema of conf9_darts.dat, early developments of vertical darting methods. This also shows the early bust dart method. June 2005.

(ORIGINAL IN COLOUR)
3.2 Conference poster presented at Knitting: Global Challenges conference, Manchester, 2005. The garment panel was knitted from the conf9_darts file in which vertical darting methods were developed.
3.3 Method for drawing schemata for larger size
Methods for drawing Shima Seiki .dat files

Vertical Darting

Effect on grid height
When adding the vertical dart narrowing pac lines, draw an extra line for them e.g. Each vertical grid = 19 rows including the pac row. The pac row is on a knit cancel so it does not represent a row of knitting.

Effect on vertical purl wales
• When using my vertical dart pac, the purl sts above the dart transfers must be deleted for one row. My pac leaves this row red, so needs filling in above Col99
• The purl sts above col 99 in the centre of the garment between the darts must be filled in with green to the edge of col99 above and below. However at the inner end of the darting, if there is a purl st above or below near the end transfer, draw red on the bordering rows so that the transfer works cleanly.
• The horizontal purl rows can interfere with the upper body narrowing, if on a row prior to or after a narrowing and col99, they will not transfer properly to knit the next selection.

Solutions:
• Either move the purl row one up (which will unbalance the grid, but only by one row and in one place), or alter narrowing sequence which is much more complex and causes more knitting defects usually.
• This also occurs in the top shoulder narrowings if used instead of bind offs.

Effect on carriage direction
When adding vertical darts, the pack develops 4 knit cancels on the line, which means that as the line itself is drawn as an extra line that equals 1 x knit cancel, then there are 3 knit cancels per repeat, so if an uneven number of narrowings, the carriage direction is affected at the bind offs and possibly the flechage, depending on where darts finish up garment.

Solutions:
• Work in even numbers of repeats or add an extra row in before first grid line at hem
• After hem put 5 lines of plain before grid starts to help prevent roll of hem. Knit hem at main 45 tension.
• At narrowings, put slow speed, different t down and knit cancels.

Making SPaint image into a working template
• Use waist and waist to hip distance to match relationships between E2, E, hip and hem.
• The 'waist' as body scan calls call it can be raised to E2 (narrowest point of torso) height by adjusting waist from top distance and use hip height at widest to tummy area if necessary.
• Make width of piece the widest of hip, waist, shoulder or hem.
• This is OK for 2D shape, but the 3D must be added initially at the edges, and then actually taken out (or added) in the middle of lines of knitting field. BUT initially it appears on the edges.
• Generate base shape in Spaint and adjust as below as necessary overall to meet calculations made manually. (eg different front and back widths).
• Add grid in SPaint and save outside, in developed stage with packs - then add darts.

Adjusting vertical darts
• Width @ narrowest where dart is to end – check it.
• Underarm shaping if needed
• Shoulder width to narrowest (or wherever where dart is to end)
• Use a free line to redraw shoulder to narrowest and edit armhole edge to dart frequencies –
• **Add the grid at this point, so that inserted rows expand the grid and lines of the grid are not lost.**
• Split @ narrowing on side (to give one empty row above each narrowing to insert pack colours into) Use Desdemona2 pack files, 162 and 161 on RH side and 164 and 160 on LH for narrowing 2s.
• Use my bind off packs as in Desdemona2 pack.

N.B. When inserting darts, try to put them inside vertical lines as then they are easier to draw and work out better.
If shoulder darts make sure front ones meet bust point and do not move into the neck, start darts after the narrowing finishes.

• Split in half and add an empty row @ dart position and fill with pack colours 168 and 169/170 (and this has a knit cancel on R5)
• Insert 2 empty rows for bind offs x2, add bind offs to 2sts inside line, they must be on a Col 6 L-R row @ RH side
• Insert 1 row @ each narrowing of Col 99 and underarm and add b off packs Cols 162 on 2s, 161 on 1son R
• Insert 1 row @ each shoulder narrowing, and add pack col;ours (162 and 166 on R)

Adding flèchage bust darts

Flechage width =
Front body width, minus (distance of bust points apart plus 8cm) \( \frac{2}{2} \)
(this allows 4 cm distance each side laterally outwards from point to avoid pointy shape, but 2cm may be better on a smaller bra cup)

Start @ approx 1 grid below armhole -this is a good position, but may need adjusting on lower bustlines. Flechage must start on a Col6 L-R row on the RH side and Col 7 R-L on LH side.

**Problems**
If number of narrowings are even = OK
BUT if there are K Cancels, they will alter the sequence, so flèchage and bind offs
will be in wrong direction - adjust if so.
One method of adjusting is to put transfer after tubular onto a Knit Cancel.
Same at top underarm narrowing and darts, all need Knit Cancels, then check with
Area – Directions on Option Line icon.

**Lastly**
Move LH flechage down or up 1 to make it start on a Col 7 R-L line, and to avoid as
much grid as possible.
If only 15 rows, no waste needed, but may need breaking and double system for tuck
in trailing system.
3.4 Schema of bil2dev22astrp12.dat, incorporating the ‘new’ flèchage method at the bust, and waste flèchage at the hem. This was the file from which the ‘Australia’ garment was knitted. A shortened version of
3.6 Spiral A and B flèchage experiments. Knitted in acrylic with grid marked on the rows to simulate effect. October 2006.
Appendix C Development of 3D body scan data into knitting processes
C 1 Supporting documentation

1.1 Definitions of 3D body scan measurements from sample scan – LCF mep file.

(ORIGINAL IN COLOUR)
### 1.2 Body scan measurement of Desdemona using LCF mep file

<table>
<thead>
<tr>
<th>Body Measurement</th>
<th>L Side</th>
<th>Measurements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chin Height</td>
<td>144.78</td>
<td>L SideBackWaistToKnee = 64.24</td>
</tr>
<tr>
<td>Front Neck Depth</td>
<td>0.25</td>
<td>L SideBackWaistToKneeStraight = 61.91</td>
</tr>
<tr>
<td>Front Neck Base Height</td>
<td>138.78</td>
<td>L SideBackWaistToGround = 62.87</td>
</tr>
<tr>
<td>R Side Neck Height</td>
<td>145.03</td>
<td>R SideBackWaistToGround = 110.44</td>
</tr>
<tr>
<td>R Back Neck Depth</td>
<td>0.50</td>
<td>L SideBackWaistToGround = 110.50</td>
</tr>
<tr>
<td>L Back Neck Depth</td>
<td>0.50</td>
<td>R Neck2Knee</td>
</tr>
<tr>
<td>R Long Shoulder Height</td>
<td>138.53</td>
<td>R Neck2Knee</td>
</tr>
<tr>
<td>L Long Shoulder Height</td>
<td>140.78</td>
<td>R Side2Knee</td>
</tr>
<tr>
<td>R Right Arm Syph Height</td>
<td>125.16</td>
<td>L Side2Knee</td>
</tr>
<tr>
<td>L Left Arm Syph Height</td>
<td>126.69</td>
<td>R Back NeckToBreastPoint</td>
</tr>
<tr>
<td>R Arm Syph Depth From Back Neck</td>
<td>20.07</td>
<td>L Back NeckToBreastPoint</td>
</tr>
<tr>
<td>L Arm Syph Depth From Back Neck</td>
<td>18.54</td>
<td>R Side NeckTo = 30.84</td>
</tr>
<tr>
<td>Across Back Height</td>
<td>126.66</td>
<td>L Side NeckTo = 30.74</td>
</tr>
<tr>
<td>R Arm Syph Depth</td>
<td>14.37</td>
<td>R Back NeckToUnderBustRelax = 50.79</td>
</tr>
<tr>
<td>L Arm Syph Depth</td>
<td>13.79</td>
<td>L Back NeckToUnderBustRelax = 50.22</td>
</tr>
<tr>
<td>R Arm Syph Girth</td>
<td>51.61</td>
<td>L Neck2UnderBust = 37.44</td>
</tr>
<tr>
<td>L Arm Syph Girth</td>
<td>50.50</td>
<td>L Neck2UnderBust = 36.95</td>
</tr>
<tr>
<td>Across Front Height</td>
<td>126.50</td>
<td>R Side NeckToWastStraight = 45.49</td>
</tr>
<tr>
<td>Bust Height</td>
<td>120.03</td>
<td>R Side NeckToWastStraight = 45.93</td>
</tr>
<tr>
<td>Cheek Height</td>
<td>127.29</td>
<td>R Side NeckToWastStraight</td>
</tr>
<tr>
<td>Under bust Height</td>
<td>114.53</td>
<td>R Bust2Wast</td>
</tr>
<tr>
<td>Waist Height</td>
<td>109.53</td>
<td>L Side NeckToWastStraight</td>
</tr>
<tr>
<td>Hip Height</td>
<td>30.52</td>
<td>L BustToWast</td>
</tr>
<tr>
<td>Top Hip Height</td>
<td>59.92</td>
<td>R Side NeckToWast2Wast</td>
</tr>
<tr>
<td>Upper Hip Height</td>
<td>104.63</td>
<td>L Side NeckToWast2Wast</td>
</tr>
<tr>
<td>Crotch Height</td>
<td>75.53</td>
<td>R Back Neck To Call Level</td>
</tr>
<tr>
<td>Body Rest Straight</td>
<td>33.69</td>
<td>L Back Neck To Call Level</td>
</tr>
<tr>
<td>Abdomen Height from Wast</td>
<td>4.89</td>
<td>L Back Neck To Call Level</td>
</tr>
<tr>
<td>Abdomen Height</td>
<td>104.53</td>
<td>L Side NeckToGround</td>
</tr>
<tr>
<td>Waist Height Average</td>
<td>18.80</td>
<td>L Back NeckToFront Ground</td>
</tr>
<tr>
<td>Seat to Wast To Ground</td>
<td>128.13</td>
<td>L Side NeckToFront Ground</td>
</tr>
<tr>
<td>R Thigh Length</td>
<td>72.53</td>
<td>R Side NeckToFront Ground</td>
</tr>
<tr>
<td>R Thigh Height</td>
<td>72.53</td>
<td>L Side NeckToFront Ground</td>
</tr>
<tr>
<td>L Thigh Length</td>
<td>27.58</td>
<td>Front Neck to Wast</td>
</tr>
<tr>
<td>L Thigh Height</td>
<td>27.58</td>
<td>L Side WastToThigh</td>
</tr>
<tr>
<td>R Knee Height</td>
<td>48.52</td>
<td>L Side WastToWast</td>
</tr>
<tr>
<td>L Knee Height</td>
<td>47.52</td>
<td>L Side WastToWast</td>
</tr>
<tr>
<td>R Med Thigh Height</td>
<td>62.02</td>
<td>L Side WastToFloor</td>
</tr>
<tr>
<td>L Med Thigh Height</td>
<td>61.52</td>
<td>L Side WastToFloor</td>
</tr>
<tr>
<td>R Call Height</td>
<td>42.52</td>
<td>R Shoulder To Wast</td>
</tr>
<tr>
<td>L Call Height</td>
<td>41.52</td>
<td>R Shoulder To Wast</td>
</tr>
<tr>
<td>R Minimum Leg Height</td>
<td>11.25</td>
<td>R Side Wast To HIp</td>
</tr>
<tr>
<td>L Minimum Leg Height</td>
<td>11.75</td>
<td>R Side Wast To HIp</td>
</tr>
<tr>
<td>R Ankle Height Outside</td>
<td>6.50</td>
<td>R Side Wast To Seat</td>
</tr>
<tr>
<td>L Ankle Height Outside</td>
<td>7.50</td>
<td>R Side Wast To Seat</td>
</tr>
<tr>
<td>R Ankle Height Inside</td>
<td>6.25</td>
<td>R Outside Leg Length</td>
</tr>
<tr>
<td>L Ankle Height Inside</td>
<td>7.25</td>
<td>L Outside Leg Length</td>
</tr>
<tr>
<td>Back Seat Ave</td>
<td>29.03</td>
<td>L Under Arm Length</td>
</tr>
<tr>
<td>Back Wast Length</td>
<td>38.78</td>
<td>R Under Arm Length</td>
</tr>
<tr>
<td>Neck2Wast</td>
<td>Contoured Back</td>
<td>35.05</td>
</tr>
<tr>
<td>R Centre Side Wast To Top HIp</td>
<td>9.93</td>
<td>L Arm Length Straight</td>
</tr>
<tr>
<td>R Centre Side Wast To Top HIp</td>
<td>19.81</td>
<td>L Crown Height</td>
</tr>
<tr>
<td>L Centre Side Wast To Top HIp</td>
<td>19.87</td>
<td>L Crown Height</td>
</tr>
<tr>
<td>R Side Back Wast To Under Buttock</td>
<td>35.31</td>
<td>R Back Neck To Elbow</td>
</tr>
<tr>
<td>L Side Back Wast To Under Buttock</td>
<td>35.80</td>
<td>R Back Neck To Elbow</td>
</tr>
<tr>
<td>R Side Back Wast To Knee</td>
<td>62.98</td>
<td>R Center Back To Elbow</td>
</tr>
<tr>
<td>L Center Back To Elbow</td>
<td>53.00</td>
<td>Total Crotch Length</td>
</tr>
<tr>
<td>Customer:</td>
<td>Garment: LCF</td>
<td></td>
</tr>
<tr>
<td>----------</td>
<td>-------------</td>
<td></td>
</tr>
</tbody>
</table>

**Measurements**

<table>
<thead>
<tr>
<th>CentraTorso Circumference</th>
<th>159.27</th>
</tr>
</thead>
<tbody>
<tr>
<td>NeckCollarGirth</td>
<td>45.61</td>
</tr>
<tr>
<td>BackShoulderWidth</td>
<td>43.91</td>
</tr>
<tr>
<td>BackShoulderWidth (contd.)</td>
<td>41.22</td>
</tr>
<tr>
<td>AcrossBackWidth</td>
<td>36.97</td>
</tr>
<tr>
<td>FrontShoulderWidth</td>
<td>36.59</td>
</tr>
<tr>
<td>AcrossFrontWidth</td>
<td>39.51</td>
</tr>
<tr>
<td>ButtleBust</td>
<td>22.85</td>
</tr>
<tr>
<td>NeckBasisGirth</td>
<td>51.00</td>
</tr>
<tr>
<td>HalfBust/Neck</td>
<td>13.36</td>
</tr>
<tr>
<td>BackNeck</td>
<td>26.72</td>
</tr>
<tr>
<td>NeckWidth</td>
<td>13.64</td>
</tr>
<tr>
<td>R. Shoulder Length</td>
<td>12.83</td>
</tr>
<tr>
<td>L. Shoulder Length</td>
<td>12.46</td>
</tr>
<tr>
<td>R. LongShoulder Length</td>
<td>12.92</td>
</tr>
<tr>
<td>L. LongShoulder Length</td>
<td>12.48</td>
</tr>
<tr>
<td>R. LongShoulder Slope</td>
<td>7.05</td>
</tr>
<tr>
<td>L. LongShoulder Slope</td>
<td>5.33</td>
</tr>
<tr>
<td>ArmSleeveWidthCaliper</td>
<td>14.72</td>
</tr>
<tr>
<td>ArmSleeveWidthCaliper (contd.)</td>
<td>15.34</td>
</tr>
<tr>
<td>ArmSleeveWidthTape</td>
<td>25.54</td>
</tr>
<tr>
<td>ArmSleeveWidthTape (contd.)</td>
<td>23.59</td>
</tr>
<tr>
<td>R. UpperArmGirth</td>
<td>34.84</td>
</tr>
<tr>
<td>L. UpperArmGirth</td>
<td>32.79</td>
</tr>
<tr>
<td>R. ElbowGirth</td>
<td>29.60</td>
</tr>
<tr>
<td>L. ElbowGirth</td>
<td>29.36</td>
</tr>
<tr>
<td>R. ForearmGirth</td>
<td>23.81</td>
</tr>
<tr>
<td>L. ForearmGirth</td>
<td>28.16</td>
</tr>
<tr>
<td>R. WristGirth</td>
<td>19.94</td>
</tr>
<tr>
<td>L. WristGirth</td>
<td>19.70</td>
</tr>
<tr>
<td>ChestGirth</td>
<td>102.58</td>
</tr>
<tr>
<td>ChestWidth</td>
<td>50.96</td>
</tr>
<tr>
<td>BustGirth</td>
<td>107.72</td>
</tr>
<tr>
<td>BustArcWidth</td>
<td>56.96</td>
</tr>
<tr>
<td>BustGirth (contd.)</td>
<td>139.17</td>
</tr>
<tr>
<td>R. BreastPerimence</td>
<td>25.04</td>
</tr>
<tr>
<td>L. BreastPerimence</td>
<td>20.64</td>
</tr>
<tr>
<td>UnderBustGirth</td>
<td>97.09</td>
</tr>
<tr>
<td>FrontUnderbustGirth</td>
<td>46.89</td>
</tr>
<tr>
<td>WaistGirth</td>
<td>56.12</td>
</tr>
<tr>
<td>FrontWaistGirth</td>
<td>47.77</td>
</tr>
<tr>
<td>UpperHipGirth</td>
<td>107.21</td>
</tr>
<tr>
<td>FrontUpperHipGirth</td>
<td>59.52</td>
</tr>
<tr>
<td>TopHipGirth</td>
<td>114.34</td>
</tr>
<tr>
<td>FrontTopHipGirth</td>
<td>60.55</td>
</tr>
<tr>
<td>HipGirth</td>
<td>116.34</td>
</tr>
<tr>
<td>FrontHipGirth</td>
<td>57.20</td>
</tr>
<tr>
<td>AbdomenFrontDepth</td>
<td>37.14</td>
</tr>
<tr>
<td>Buttocks BackX</td>
<td>83.36</td>
</tr>
<tr>
<td>Abdomen FrontX</td>
<td>120.50</td>
</tr>
<tr>
<td>R. ThighGirth</td>
<td>67.03</td>
</tr>
<tr>
<td>L. ThighGirth</td>
<td>67.55</td>
</tr>
<tr>
<td>MidThighGirth</td>
<td>55.15</td>
</tr>
<tr>
<td>L. MidThighGirth</td>
<td>64.35</td>
</tr>
<tr>
<td>R. KneeGirth</td>
<td>44.38</td>
</tr>
<tr>
<td>L. KneeGirth</td>
<td>43.55</td>
</tr>
<tr>
<td>R. LowKneeGirth</td>
<td>41.02</td>
</tr>
<tr>
<td>L. LowKneeGirth</td>
<td>39.99</td>
</tr>
</tbody>
</table>

**Measurements**

| R. CalF Girth            | 40.57  |
| L. CalF Girth            | 39.66  |
| R. Minimum Leg Girth     | 26.55  |
| L. Minimum Leg Girth     | 26.68  |
| R. Ankle Girth           | 33.97  |
| L. Ankle Girth           | 31.76  |
| R. LongFootGirth         | 34.58  |
| L. LongFootGirth         | 35.49  |
| R. FootGirth             | 23.66  |
| L. FootGirth             | 22.94  |
| R. FootWidth             | 5.02   |
| L. FootWidth             | 7.02   |
| R. FootLength            | 24.53  |
| L. FootLength            | 24.00  |
| MaxGirthBelowWatas Height| 56.93  |
| MaxGirthBelowWatas       | 119.20 |
| FrontNeckToBustLineEdit  | 24.85  |
| FrontNeckToBustRightLine | 24.83  |
| C:FrontNeckToBustLine    | 22.22  |
| B:NeckToBladeDistW1      | 19.14  |
| B:NeckToBladeHorizontalW1| 4.78   |
| B:NeckToBladeVerticalW1  | 18.25  |
| B:NeckToBladeDistanceW1  | 19.45  |
| B:NeckToBladeHorizontalW0| 5.76   |
| B:NeckToBladeVerticalW0  | 18.25  |
| FrontShoulderToPOFWestLeft| 44.23 |
| FrontShoulderToPOFWestRight| 42.81 |
| BackShoulderToPOFWestLeft| 41.26 |
| BackShoulderToPOFWestRight| 41.16 |
| OuterArmMinSubscapLine   | 34.82  |
| OuterArmMinSubscapRight  | 34.69  |
| Volume                   | 96.39  |
| Joints All               | 18.00  |
| Head Top Height          | 161.74 |
| Torso Slice File         | 236.76 |

(ORIGINAL IN COLOUR)
1.3 Body scan measurement of Portia using LCF mep file

![Body scan measurement diagram](image-url)

(ORIGINAL IN COLOUR)
<table>
<thead>
<tr>
<th>Measurement</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chn Height</td>
<td>140.89</td>
</tr>
<tr>
<td>Front Neck Depth</td>
<td>6.00</td>
</tr>
<tr>
<td>FrontToBackNeckHeight</td>
<td>141.14</td>
</tr>
<tr>
<td>R Side/NeckHeight</td>
<td>147.14</td>
</tr>
<tr>
<td>SideNeckHeight</td>
<td>140.89</td>
</tr>
<tr>
<td>BackNeckHeight</td>
<td>147.14</td>
</tr>
<tr>
<td>R BackNeckDepth</td>
<td>0.00</td>
</tr>
<tr>
<td>L BackNeckDepth</td>
<td>0.06</td>
</tr>
<tr>
<td>R Long/ShoulderHeight</td>
<td>159.90</td>
</tr>
<tr>
<td>L Long/ShoulderHeight</td>
<td>142.64</td>
</tr>
<tr>
<td>R RightArmsCrossHeight</td>
<td>152.14</td>
</tr>
<tr>
<td>L LeftArmsCrossHeight</td>
<td>150.60</td>
</tr>
<tr>
<td>R ArmsCrossDepthFromBackNeck</td>
<td>17.00</td>
</tr>
<tr>
<td>L ArmsCrossDepthFromBackNeck</td>
<td>16.54</td>
</tr>
<tr>
<td>AcrossBackNeck</td>
<td>132.10</td>
</tr>
<tr>
<td>R ArmsCrossDepth</td>
<td>6.75</td>
</tr>
<tr>
<td>L ArmsCrossDepth</td>
<td>12.04</td>
</tr>
<tr>
<td>R ArmsCrossGirth</td>
<td>43.34</td>
</tr>
<tr>
<td>L ArmsCrossGirth</td>
<td>44.91</td>
</tr>
<tr>
<td>AccessFlrRateHeight</td>
<td>130.55</td>
</tr>
<tr>
<td>Bust Height</td>
<td>121.89</td>
</tr>
<tr>
<td>Chest Height</td>
<td>128.39</td>
</tr>
<tr>
<td>Underbut Height</td>
<td>115.86</td>
</tr>
<tr>
<td>Waist Height</td>
<td>107.59</td>
</tr>
<tr>
<td>Hip Height</td>
<td>66.39</td>
</tr>
<tr>
<td>Top Hip Height</td>
<td>97.04</td>
</tr>
<tr>
<td>UpperArmLength</td>
<td>102.37</td>
</tr>
<tr>
<td>CrotchHeight</td>
<td>75.68</td>
</tr>
<tr>
<td>BodyRate(Straight)</td>
<td>31.80</td>
</tr>
<tr>
<td>AbdomenHeight/FromWaist</td>
<td>10.30</td>
</tr>
<tr>
<td>AbdomenHeight</td>
<td>87.50</td>
</tr>
<tr>
<td>Waist/ToWaistToGround</td>
<td>128.99</td>
</tr>
<tr>
<td>Seat/ToWaistToGround</td>
<td>128.99</td>
</tr>
<tr>
<td>R Thigh Height</td>
<td>72.89</td>
</tr>
<tr>
<td>ThighLength</td>
<td>30.59</td>
</tr>
<tr>
<td>L Thigh Length</td>
<td>30.68</td>
</tr>
<tr>
<td>Knee Height</td>
<td>46.89</td>
</tr>
<tr>
<td>L Knee Height</td>
<td>45.89</td>
</tr>
<tr>
<td>R Mid/Thigh Height</td>
<td>90.89</td>
</tr>
<tr>
<td>L Mid/Thigh Height</td>
<td>60.89</td>
</tr>
<tr>
<td>Calf Height</td>
<td>33.89</td>
</tr>
<tr>
<td>L Calf Height</td>
<td>35.89</td>
</tr>
<tr>
<td>R Minimum Leg Height</td>
<td>10.50</td>
</tr>
<tr>
<td>L Minimum Leg Height</td>
<td>10.50</td>
</tr>
<tr>
<td>R Ankle Height Outside</td>
<td>7.75</td>
</tr>
<tr>
<td>L Ankle Height Outside</td>
<td>5.50</td>
</tr>
<tr>
<td>R Ankle Height Inside</td>
<td>10.00</td>
</tr>
<tr>
<td>L Ankle Height Inside</td>
<td>6.75</td>
</tr>
<tr>
<td>Back Seat Angle</td>
<td>22.67</td>
</tr>
<tr>
<td>Back2WaistLength</td>
<td>43.76</td>
</tr>
<tr>
<td>Neck/WaistContouredBack</td>
<td>41.69</td>
</tr>
<tr>
<td>R Centre/SideWaistTopHip</td>
<td>10.97</td>
</tr>
<tr>
<td>L Centre/SideWaistTopHip</td>
<td>10.79</td>
</tr>
<tr>
<td>R Centre/SideWaistHips</td>
<td>22.26</td>
</tr>
<tr>
<td>L Centre/SideWaistHips</td>
<td>22.30</td>
</tr>
<tr>
<td>R Side/BackWaistToUnderButtck</td>
<td>32.92</td>
</tr>
<tr>
<td>L Side/BackWaistToUnderButtck</td>
<td>32.99</td>
</tr>
<tr>
<td>R Side/BackWaistToKnee</td>
<td>83.81</td>
</tr>
</tbody>
</table>

**Turning Research into Reality**

**NX12 3D Body Scanner**

**Customer:**

**Garment:** LCF

-402-
1.4 Portia measurements from Vikkiknit1.mep file – related to manual landmarks

Key to letter () = manual landmark
C = Chest (chest)
B = Bust (bust)
S = Stomach (E2)
W = Waist (E)
A = Abdomen (tummy point)
H = Hips (hips)
S = Seat (thigh)

(ORIGINAL IN COLOUR)
<table>
<thead>
<tr>
<th>Measurement</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bust_Full</td>
<td>107.7</td>
</tr>
<tr>
<td>Bust_Front</td>
<td>58.0</td>
</tr>
<tr>
<td>Bust_Back</td>
<td>49.7</td>
</tr>
<tr>
<td>Bust_Height</td>
<td>121.9</td>
</tr>
<tr>
<td>Bust_Full(Contoured)</td>
<td>110.2</td>
</tr>
<tr>
<td>Underbust_Full</td>
<td>89.7</td>
</tr>
<tr>
<td>Underbust_Front</td>
<td>43.7</td>
</tr>
<tr>
<td>Underbust_Back</td>
<td>46.1</td>
</tr>
<tr>
<td>Underbust_Height</td>
<td>115.9</td>
</tr>
<tr>
<td>FrontNeck2Bust_Left</td>
<td>25.4</td>
</tr>
<tr>
<td>FrontNeck2Bust_Right</td>
<td>24.8</td>
</tr>
<tr>
<td>SideNeck2Bust_Left</td>
<td>31.0</td>
</tr>
<tr>
<td>SideNeck2Bust_Right</td>
<td>30.8</td>
</tr>
<tr>
<td>BustToWaist_Left</td>
<td>16.6</td>
</tr>
<tr>
<td>BustToWaist_Right</td>
<td>16.3</td>
</tr>
<tr>
<td>Bust2Bust_Horizontal</td>
<td>22.0</td>
</tr>
<tr>
<td>Bust2Bust_Around_Neck</td>
<td>79.0</td>
</tr>
<tr>
<td>Bust_Prominance_Left</td>
<td>31.3</td>
</tr>
<tr>
<td>Bust_Prominance_Right</td>
<td>29.6</td>
</tr>
<tr>
<td>Landmarks</td>
<td>9.0</td>
</tr>
<tr>
<td>Stomach2_Full</td>
<td>95.4</td>
</tr>
<tr>
<td>Stomach2_Front</td>
<td>47.2</td>
</tr>
<tr>
<td>Stomach2_Back</td>
<td>48.3</td>
</tr>
<tr>
<td>Stomach2_Height</td>
<td>106.4</td>
</tr>
<tr>
<td>Stomach2_FrontX</td>
<td>118.3</td>
</tr>
<tr>
<td>Stomach2_BackX</td>
<td>91.0</td>
</tr>
<tr>
<td>armhole_depth_L</td>
<td>20.1</td>
</tr>
<tr>
<td>armhole_depth_R</td>
<td>17.8</td>
</tr>
<tr>
<td>Shirt_Sleeve_Left</td>
<td>71.5</td>
</tr>
<tr>
<td>Shirt_Sleeve_Right</td>
<td>73.6</td>
</tr>
<tr>
<td>arm_length_L</td>
<td>52.1</td>
</tr>
<tr>
<td>arm_length_R</td>
<td>53.8</td>
</tr>
<tr>
<td>Waist_Front_X</td>
<td>118.1</td>
</tr>
<tr>
<td>Waist_Back_X</td>
<td>92.1</td>
</tr>
<tr>
<td>Seat_Front_X</td>
<td>114.9</td>
</tr>
<tr>
<td>VRise_Front_X</td>
<td>30.2</td>
</tr>
<tr>
<td>VRise_Back_X</td>
<td>29.1</td>
</tr>
<tr>
<td>Neck_BackHeight</td>
<td>147.4</td>
</tr>
<tr>
<td>stomach_to_neck</td>
<td>41.0</td>
</tr>
<tr>
<td>stomach_to_shoulder_L</td>
<td>37.5</td>
</tr>
<tr>
<td>stomach_to_shoulder_R</td>
<td>36.2</td>
</tr>
<tr>
<td>stomach_to_abdomen</td>
<td>9.0</td>
</tr>
<tr>
<td>stomach_to_hips</td>
<td>14.5</td>
</tr>
<tr>
<td>abdomen_to_hip</td>
<td>5.5</td>
</tr>
<tr>
<td>Chest_Front</td>
<td>49.6</td>
</tr>
<tr>
<td>Chest_Back</td>
<td>54.1</td>
</tr>
</tbody>
</table>

(ORIGINAL IN COLOUR)
C 2 3D knitwear programming method

2.1 Method for generating knitwear with 3D shaping for larger body shape using the SDS-ONE® SPaint programme

1. Create a new size-based file: New- SPaint- Size

(ORIGINAL IN COLOUR)
2. Choose ‘Set in A (round)’ with angled shoulder seams (ORIGINAL IN COLOUR)

3. Match the required garment dimensions to Shima Seiki terms (see Chapter Five, Figure 5)
4. Add dimensions to table and save as .sch file

(ORIGINAL IN COLOUR)
5. Generate the 2D pattern pieces
(ORIGINAL IN COLOUR)
6. Add the stitch/loop density of the intended fabric
(ORIGINAL IN COLOUR)
7. The first 2D block is generated, and any adjustments can be made here. After this the front is adjusted in length to include the bust flèchage rows and the grid is imposed on the shape. (ORIGINAL IN COLOUR)
C 3 Proof of concept garment


Equipment used:
SSG122SV V-bed machine
RD2-SDS-ONE Programming system

Working with Technician Jeff Hill to knit a garment from my original files, Portia14F_RS (front and right sleeve) and Portia 13B_LS (back top and bottom and left sleeve).

These files had been sent electronically to him in advance.
It had been agreed by Richard Webster in summer 2007 that Shima would be willing to knit a garment for me at some stage before I finished. In late 2009, Richard said to send them and they would definitely do so by summer 2010 as I was originally finished then. Finally I sent them Feb 2010, followed this up in April/ May and June and finally offered the 20th and 21st July as they had a SSG122SV (sinker plus variable stitch) 12gge available for use then and Jeff Hill one of the Technicians was designated to work with me.

The SSG model is the latest version of the SES series machine. It has sinkers, so the waste flèchage technique I had employed at the start-up to aid the knitting of the bust flèchage was unnecessary. Unlike the presser foot present on both the SES and the SS, which only allow a few short rows (flèchage) to be knitted at a time, the sinkers hold non-knitting stitches down in the hooks to prevent them lifting off the needles whilst any amount of shaping rows are knitted across the remainder of the needles.

Jeff’s first impression of my files was that they were OK, and knitable, he had already knitted the front piece in taupe 2/30s acrylic and lycra before I arrived as the information they contain is sufficiently explicit. His words in regard to whether he could understand my files and work with them easily was, “I can see we are working from the same page”. He added that some designers expect either the Technician to do it all from a sketch, or the computer to do it all without understanding the knitting processes necessary for the result required. Sometimes what is required is just not knitable. His comment when we sat down to work on the front panel with vertical darting made by wale transfers at the shoulders was, “When I first saw this I thought, why’s she doing all this darting, its funny we had someone come in last week with darting, and now I see what you’re doing. It makes sense now, I can see what you’re doing.” This was accompanied by him looking at the sample, and also after my explanation of what the research was about. Until then he had been working 'blind', with no information about the purpose of the research garments, so being able to work directly from the files demonstrated quite clearly to me that they were:
1) readable
2) professionally programmed to a suitable level
3) contained understandable and effective knitting methods.

This was confirmed by Jeff Hill.
Portia 14F_RS (Portia14SSGNEW) Front piece.
Sample1: Complete front piece in Zegna Baruffa 2/30s and Bilorex 7034 plating together.

Progress:
Coming up a little small, this could be due to using digital stitch control which for best fabric works at 6.60mm and at a slightly tighter stitch tension than on the SES
Because Jeff had already spent time setting up digital stitch and knitting samples to attain a good fabric, and because the 2/30s was coming up well on this, as time was of the essence and limited, I decided to work with this rather than spend longer re-doing what was already done. Therefore the stitch density has altered and is no longer 70sts and 90courses per 10 cm. This means that the grid is now coming up fractionally smaller, being 1 stitch short of 2cm wide, and 1 row short of 2cm high. Because at this stage I am testing the method rather than using the grid, it has become a comparison not a measuring tool with which I can compare my files with what is happening on the fabric and see where additions can be made, and aided any re-draughting of the programmes. It must be stressed however, that the grid on this sample is not longer an accurate measuring tool. It was particularly useful as a rapid way of checking that front and back were coming up the same length/width when altering files.

This is a result of taking the pattern onto another machine, and having limited access to the workshop, and not as Jeff points out a fault in the file or the concept. He wanted at one point to move the darts on the stomach out to the side to edge shaping and I had to explain that by them remaining in the middle of the panel it gave the flare that I wanted for fitting the stomach shape. His response was that he was looking for the easy option, which is the technician’s way.

Sample 2: Complete front piece.
For this sample, an additional grid square of 14 sts was added straight down the middle, adding 14st to the width of the centre of the garment, which adds it to the bust to bust point width where it was lacking, to the chest, and to the bust, but also to the neck width. To alleviate this, an additional bind off of 7 sts each side was added at the neck/shoulder join.

An additional grid (14st, 2cm) was inserted in the length below the tummy darts to increase the length by 2cm.

The width is now correct, however, the length is still 3cm short.

Sample 3: Complete front piece.
As the armhole lengths are correct, and additional 28rows (3cms) is to be added as follows: 8r between bust fléchage and underarm bind off, 10r between fléchage and dart and 10r between dart and hem.

5pm. Sample left to knit. Size is fine, some drop sts and a little dirt on R but as time is short and I only have the machine today, this is proof enough. Off the machine in the morning, and it is fine for size now, some mending needed.
21st July 2010
Portia13B_LS (Portia13BSGGNew) Back piece.
In anticipation of the size coming up small as with front, in advance I have inserted the equivalent no of rows and sts into the bottom file. Therefore 18 rows (1 grid) is still to be inserted between underarm and dart top, whilst 28 rows (1.5 grids) have been inserted below dart. The grid must match up at the join, and at the sides. The bottom piece has had 14sts (1 grid) inserted cf. As on the front these are not quite 2 cm grids, but make a rough guide, and also a comparative system for sampling. Even with the tighter tension there are dropped sts, Jeff’s advice is to mend it, as in I don’t have the luxury of time to perfect the knitting, and still get a complete garment off in time. This is re-assuring and replicated my experience, validating that the sampling is never easy, and its not my machine, files, yarn, ability etc but common for even the most able and experienced professionals to have this occur.
Jeff will consider the problem of the darts finishing wider, not tailing off and therefore having to make two files and graft them together, but as time is short he will use my method.

Sample 4: lower back piece
Bottom of back, came up 2cm wide but the correct length, so take out the 14st (1 grid) inserted down cf.
Graft the top to the bottom and knitted next sample.
Sample 5: Complete back piece
Came up 1 grid short at the side seam, when compared to front, otherwise is the correct size. Realised had omitted to add 18r between underarm and darts. Added grid, now correct length and size.
Sample 6: Complete back piece - correct size, but damaged lycra broke.
Sample 7: Complete back piece - correct size –Final piece.

Sleeves
Portia14F_RS (Portia14SSGNew): right sleeve piece & Portia13B_LS (Portia13SSGNew)
Based on the experience from the front and the back pieces, I decided to add 28 rows (1.5grids) to the underarm length of the sleeve only; as the armholes on the front and back pieces had not been altered, the sleeve heads were to remain the same. The addition of 28 rows was based on the knowledge that the lower back piece, which is approximately the same length as the lower sleeve, attained the correct length by adding 28 rows. From the experience of fluctuating width, possibly affected by the darting, additional width has not been added at this point.
Sample 8: Right sleeve piece.
Sleeve head short by .5cm, so added 6 rows at top so can shape to height on linker.
Width is 2cm narrow, so added 14sts (1 grid) to the width in middle. As sleeves are symmetrical to underarm, and therefore the width will need adjusting the same on both, the left can be adjusted in this way, and the additional sleeve head height added will be used in same way as described on the right one above.
Sample 9: Right sleeve piece.
Correct size
Sample 10: Portia13B_LS - left sleeve piece.
Correct size
Portia14F_RS 4/2/2010  front
left shoulder raised 8 courses (8cm) higher than right
as slant is altered, and shoulder lengths are different
this has been altered to compensate
R shoulder length = 14.8, L is 13.5, knit them as 14.5
and 13 to allow for some stretch on seam, but tape the
seams to these lengths. Back neck is 16.6cm
Bust darts raised by 3cm (22r) and width boffs balanced
at 33 sts each.

(ORIGINAL IN COLOUR)
Testing stitch density/size

Working with dimensions – back

Working with dimensions - back

Back – final piece

Back – final piece

Left sleeve – final piece
Left sleeve - final piece

Right sleeve – final piece

Working with dimensions – right sleeve

Front – specification sheet
Front – final piece

The research file on screen

Steaming garment pieces

(ORIGINAL IN COLOUR)
C 4 Communications regarding 3D body scanning

Subject: RE:NX12 software for research request
From: David Bruner
Date: Wed, 5 May 2010 09:41:52 – 0400
To: Vikki Haffenden

Vikki – sorry it took so long to arrange – good luck and let us know how it goes.

Thanks,
David Bruner

[TC]2

From: Vikki Haffenden
Sent: Wednesday, May 05, 2010 9:44 AM
To: David Bruner
Subject: Re: NX12 software for research request

Dear Dr Bruner,
Thank you for your help in this matter, my research tutor has passed the software on to me. It was most kind of you to arrange this for me to enable completion of my research and I will ensure that TC2 are recognised in my text for your support.

Kind Regards,

Vikki Haffenden

On 28/01/2010 14:20, David Bruner wrote:

Vikki,

Could you do the work with NX-16 software? It will read NX-12 files and extract all the measurements as before (only more). If you could just send your advisor’s email contact at the University I will try and get this through. The NX-16 requires a “dongle” instead of a password but will work for 30 days (if you are installing it on a machine that previously had some version of our software it may not work).

Regards,

David Bruner

[TC]2
Subject: Your enquiry regarding our 3D solutions
From: Thiex Erika
Date: Tue, 25 Nov 2008 14:25:16 +0100
To: Vikki

Dear Vikki

Thank you very much for your nice telephone call and your interest in our 3D solutions for made to measure applications.

Enclosed you will find some documents about INTAILOR, our MiM solution for manufacturers:
INTAILOR_IB: Image brochure with a brief overview / functionalities
WP_INTAILOR: White Paper
INTAILOR – Summary: more detailed overview / process
Data_sheet: technical details about our two 3D body scanners LC (3 column scanner) and XXL (4 column scanner)
WP_Laserscanner: laserscanner and white light scanner in comparison

You are very welcome to visit us at the IMB in Cologne (http://www.imb-cologne.com), which will take place from April 21st to 24th 2009.
You will find us in booth 5.1, stand C10 / D11.

Dear Vikki, I hope to having been able to help you with the accordant information?

I wish you a lot of success for your research and doctorate!

Kind regards from Germany

Erika

Erika Thiex
Dipl.-Des. Fashiondesign

HUMAN SOLUTIONS GmbH
Erika Thiex
Marketing
Europazent 10
67667 Kaiserslautern
Germany

Phone: [REDACTED]
Fax: [REDACTED]
E-Mail: [REDACTED]
Internet: http://www.human-solutions.com

Geschäftsführer: Dr. Andreas Seidl
Eingetragen beim Registergericht Kaiserslautern HRB 3636
Sitz der Gesellschaft: 67657 Kaiserslautern

/---------------------------------------------------------------------------------------------------------------------

Von: Thiex Erika
Gesendet: Montag, 10. November 2008 14:37
An: [REDACTED]
Betreff: Vikki Haffenden Your enquiry regarding our 3D solutions

Dear Vikki Haffenden

Thank you very much for your enquiry regarding our 3D solutions for the clothing branch.
Appendix D Final design developments - evaluation on participants
D 1 Juliet 2-4 evaluations

1.1 Juliet 2

Back view – tight on buttocks
(ORIGINAL IN COLOUR)

LH side view – note tummy prominence
with pull-in underneath and peaking hem
back and front (ORIGINAL IN COLOUR)

Shows the M distortion on the upper back
(ORIGINALS IN COLOUR)
| LH armhole with sleeve lowered – neat ‘cupping curve’ of body and sleeve meeting | LH shoulder armhole and bust dart |
| RH bust dart, shoulder and armhole | RH armhole and rear underarm dart with sleeve extended |

(ORIGINALS IN COLOUR)
1.2 Juliet 3

R rear vertical dart on clone-

Detail – not extension of stitches

Back right shoulder

Back shoulders – some M distortion of grid

Bust darts are riding up, sleeve head fits well, shoulder moulds to shape

Back shoulder and underarm sits well, no wrinkles or stretching of grid

(ORIGINALS IN COLOUR)
Shoulder (R) point sits on correct place, no visible extension of grid on movement  

Tummy prominence visible, could be looser over this? Bust darts are riding up, causing wrinkles at underarm  

Some pull at underarm, she is reaching forward – note wrinkling on front shoulder  

Bust darts to high by 2.5 grids, causing wrinkling at underarm and stretch on bust apex  

(ORIGINALS IN COLOUR)
Hem is curling back and front

(ORIGINALS IN COLOUR)
Pulling in under tummy point

Good range of movement without over extension of stitches or grid

Back shoulder follows body contour so does not ride up when bent forward

Back shoulder contours body well

(ORIGINALS IN COLOUR)
Some diagonal wrinkles on back

Detail of this – could try increasing depth of underarm dart

Good range of movement without distorting fabric

Good silhouette, except for bust dart and hem

(ORIGINALS IN COLOUR)
<table>
<thead>
<tr>
<th>Detail of R bust dart</th>
<th>Detail of R rear underarm dart</th>
</tr>
</thead>
<tbody>
<tr>
<td>Back R shoulder/ sleevehead, armhole and dart detail</td>
<td>Detail of R shoulder dart</td>
</tr>
</tbody>
</table>

(ORIGINALS IN COLOUR)
1.3 Juliet 4

Fit is good on shoulder, chest and armhole

Detail of bust darts now in correct place

Movement not fitting wrinkles on chest

Movement not fitting wrinkles on front shoulder

(ORIGINALS IN COLOUR)
Views of front with movement not fitting wrinkles

(ORIGINALS IN COLOUR)
<table>
<thead>
<tr>
<th>Sideviews, does not drag or wrinkle in vertical or horizontal direction</th>
<th>Note good bust contour, cuff good length now and width is fine.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Three quarter views- back sleeve fit is improved, shoulder contours to body neatly (ORIGINALS IN COLOUR)</td>
<td>Minimal extension of grid when she reaches forward, the enhanced armhole shape enables this</td>
</tr>
</tbody>
</table>
Sleeve fits well and does not wrinkle or show extension of grid

Tummy prominence now glided over, and fabric drapes smoothly between bust and tummy

Back view- no fitting wrinkles, minimal movement wrinkles and not grid extending over buttocks or round of upper back

M not apparent in grid on upper back and minimal extension even on bending forward as curve of back has 3D shaping to accommodate this

(ORIGINALS IN COLOUR)
## D 2 Desdemona 2-4

### 2.1 Desdemona 2 – on clone

<table>
<thead>
<tr>
<th>Checking dimensions pre making up</th>
<th>Body pieces</th>
</tr>
</thead>
<tbody>
<tr>
<td><a href="#">Image</a></td>
<td><a href="#">Image</a></td>
</tr>
<tr>
<td><a href="#">Image</a></td>
<td><a href="#">Image</a></td>
</tr>
<tr>
<td>Sleeves</td>
<td></td>
</tr>
<tr>
<td><a href="#">Image</a></td>
<td><a href="#">Image</a></td>
</tr>
</tbody>
</table>

(ORIGINALS IN COLOUR)
Front view - No obvious distortion of the grid, although the 9th grid up from the hem on the right hand side of the lower abdomen on the right hand side has a slight distortion widthwise

Back view

LH sideview

RH sideview

(ORIGINALS IN COLOUR)
RH armhole and body meeting - This does not appear to strain

Look to high at apex - check on participant. On clone need lowering by 2cm.

LH bust dart

Shoulder lies well on shoulder line, meet shoulder point

(ORIGINALS IN COLOUR)
Back neck lies well and does not distort the back panel

Needs more fabric over upper tummy and this could extend to hem

(ORIGINALS IN COLOUR)
2.2  Desdemona 2 on participant

Sleevehead to high and sleeve too wide and long

Front sleeve before alteration  After alteration

Back shoulder and armhole before and after adjustment (ORIGINALS IN COLOUR)
Front bust dart before and after adjustment

Sleeve too long and wide
Remove this from sleeve width

LH sleevehead before and after adjustment

(ORIGINALS IN COLOUR)
2.3 Diary page on re-working Desdemona 2 bust darts

(ORIGINAL IN COLOUR)
2.4 Desdemona 3 on clone and then on participant

Fits well on torso/stomach and hips
Fits well hips and buttocks

Hem lies horizontal upper back fits contours of shoulders
Vertical darts provide skimming not clinging on the tummy point

(ORIGINALS IN COLOUR)
Bust darts seem in correct position

Sleevehead needs adjusting – re-set in sleeve

Lost weight so evaluated shoulders and top fit mainly

Sleeves too long and wide, shoulders too wide

(ORIGINALS IN COLOUR)
Adjusted sleevehead, but body obviously too loose

Bust darts low by 4cm, will could due to weight loss probably – check this out

Hem at front too wide

Rear hem too wide

(ORIGINALS IN COLOUR)
Adjusted sleevehead back And front

When arm lifted front And back

(ORIGINALS IN COLOUR)
2.5  Desdemona 4 – on clone

| Revisions were to sleevehead and armhole |

(ORIGINALS IN COLOUR)
**D 3 Portia 4a**

<table>
<thead>
<tr>
<th>After weight loss – looks wide on lower torso and drops off shoulders, but bust area not bad, !</th>
<th>Diagonal wrinkles show too much fabric in width, back needs revising in width – front as well</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peaking of hem and droop at side seams because too much width - check bust darts</td>
<td>Same from RH side – note diagonal wrinkle between bust point and hip</td>
</tr>
</tbody>
</table>

(ORIGINALS IN COLOUR)
Sleeve head drops off shoulders both sides

Hem is not level from side

Bust dart too low – is this weight loss? Can’t be this much- she was wearing a new type of bra so that would account for this maybe?

(ORIGINALS IN COLOUR)
Although too long, the shoulders and chest area fit her contour well and her asymmetry.

Obviously too wide, difficult to assess movement wrinkles because of this. (ORIGINALS IN COLOUR)

Shoulders pulling up and wrinkling upper back as too long on shoulder line, but fell back to fit chest and bust well (see first picture).
3.1 Example of the participant garment evaluation form – Portia 4
<table>
<thead>
<tr>
<th>CONSTRUCTING</th>
<th>CONSTRUCTING</th>
</tr>
</thead>
<tbody>
<tr>
<td>When in movement</td>
<td>When in movement</td>
</tr>
<tr>
<td>LOOSE</td>
<td>LOOSE</td>
</tr>
<tr>
<td>COMFORTABLE</td>
<td>COMFORTABLE</td>
</tr>
<tr>
<td>CONSTRUCTING</td>
<td>CONSTRUCTING</td>
</tr>
<tr>
<td>COMMENTS</td>
<td></td>
</tr>
</tbody>
</table>

### Bustline

<table>
<thead>
<tr>
<th>Your left hand side</th>
<th>Front</th>
<th>Back</th>
<th>Your right hand side</th>
<th>Front</th>
<th>Back</th>
</tr>
</thead>
<tbody>
<tr>
<td>When standing still</td>
<td>When standing still</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LOOSE</td>
<td>LOOSE</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMFORTABLE</td>
<td>COMFORTABLE</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CONSTRUCTING</td>
<td>CONSTRUCTING</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>When in movement</td>
<td>When in movement</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LOOSE</td>
<td>LOOSE</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMFORTABLE</td>
<td>COMFORTABLE</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CONSTRUCTING</td>
<td>CONSTRUCTING</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Waistline

<table>
<thead>
<tr>
<th>Your left hand side</th>
<th>Front</th>
<th>Back</th>
<th>Your right hand side</th>
<th>Front</th>
<th>Back</th>
</tr>
</thead>
<tbody>
<tr>
<td>When standing still</td>
<td>When standing still</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LOOSE</td>
<td>LOOSE</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMFORTABLE</td>
<td>COMFORTABLE</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CONSTRUCTING</td>
<td>CONSTRUCTING</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>When in movement</td>
<td>When in movement</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LOOSE</td>
<td>LOOSE</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMFORTABLE</td>
<td>COMFORTABLE</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CONSTRUCTING</td>
<td>CONSTRUCTING</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Hip

<table>
<thead>
<tr>
<th>Your left hand side</th>
<th>Front</th>
<th>Back</th>
<th>Your right hand side</th>
<th>Front</th>
<th>Back</th>
</tr>
</thead>
<tbody>
<tr>
<td>When standing still</td>
<td>When standing still</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LOOSE</td>
<td>LOOSE</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMFORTABLE</td>
<td>COMFORTABLE</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CONSTRUCTING</td>
<td>CONSTRUCTING</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>When in movement</td>
<td>When in movement</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LOOSE</td>
<td>LOOSE</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMFORTABLE</td>
<td>COMFORTABLE</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CONSTRUCTING</td>
<td>CONSTRUCTING</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Chestline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Your left hand side</td>
</tr>
<tr>
<td>---------------------</td>
</tr>
<tr>
<td>When standing still</td>
</tr>
<tr>
<td>LOOSE</td>
</tr>
<tr>
<td>COMFORTABLE</td>
</tr>
<tr>
<td>CONSTRUCTING</td>
</tr>
<tr>
<td>When in movement</td>
</tr>
<tr>
<td>LOOSE</td>
</tr>
<tr>
<td>COMFORTABLE</td>
</tr>
<tr>
<td>CONSTRUCTING</td>
</tr>
<tr>
<td>COMMENTS</td>
</tr>
</tbody>
</table>

Please add any other observations you may have, including suggestions for improvements to the fit of the garment.

---

Loose last I've lost weight since measured
### 3.2 Portia 5 – on clone

<table>
<thead>
<tr>
<th>Photo</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.jpg" alt="Image" /></td>
<td>The symmetrical shoulder line is evident, but is it resulting in wrinkles below the RH armhole? Skims narrowest (E2) and then has room for hips below – same on back.</td>
</tr>
<tr>
<td><img src="image2.jpg" alt="Image" /></td>
<td>Possible M curves on upper back? Otherwise fits well at back armholes, and no visible distortion of grid on buttocks/hip.</td>
</tr>
<tr>
<td><img src="image3.jpg" alt="Image" /></td>
<td>Hem lies straight. No diagonal wrinkle so body width below armhole is good.</td>
</tr>
<tr>
<td><img src="image4.jpg" alt="Image" /></td>
<td>Bust and chest contouring is good, no distortion of grid or wrinkling.</td>
</tr>
</tbody>
</table>

(ORIGINALS IN COLOUR)
Details of successful shoulder dart and armhole/sleevehead shape

(ORIGINALS IN COLOUR)
Appendix E  Supporting documentation- interviews and survey data
E 1 Interviews with participants

1.1 Portia

Video interview pre-measuring Portia 19 July 2006
Selected quotes:

I’m certainly bigger than I was so buying clothes has got more difficult.

I buy a lot of clothes via the Internet because it’s easier.

I buy quite a lot of clothes from Boden, these are Boden trousers, and I quite like their clothes but again your find that, I think I size 18 – that should fit me but in fact it doesn’t always fit. Well the trousers are slightly large - the tops are sometimes slightly small. And then you think, ‘Can I be bothered to send this back? Or will I just wear it slightly small or slightly large? I tend to wear them not fitting as well.’

As I told you before, ...when I go on my summer holiday I take the opportunity to buy some trousers or something for the winter whilst in France. Because I find French ..sort of one up from the supermarket – stores, chains, are more sympathetic. They also have, I think they have, nicer clothes for the money than I would get here in Marks & Spencer, or I don’t know where else I would go – perhaps Jaeger in the sale. They will take things up – so if I bought a suit and the sleeves are too long, ‘pas de probleme madame”, come back tomorrow.

The attitude of the staff in the shops is that it is perfectly normal that you should want to have a nice, pair of trousers ....and that you will pay a certain amount for it, not in the shops that I go to at least, not hundreds of pounds. But that you are prepared to pay for something that is good, and there’s nothing strange about that. You wouldn’t expect it to be cheap, but you’d expect it to fit you and make you look good. You don’t get that in English shops at the level that I can afford. So I end up wearing a strange mixture of internet clothes. Well this – this came from a dress agency (speaking of her blouse).

I know we’re on tops today, but trousers are a particular challenge.

There’s too much of me round the middle. To get them comfortable at the front, they inevitably gape at the waist (gestures to her back waist). And then I end up with a ruffled bit that I put a belt on. So I end up looking worse than I was.

I do like jumpers, I like to wear a V necked black sweater. What I find there is that very often they’re a bit short. Because all tops are short now, they’re all designed for skinny teenagers. And I like something a bit longer, and that’s quite hard to find.

You know, a sort of thin, thin ply well, nicely fitting V neck sweater looks quite good on slightly larger ladies.

But its surprisingly difficult to find.

I’m more the pear shape....but I’m also ...lordosis - .all my life, even when I was a size 10, I’ve had this problem with my lower back.

So I’ve had a history of back problems, and I’m slightly lop-sided as well.
I’m aware that I’m not very symmetrical, one shoulder is slightly raised.

I used to like jumpers, particularly patterned jumpers. But I realised, you know, a few years ago, that perhaps that wasn’t such a good idea any longer. Its a strange thing that you want to find clothes, that - cos when you get a bit bigger the temptation is to wear a tent, and that isn’t always the best answer. But to find something that sort of skims the body and is flattering without sort of sticking to you and showing up every wrinkle of flesh is quite difficult. 

What I need are finely knitted – if I had the money perhaps I’m looking at cashmere- but I don’t have that sort of money. So I’m looking for things that are sort of a fine wool and are reasonably close fitting. And thats quite hard, thats quite hard to achieve.

How much do you spend on a jumper that you’re going to wear for work? If I spend a hundred pounds on a jumper – I can’t hand wash my jumpers. If I’m buying that expensive jumper it needs to be hand washed, but if I’m wearing it for work , you know...life is to short to hand wash jumpers.

Machine washable , I can do them on the delicate cycle.

I like it longer. 
I suppose just below the stomach, because thats the bit that sticks out, so if you cut it off in half you look... Because what happens with those shorter ones is that they ride up ..and its just not very attractive.
1.2 Desdemona

Transcript of Interview with Desdemona after weight loss, about shopping and clothing choices - 9th January 2008

Between March 2007 and November 2007 I lost 32lbs. I hardly noticed it, I hardly that I lost it, but it was triggered by what I said, by me seeing that body sculpture. So when I cut the clone off you, what were your thoughts?

No, no , not when you cut it off me. Oh yes, you cut it off me and you hung it, and I thought it looked like Pauline Quirk, you know when she does this, she’s in this role where she plays this really fat woman. It was the first time I had really clocked, in my head, that that was my shape and I had put on some much weight. and I hadn’t consciously recognised it, I mean I’ve seen my clothes size change from a, I used to be a 12/14 and I was nearly up tp 20 at that point so and my Mum…and when I saw that, something triggered in my head and I thought – this isn’t me, that’s not me and I couldn’t recognise myself.

So that took you…

April , May, June, July, August, September, October, November, eight months.

So we were just saying in Summer 2006 and then in Spring 2007 you decided you eanted to do it.

It really struck me, I thought I have to do something about it.

And then you reached your weight you are now in November?

Yah, round about November and it hasn’t changed much because of the Christmas period and I thought won’t worry about it and I still want to go by another 10 pounds to get to a size 14. Thats where, that’s really, I figure, because I know that’s where I can buy the clothes I want to buy and I think it’ll be just right, it’ll look right.

So you’ve gone from a, nearly a 20, Yah, nearly a 20.., 18-20 to a, nearly a 14?

Yah, its the tops, but for a lot of the tops I needed a 20.

Right

What, what was it that, I know often you need a different top to bottom size, but which, what was it that, was it shoulders, was it bust, was it tummy.

It was both, it was both of the, the middle bits (gestures around midriff with hands) the midriff bits because you know the trouser sizes had to be big enough to get round this stomach bit. And it also was my chest, my breasts. They grew and grew and grew and I had none before, and that was a massive experience, having breasts you know, (laughing) almost a tent, I used to laugh about it. And then there was the other thing, I used to hang the bras on the line and I thought they’re not my bras, whereas before I didn’t wear bras, until I got into the menopause, abut five or six years ago. I didn’t have enough to put in a bra and suddently I had this tent hanging on the washing line. But that didn’t trigger it though because that was just a funny experience suddenly having it and the weight its just that it was, it was really odd. And I never had experienced it, so in a way they were quite interesting experiences, but it did make me
think what kind of blouses I could buy, I would fit on the top part and then of course the middle bit, here, the bit where the shape went.

Did you find that having big breasts effected your posture? And has it changed now you have lost weight again?

No because I’ve always had problems with my shoulders and I’ve always tried to sort of sit up straight, so that didn’t change - they weren’t, not that heavy. Actually in proportion they were a good size now, suddenly it seemed suddenly more in proportion with me to have the bigger breasts than before. Before I was always quite shapely, thin but shapely but no breasts and there, now there were breasts and I had a cleavage and could wear things with a... I could wear things I’d not had before, so it didn’t bother me that much actually, it was just that I couldn’t find clothes that were nice any more in the sizes, whereas in Germany I can, or still could. I could still go to the shops and find lots of clothes that fitted. It got a bit more difficult to 18 and 20 but uh, whereas here I couldn’t find anything fashionable or nice.

So in Germany you could buy fashionable, clothes you wanted to buy, not just because they fitted, they were the right size, but they’d fit better as well.

Yeh, and they were stylish

Uh hu (nodding in affirmation)

And the other thing which happened with the big sizes what bothered me was that I like to knit and knitting and I like to choose nice, structure wools, heavy wools and knitting them in the big size, they just would drag, ‘cos they were so heavy. And do you know I loved my knitting when I was size 14, size 12, I could knit nice little tops and they didn’t look right any more, I was to big for them, so I knitted big garments and they would hang on you, they were dreadful. Go down to my kneecaps and you’d just think (fakes crying), they looked so nice in the picture ‘cos they were a smaller size, but as soon as I knitted them up in my size they weren’t the right sort of thing. The weight of the wool, what the wool weighs, because a lot of it is thicker wool, chunky wool. (laughs)

But its about 32lbs I lost, getting back to your question, I don’t know what that is in English pounds, probably more, because I was thinking German.

What kilos?

Not kilos, no. Oh yeah, because an English pound is 460grams and a German is 500.

Oh really,

So its actually more than 2 stone.

So you lost German pounds

No I lost 32 German pounds, yeah so if you think 16 kilos, its 16 kilos. 16 kilos, that quite a lot but it wasn’t that difficult, that was the other surprise, so ‘i was learning throughout, I was thinking hey why did I think this was so hard, it was just eating less.

Just eating less?
Less and lots more vegetables, making up the bulk with vegetables and stuff, but I’ve never snacked or anything, but it really must have been quantity mostly. So that’s all I’ve done, unless something else is happening that I don’t know about, it’s just dropped off. (laughs)

So we talked about changes in your tummy, you feel your boobs have shrunk a bit and are more in proportion

Since I’ve lost weight?

Since you’ve lost weight, yes

Is there anything else?

The waist in particular has come back and I can actually wear a dress and I can wear a broad belt and it looks like a lovely shaped figure, which I couldn’t do anymore ‘cos it was just round before, at the tummy. Obviously that middle bit, the stomach, just expands. So that’s nice. I’m pleased that I can wear that again, skirts I’m wearing again which I didn’t before. I, ahh the other thing that’s really interesting, people, I get compliments. Which you know, people normally would say, you wear something or other and they actually would say, you’ve got a nice pair of legs, or you’ve got a nice shape. Which I hadn’t thought about anymore, I’ve always taken it for granted in the past because I was sort of shapely, well without the big breasts but you know, and now its coming back and people are actually saying that again. And I am accentuating it with clothes I wear now whereas I wore nothing but big shirts and I hid it so well people didn’t realise how big I’d got.

So you learned to dress to fit your shape? To disguise your shape?

To disguise my shape, loose shirts, loose jumpers, with a nice little tee shirt under so, you know, it looked flowy, whereas now I can wear tight, I can wear small jackets again, which I hadn’t worn before. And the best thing was the other day I went to a wedding and I’ve got this lovely Italian designer suit that I never wanted to part with, a really tailored jacket and trousers with a big slit up the side, I bought it for **** daughter’s wedding 6 years ago and then I was a size 14 I think and it fitted, it fitted, it looked brilliant, but funny that I’d never got rid of it, I always thought I love this suit so much and now I fit it again and it shows my shape, its nice. It was really nice. So its going back to more shapely, I haven’t quite got the confidence to wear really tight stuff but I’m getting there so. I haven’t changed my wardrobe yet, because I’m losing more weight aren’t I? So….

So, so your actually feeling happy about your shape?

Yup

And, and before you lost weight you tried to disguise it

I think yes, I did, I adjusted and I made excuses, I didn’t sort of accept that I was fat. But, and I always found the clothes, it got to the point when I got to a size 20 point I couldn’t find clothes that I liked anymore, and I think that it was already in the pipeline that I thought, I think that I thought there’s something wrong here and you’ve
I think that’s really interesting..
Yeah?, just facial ones and…
You said earlier that when you were young you were very thin
Very thin
And that actually your shape became fashionable with the ‘Twiggy’ look.
Ohhh, that was my absolute life saver.

So, we were talking about confidence levels and you’ve never actually lost confidence in yourself.

Not after that, the 60’s because I was the perfect shape, I was like a beanpole, flat, no shape, well I always had a little bit of a waist because I’ve been quite broad in my hips but I was skinny and I could eat like a horse, oh it was lovely. I was very, I was also more energetic, athletic, did more, danced more, you know you do all those things as well, but that whole Twiggy trend with the short skirts and all that was absolutely perfect to give me confidence and I never lost that really. And in my head I stayed like that.

So partly because you were deceiving yourself as well you think your confidence…

Oh yeah.
So you couldn’t, you couldn’t really…One of the questions I asked was have you had any significant changes in your attitude to life? But you answered, not really because my confidence was already, because as a teenager your confidence levels were raised you maintained that as an adult.

Yeah, I just didn’t just accept that anything had changed. Didn’t want to accept. But I did get lots of hints from people, I did actually get hints from people but I would not take them. For example a couple of years ago it must have been when I’d already got quite big, I saw someone who I hadn’t seen for ages, the husband of a friend of mine, and he just looked at me and he said, “you’ve shrunk”. (laughs) Because, going broader, I looked shorter. But I hadn’t, and that’s what people saying to me now, you’re really tall, because the weights not there, because I am quite tall. But, and that’s probably why I carried off the weight quite well because you know it, and people didn’t see me as really fat, but…

So their perception was to see you as taller or shorter?

Yeh, I thought that was fascinating because he didn’t say “you’ve gone fat”, he said that “You’ve shrunk”. So he couldn’t quite figure, because I still looked alright in my clothes, and the way I dressed but something wasn’t quite right. I find it really interesting.
Before you lost weight what was your favourite part of your body and what was your least favourite would you say. Which bits did you want to disguise. Or which bit were you happy to show?

That’s, that’s difficult because I definitely did not want to show any of the middle bit because it has, it had lost shape, it was just a bulge, and the rolls and stuff. Now I wouldn’t wear a swimsuit , I wouldn’t be seen in a swimsuit or a bikini anymore. Uhmmm, but I’m trying to think it there was something that.. also wasn;t very happy with my face and neck, because the double chin was showing throught the weight and I’ve got big cheeks, and I’ve still got them a little bit but they really, really, you know how in photographs they exaggerate,a nd it showed, I looked like I had a fat face. So it was really the middle bit and the face and the neck area where…oh and here at the back. It was almost tlike a bulge, thers still a little bit there, sort of you know like I had sort of an extra cushion  fitting up here (gestures to back of neck/cervical spine) So even when you tried on the things, I wouldn’t wear something that had no collar, or something because it showed that there was that fat neck, and this is going with the weight loss and I’m really pleased about it. I think the lower bits of my legs were alright, you know I could wear trousers up to here ( gestures to upper calf) but I wouldn’t wear shorts anymore.

Or skirts?

Very rarely skirts, I got mostly into trousers but also cropped trousers , so you could still see the feet and the leg, that was also fine, but anything above. Chin to knee, yeah. Thats basically the one that didn’t work at all anymore and the legs they still looked, down here, they didn’t put on weight, they were alright down here (calf).

So those were your favourites?

Probably

And now, how has that changed?

Yeah, cos I mean I actually even wore short sleeved which I haven’t done for ages when I went to that wedding, when I wore the suit. I had a really cut top on it and I didn’t feel ashamed of my arms because that’s where the weight hung as well, you know it was really sort of, its not just the fleshy bit its also usually with no exercise you know, it just hangs and it looked horrible when I wore, so I didn’t wear short, that’s why I always wore long sleeved blouses with rolled up sleeves or something to hide it. And I actually had the courage to, to wear sh...still not a hundred percent but I don’t mind showing it.And the other bit is obviously when I wear a dress like I did the other day, so an almost straight cut straight dress, but then I put this really broad black belt around it, it looked lovely! And I look taller through it as well.

As well, the whole area here has changed as well (gestures to neck and shoulders)

The top you’re wearing today is open…

Yeh

…whereas I know you used to wear…
Collars

Do you, so its reversed, your middle bit you used to want to hide, you now accentuate.

Beginning to show, things I can wear now that I didn’t wear for a long long time. It looked funny before.

When you noticed you were loosing weight did you begin to notice a change in the fit of your clothing. what was the first thing you thought, Hey, you know, this is something that feels different?

The waist and this was particularly interesting because I didn’t straight away buy new clothes because I had no confidence that I would loose weight, because in the past very very occasionally I would try a diet and it would last for a week. But this time I thought, I’m not dieting, I’m eating differently. And I didn’t think of buying, I didn’t buy any clothes from I think until September?

That’s restrained.

Because, because I went to Germany in September you see I thought, Oh no I’ll buy a new lot when I go there. And God they were getting big, it was getting funny because my trousers actually just slipped down, so everything just was very, very loose and you know, then I could go back to some old clothes and suddenly they fitted properly, you know tee shirts, and stuff like that. They just had a better fit.

So ,so you noticed that you could wear clothes that you used to wear and you noticed that your trousers were loose, that your tummy was loosing, that you seem to have lost a lot.

Oh the waist,

The waist was probably what you noticed first, would you say?

You should see I’ve still got the trousers left, they’re so funny they’re size 18 and they just fall down. But funnily enough I haven’t thrown them out yet.

Your security blanket?

Yes its still there, its er.

Chuck ‘em out go on, chuck ‘em out.

No, and then the next step then was, I went to Germany in September and in Germany I fitted into a size 14/16 and I could not believe it , I really could not believe it. And that was really lovely because trousers ,trousers, I could always wear trousers, they always fitted me whatever sort of size I was in, they were cut I’ve somehow got the shape to wear trousers alright. But they fitted sort of snugly and with out tension, there were no bulges anywhere and it was brilliant, I was so excited about it. And it was lovely and I wore skirts. So that was really nice, and everyone noticing and saying something about it so it was really nice.
Did that spur you on?

Yeh, and the other thing, the other thing is obviously I had more choice, much more choice than I had in the bigger sizes.

So when you were larger, what, um, what sort of shops would you go into to look for clothes in the UK? I know in Germany but in the UK?

When I was larger?

Yes when you were larger.

It got really a bit difficult and it ended up with Marks and Spencer because they always have quite generous cuts. But you see I could compare because I used to wear, go to traditional shops, Laura Ashley, all the big, you know on the bigger sizes but they used to look OK on me and I couldn’t find clothes in Laura Ashley anymore, I couldn’t find, there was another firm I really used to like, ohh, in Debenhams they’ve got a branch of it, K something, really expensive one.

Kaliko? Spelt with a K?

No not Kaliko, not Kaliko, expensive and they’ve got a very small range but its treally lovely and I couldn’t fit into any of their stuff anymore. But Next you could forget about, I couldn’t, couldn’t fit into any of their stuff. But I’m terribly disillusioned with most of the clothing in this country anyway, I’ve never been, found it easy, I prefer small boutiques or small places, not the sort of trendy ones, I’ve never found stuff I wanted in there. But I had to give all that up and that’s why I ended up in Marks and Spencer and Debenhams and you know, ohh, the other one I ended up in, oh my goodness what’s it called, with E

Evans?

Oh yeah, I did! (laughing) and it was so sad, its so depressing, because the quality is so poor

Its cut like a tent isn’t it, they assume you’ve got massive boobs, massive shoulders, long arms

But that’s where I ended up, where anything fitted. I couldn’t find anything anywhere else, and that’s why I ended up, especially the last few years buying stuff in Germany because they have cheaper shops like Evans, (its not expensive), umm but the quality is better and the variety is better

And are there, are things like the sleeves in proportion, so they don’t assume you’re a gorilla?

No, no they don’t, no.

And the length of the trousers, you can buy a length that’s standard, but it’s a 20 waist?
Yeah, yeah, they’re standard sizes.

And so you say you haven’t done very much recent clothes shopping, except in September in Germany, but have you been shopping in the UK in your new size? Would you go back to looking in the boutiques, where do you think you might go looking now?

Yes, no, I think, I think I’d still look back, ‘n because I have sort of looked, I looked in Monsoon, and its all, I still, its not to do with size its something about……. I guess that I like and what has always suited my shape is classic styles, unfussy classic, stuff that I could combine in different ways, I always look for something a little bit unusual, a little, either a little decorative thing or something on there that’s different not, most of the shops I find, Marks and Spencers, Next anyone, all the stuff is the same, there is nothing, and I like to look for unusual things and I don’t find them, so it will be a whole new experience looking again because I haven’t looked, I haven’t looked for years because I knew nothing would fit me. I see often for younger people, really lovely and I think ‘ohh’, but I walk past it. because it would depress me so much just trying it on ‘cos it wouldn’t fit. Its a bit like with the knitting patterns, that they show them on these small sizes and you think ‘this looks lovely’, but I know that if I try it on it won’t look right. And I haven’t tested that yet, but I can find the kind of things that I like. So that’s an experiment yet to come. (Laughs)

But you might consider, if you saw something in a window that you liked, going in and trying it on?

I probably would, its funny that, because I haven’t bought clothes! Its really strange, since I’ve been to Germany, I’ve not bought anything for Christmas, I’ve not bought anything.

Why’s that?

Because I think in my head that I’m still not the right size, I still want to do that extra 10lbs, because I think that when you get to a size 14, which is my size, that’s when it starts getting really interesting. But I haven’t quite explored that yet.

Alright, what umm, so there were clothes you wouldn’t wear, you said you wouldn’t wear dresses, you wouldn’t wear skirts, now you are wearing them. Is there any other things, off the top? Tight clothes you said were off limits.

Tight clothes, anything fitted I just wouldn’t wear, I wouldn’t show my arms, I definitely wouldn’t show my arms.

What about your neck? You said you like to wear collars.

You know with the neck thing, because it got so big I didn’t wear anything that covered my neck really high up. I used to like wearing high roll neck jumpers and stuff like that but I just didn’t because my chim, you know all you could see was my double chin hanging over the top of it. And yes, I didn’t wear that much any more. I probably would, same as you want to expose it it also looks nice when its up, but I
haven’t done that much. I haven’t gone back to that. I should try it out and see if it works.

So you’re trying dresses, skirts, short sleeves, you’re trying lots of things that you wouldn’t have worn before you lost weight.

Yes I suppose they are slightly more trendy things, again because I used to buy wacky clothes occasionally, you know something that was really sort of, ‘cos you’d occasionally find it little boutiques or whatever, something that was really out of the ordinary. I wonder if, I haven’t looked for it, I wonder if it has something to do with drawing attention to yourself? You know if I did wear it? And that’s not to do with any particular part of my body, its to do with the kind of outfit it is. Like I described that outfit, the suit.

Yes.

It’s a very unusual outfit, it looks Sixties in some ways because it has a big appliqué of daisies, white daisies and when I describe it, it doesn’t look right, but it is so well designed and well made, it looks stunning when its on. Its got one big daisy here, and one button with one big daisy here and cuffed sleeves with little daisy petals here. Now, when I was big I wouldn’t have work something, it only looks good when you’re tall and slim, yeh. So its about finding things that are really unusual and different, but only work if you’ve got the shape to carry it off. Its like a lot, if you look at the catwalks stuff, most of that stuff couldn’t be carried off by normal people could it? So that’s the sort of thing I’ve avoided but might go back to, if I see the odd thing and can afford it, and I tend to spend a fortune if I do see something, you know if I see something that’s really stunning, but I haven’t done that...

Did you find that when you were a size 18, that you would buy things because they fitted, rather than that they were what you wanted?

Yes, I was totally limited, even in Germany it was about looking through and anything that was reasonably nice and fitted me, I would buy. And now I would look at it and think ‘not really’. So it has actually changed the way I dress, because it wasn’t what took my fancy or that I really liked, or…. it was really about what was available more than …in my size, and that I could get away with.

Even if you were a size 18, if you had that choice...

If it fitted right, you see there was something you said about, something you just described about when you go to Evans. There is something about the way these big clothes are tailored.

Cut do you mean?

Cut, yes, they just don’t look nice, they they’re usually not right, they’re, they don’t firm properly, if sometimes you see on television or films, you see really big women dressed flamboyantly and I think it all has to do with a good cut. Clothing, that’s also why I’m wearing a lot of classic styles, because they’re well tailored and even if your big it doesn’t matter ‘cos I notice sometimes when I was a big size that in a really,
really expensive outfit I could look a different person, I could look like a million dollars. But you know I can’t go out and buy them.

Spend a million dollars (laughs)

So you have to have a designer who can actually tailor for it because I don’t think that big necessarily means ugly or whatever, I don’t think it means that at all but it is about the kind of clothes you can then put upon that shape. And I’m sure you know, with a bit of help, you know, you can really look brilliant in the bigger sizes as well. But it’s the clothes you get to fit those sizes are useless.

Because I mean, I’ve noticed that your shoulders have changed incredibly.

Really?

You’ve got lovely slender, sort of umm, your shape is totally different from here to here (indicates chin to waist) your shoulders, I can just see why, you know the difference in that is immense.

You see I used to wear little strapped tops, that was a lovely part of me, and, but I’m not sure I can quite go back to what I was but I want to improve it.

Well I think age plays a part.

Yes,

Everyone changes as they ages, whether its bigger or an overall shape change. But its noticeable and I noticed it when I tried the third garment on you. Your shoulders were the bit that sort of threw me.

Uh hu.

Because they’d changed so much. And like you said that bit (indicates front neck), and also here (indicates chest) on your chest, there’s a sort of pad gone.

Yeah. But you see that’s the way I put on weight, its like a real padding, that’s what I saw and thought of Pauline Quirk because of that. She had pads, layers and that’s how it worked for me, some people put on weight just around the hips more, with me its really all over. (laughs)

So what else, is there anything else, have you go any other observations you want to make about it, your decisions, your process, results, umm.

I think it will lead to other things which are not connected with clothing, I think it will lead to me, I’m pretty sure the next bit that will kick in now that I’ve got over the Christmas period and enjoyed myself

Of course
Well I’d have enjoyed myself anyway but I wasn’t, haven’t been as careful as I have been the last few months, but I think I want to be fitter, I want to loose more. It seems like its getting moiré fun again, because I used to enjoy dressing and I haven’t for the last couple of years and didn’t realise it had a lot to do with me putting on the weight. And I think I will continue enjoying it, it probably won’t do my purse any good but it doesn’t matter, I used, I used to, every birthday I’d go to one or two of my favourite boutiques, there used to be one in Lewes, they’ve changed now though they’re Capriccio.

Is that the one on the top street?

But they always used to have these fantastic summer dresses and at my birthday in May I always would buy an expensive dress for myself then, it was fun, it unusual they used to have one-offs, I used to buy the Mason stuff, I used to buy all the sort of, I always treated myself, for me that was a massive treat buying clothes and then I ended up just buying what fit and a lot of funs gone out of it.

Do you think if you’d been able to find those clothes in the size, in a nice fit you would have maintained that?

I would have maintained that, I think I lost that because of the weight because I still might have decided at some point that I wanted to do it, because I just couldn’t find anything. Even now I look and I think its become more than just the size thing, I just don’t like what I see in shops. I think clothing in this country is not very attractive whereas I can go out anywhere abroad and think ‘ohh’ you know? It all goes in the basket, but here…

So if its not just a size thing what is it then, is it an age issue?

There is an age thing on the one hand, there seems to be almost like a consumer market here its all for the young people, as cheap as possible, using as little material as possible, you look at the hems, you look at the finish of the clothes, such poor quality, its trashy.

What about the fabrics?

A lot of them are colourful, sometimes I see something really nice and then I think well if that was finished better it would work perhaps for me but …its …at the moment the colours are a bit drab again, I find it just goes….there is another thing is there isn’t awful lot of variety, there is a same, if you go through all the shops there is such a ‘sameness’ in cut style, colour pattern, everyone looks the same. Do you know, it might have something to do with the British and their school uniform?Do you know, because that’s the first thing, actually that’s another thing I have to tell you about. (laughs) When I came to England, I was 19 years old and never in my life thought about school uniform. At school, especially in the 60s, you know I used to go as I normally was, dressing was fun, I used to wear the skirts up to here, little cropped tops and it was all about dressing up, jewellery and looking attractive. And I came here and I saw all these poor kids in uniforms and the only time they bought something was at weekends. If you can imagine how expensive that is in real terms for parents? Having
to buy the uniform and an outfit that’s fashionable for the weekend, so of course the outfit for the evenings and weekend has to be cheap.

That’s a good point.

Yes and if you sort of make all those connections. And I found that really really hard because all the time, even today I find that British men are the most boringly dressed men in the universe. Because they’ve been brought up on uniforms, and only difference they have in uniforms is rolling the skirt up or having a scruffy jacket. So I think there is a whole thing about the uniform culture and the way that influenced fashion, but then you’ve got I think, you have the opposite extreme, you’ve got the really wacky fashion. What I dreamt about in Germany was, when I was little I wore the classic styles, the you know the expensive material s and all that, and you saw all this really wacky stuff, what was it, Biba. Everyone in Germany wanted to go to Biba’s in London, Carnaby Street, it was colourful, it was wacky, wacky is probably the best description. So you get that other extreme in this country, but you don’t get the classic middle range where all, at any different shape, age or size you could go to a shop and find attractive clothing. And I think they cater much better in the rest of Europe for the different ages and sizes and shapes wheras here you get those extremes I think so I don’t know how to connect that all up, but its not just you know about big body shape, its an awful lot of things.

So in Germany what companies would you look for, is there a brand or is there a shop you could say ‘that’s what fits me’?

No, no so whats happened now because I’ve been away for so many years and it is really difficult, what you still get in Germany is a lot of boutiques, small shops with no big plans and in Germany you’d have a lot of Italian clothes you will have a lot of, and you know, so . The shop I used to like here so it gives you some ides, what was it called? Its an Italian shop, its got an Italian name and they’re just closing down the Laines one.

Not Moda?

No, no.

Where is it?

Its you know,its along past the ….., its past a resuarant, its opposite, its got a little awning, its got a men’s awning and….

I know the one you mean.

Thats where I always find something unusual, good quality and well designed and that’s the sort of stuff I would have gone for, and I don’t think you find that anywhere else.

No there aren’t many shops like that in the UK, not in towns this size, there might be in smaller towns?
See what they’re doing now in Germany you get small chains and they’ve got all the English brands anyway, so you find in the high street, Next you find umm, what are the main ones, what, I’m not very good at brand names, but most of the English stuff you can get, they’ve got all that stuff what they also have is the small quality shops, there is some bigger ones, other than the warehouse ones in the range of Debenhams and whatever, where you also get good quality classic cuts, so but its not a particular brand I don’t think.

I thought you might say that, or someone like Boden.

Oh I do but from them, yeh, I’ve got jackets. And that I bought in the warehouse, I went in and the jacket was there, and I didn’t have to search for it or go to a special shop for it and it was in the size as well, so yeh, I’ve never been into labels, I can’t remember them so I’m not very good. But that’s what’s in the back of my coat so… I shop by the eyes, I don’t shop by label or whatever, shop with the eyes, look at the quality and I just know I don’t get the variety here or the quality here, its such extremes. And in Brighton at the moment I just don’t know where to look. I really don’t.

In Debenhams, they’ve got a plus size range called Gorgeous, have you looked at that at all? I’m interested because I won’t say my opinion, but I wondered what you thought?

No, I haven’t looked there.

Anne Harvey, did you look in there?

Which one’s Anne Harvey?

Its on Western Road, opposite what was Primark. Its smallish shop, have you looked in there? Because I know its Evans competitor.

It would depend, because I go in the North Laines, and there’s loads of big sizes shops there and its all big, its not flattering its not feminine its not…

Its not work clothing either, it might be ok for special event clothing when its held together with a lovely brooch and swathed everywhere.

Its dramatic.

That’s right its dramatic but its not everyday.

No but its not vanity is it, if you look round at work what people are dressed in, you know I hardly even notice what they’re wearing? Because its so boring. But I know the women have bought, have got it entirely of ***** of the female staff, there are very, very few who make an effort to dress attractively. They either wear jeans and tops or something very casual, I know this campus is different as we have the art school and whatever, but if you go up the road its, but then they go into the formal school uniform type, but there’s nothing in between, and there’s no…and the other thing, no individuality. That’s probably the thing that bugs, its so funny you see its
individuality I like, that’s, that’s what’s bugging me because like I said before, the shops look all the same even for the younger generation there’s such a sameness about it all, whereas we used to make, when I was at home, and still at school, that each of us developed our own style of dressing so we looked at our own shape, we looked at what suited us and then we would put, we would take pride in putting something together, no-one else, we would have died if anyone else had worn the same combination of clothing. Like me you know it was not the, what I wanted and I find I can’t do that here anymore, I’ve lost almost interest in that because there isn’t enough variety for me to do that. Its really, they all look the same. What’s the thing to wear? I’m sure it’s got to do with uniform.

Yes, I have heard people say about why there are so extremes of fashion England, but I’ve not heard many talk about why there aren’t either, you know, why people don’t know how to dress. And I think the piece about cheapness and the weekends, I say to my son, “if you have those shoes you have to wear them for school and home”, they’re a £49 pair of shoes.

No…..

The end of the taped conversation.
1.3 Portia second interview
27th February 2009

The answers shown were from a semi-structured interview after an evaluation session, where Portia had been given the questions in advance to think about, and the session was recorded. Unfortunately however, the equipment failed and so the interview had to be written up from notes taken at the time rather than transcribed as the one with Desdemona was.

Would you mind telling me approximately how much weight you have lost?
A. About a stone.

Was the motivating factor that triggered your weight loss anything to do with your participation in the research project?
A. No it was the result of catching pneumonia as a result of a cold caught on a cruise with her Mother. She was in hospital early in 2007, and during this time her marriage broke down and she separated from her husband. The weight loss is a direct result of these two occurrences.

What was your approximate UK clothing size when you were body scanned?
A. She was a 16-18

What is your approximate UK clothing size now?
A. 14-16

How has your body shape changed since weight loss?
A. Not really, she was a pear shape before and still is, but is more toned form exercise as took up horse riding after she separated from her husband. Something she has always wanted to do.

How did you feel about your shape before your weight loss?
A. Overweight but not bothered by this.

How do you feel about your shape now?
A. More confident and willing to try things.

What was your least favourite part of your body and your favourite part prior to weight loss?
A. Still the same, she doesn’t think that this has changed, it was her hips, tummy and upper thighs, and this is till the same.

Are these different now? Can you tell me your favourite and least favourite parts?
A. see above answer.

What was the first thing you noticed about the fit of your clothing after weight loss?
A. Wearing skirts again, because they fitted better on her thighs, and her legs didn’t rub together. She went to Marks & Spencer and three skirts, cheap ones. A pencil, and ‘A’ line and a box pleat style, and wore them to work to see how she felt in them and which she liked as a style best. Her colleagues commented favourably on the pencil one, and although did not seem to have any sexual interest, made complimentary remarks. Portia however, preferred the ‘A’ line style as she felt the pencil was a bit tight (she ran her hands down her thighs as she said this in a descriptive way). She didn’t rate the box pleated one at all as it still opened up on the pleats at the widest part of her thigh.

Overall what is the most noticeable change to you as the wearer in clothing fit?
A. Wearing skirts and being able to buy trousers that fit.

How did you find clothes shopping in the recent past when you were a larger size?
A. Difficult and depressing, used to buy mainly from Boden as they made a size and style of trousers that she knew would fit her.
How do you find clothes shopping at your new size?
A. More experimental, she tries new things, and will spend more money, but this may also be due to the fact that she was the main salary earner in her marriage, and can now spend more freely without feeling guilty. She is prepared to pay £100 on a pair of trousers now which she likes and fit her well, she explained that she does not do this often but it is now part of her shopping habit to consider it. She also shops less in charity shops, although occasionally still does.

Which shops did you look /buy in at your old size?
A. Boden, Marks & Spencer and European shops. Mail order.

Which shops do you or might you look/buy in at your new size?
A. Lewes shops that cater for the ‘more mature’ woman, has another branch in Seaford, and sells things she likes, can afford and fit her now. She spends more on clothes now. She will still look in Marks & Spencer, and still likes Boden, but is more experimental in her choices. If she makes a mistake she doesn’t mind sending items to the charity shop, [could this have something to do with financial situation as well?]

Are there clothes you would wear now that were ‘off limits’ before due to your shape?
A. Skirts, bright colours, she had a ‘Colour Me Beautiful’ session, in which she was told to wear bright colours, especially a strong Kelly green shade which she has tried and now wears with other greens a lot. She has tried to act on this, because in the past she felt dull was better as a disguise, she did wear quite a lot of pale pink, and still does. Horizontal stripes have come back into her wardrobe, and she wears bright blue and red as well.

Are there any significant changes in your attitude to life since loosing weight?
A. More confidence, being noticed and complimented on her looks by colleagues (even though there is no sexual connection or inference), and she generally feels happier to be thinner. She thinks a lot of the notice is caused by her being more toned in general as well due to exercising more. Her osteopath recommended riding as long as she does not fall off heavily.

Would you like to you tell me anything else about your new shape?
A. She was much thinner a year ago, and has put some weight back on, but is exercising now so is a better shape. She attributes the change to her husband saying ‘we don’t do anything interesting’ as he was leaving. So she decided to do something she’d always wanted to, and started taking riding lessons and now goes on holiday to France whenever she can to ride in the Lot region. She explains that this is not for finding a new partner, its for personal enjoyment.
Interviews with designers and industry

2.1 Email interview with Anna Koski, American Eagle. 11 April 2011

Hi Vikki

I can give you a little outline let me know if this is to brief and I can write a little more.

So we have a concept team who surfs the web, go to trend shows/fairs, shops europe, asia, america, go to music festivals to see what everyone is wearing latest trends etc.........They present concept to the designers who then do their own research and compile ideas worked around the concept.

Designers meet with the merchant team who present a roadmap of how many styles they wish to buy each season, how much they are going to retail them at, how many are fashion pieces how many are key items etc. The designers have to bare this in mind when designing to make sure we have all the needs of the merchant teams road map covered. Normally we design 3 to get to 1 (normal ratio) Our director works to make sure each category works well together. le woven/knits outfitting

Designing.......*Source yarns – trade shows pitti filatti, PV, expofile, meet with factories who manufacture the garments to source local yarns more affordable options

*Designing- meet with swatch studios buy swatches, internet research, shopping, sketch ideas..........sketches are narrowed down by our director

*Development – we create technical packages, with drawn sketches,with design details- including body stitch, trim construction (ie 2x2 rib), bttns, zip etc, BOM (bill of materials) calls out color, trims bttns etc, call out yarns (sometimes we develop one style in multiple yarn choices) embroideries logo’s and marketing is also called out. Finally the technical pages are added these are owned by a tech team we pass our designs off to tech and they spec it and create graded specs.

- Takes normally 6 weeks to receive a sample back we are on a new schedule where we actually have 2 1/2 months before we see a sample which is a long time. I don’t travel overseas to see the garments being made anymore as there is less pressure in children’s wear but in women’s you normally put styles into work and then you give the factory two -four weeks to make them before going overseas to see the garments, to make quick changes, its so much easier and faster rather than communicating through emails.

- Normally we see one round of samples present to merchants and higher levels and then we re-work, assort line, add styles and see a second round before the merchants buy the line.

- Once samples have been bought and ticketed by merchant team we request styles to fit we normally fit 2-3 times before approving to pp which is pre pro (before production sample) once that is approved style goes into production by this time all lab dips for color and trims bttns etc should also be approved. We have just finished approving BTS/FALL 2011 which will hit stores July 17th so that gives you an idea on timing from approving sample to finishing production shipping and into stores.

I design sweaters and cut and sew knits we have different vendors/ factories that make sweaters and cut and sew as the facilities, machinery and skills needed to make these are very different. Cut and sew knits are obviously cheaper depending on fabric but normally the production is much quicker with cut and sew. There are more restrictions with sweaters in
terms of linking and shaping. Cut and sew you have much more freedom in fashion silhouettes printing stripes/ verses y/d making the product more affordable.

Not sure what you mean by the impact of complete garment knitting? The trend for sweaters verses cut and sew knits I think have grown since I have been in the US sweaters are defintely a more noticeable trend. The product looks so much more elevated in sweaters the use of fine gg as well as texture. I think sweaters were stereo typed as fairisle patterns/ chunky aran cable holiday sweaters but they are much more versatile now. Before sweaters were only developed in fall/holiday we now design all year round including summer. (does that help?)

My position -Girls knits designer (sweaters, cut and sew knit tops and dresses age 5-14)

You may have to edit or re write hope it makes sense, let me know if you need anything else? Or have any questions

Good luck! Anna
2.2 E mail interview with Frances Tobin ex buyer and designer – 13th June 2011

When working as a designer at Evans and also a buyer at Mackays Stores, I had to be aware that the machine bed dictated the maximum width of a garment, to keep to price 2 sweaters are knitted at once. The machine beds could manage 2 x size 16s but if you wanted size 18 and above, you would plan an 18 next to a 14, 20 to 12 etc - of course it depended on style, but it wasn't just the extra yarn that effected the price.

Buyer at Mackays 1994-6
Designer Evans 1987-8

Frances Tobin
2.3 Excerpts from an interview with Richard Webster Sales Director of Shima Seiki Europe Ltd. - 22nd July 2009.

Machinery

VH When reading Knitting International it seems that circular fabric machines, and V bed flats seem to have taken over the knitting manufacturing world, would you say this is correct?
RW Yes V beds and circulars, yeah, not, fully fashioned’s gone, the 16 section machines, the [ike the cotton type machines?] yeah that’s right, the Cotton Patent. Of the V beds, main players now are Shima and Stoll. There are a few smaller companies, I think Protti’s still around…(Steiger?), Steiger? I think they are in a small way.

About flat frame machinery

VH So you said there aren’t any flat frames today?
RW Theres plenty still in use, but not er,.. I don’t know if anyones actually making them. There’s bound to be some manufacturers somewhere or other but its not a market we deal in. So theres nothing. I’ve not seen any come into this country. There are people who’ve got them still in production, the old Cottons.
VH So they are still using them…?
RW Yes, John Smedley for example.
VH Oh right so Smedleys..
RW Yeah, Smedleys, they must have, I don’t know, they must still have about twenty in production.
VH And are these ones that knit the rib integrally, or do they automatically load them on?
RW Its, they have other machines to knit the ribs onto the bars.

About old machinery still in use

Can I just ask you what other any older types of machines you have seen recently being used in factories?
RW The old Shimas and the old Stolls, the SECs series
VH Are they electronics?
RW They are electronics, they are the long bed machines, chain drive so the cam box just goes from end to end, same, Shima are the SEC series and the Stoll are the ANV and the CNCA series. Machines, mostly on that route. Although Dubieds as well, you see the odd Dubied, yeah.
VH Poor old things..
RW Its usually just sat in the corner with a cup of coffee on it.
VH So these machines, these machines the CNCs and the other ones, do they knit fully fashioned or do they, are they just fabric machines?
RW They’re mainly for blanket fabric for cut and sew, but you can do shaping on them.
VH Can you?
RW Yeah, but the restricted part on them is the memory size on those machines.
VH Right
RW Yeah you can do basic shaping, but… its slow..
VH So you could shape a sleeve out or..but?
RW Yeah or you can shape in, you can do a little bit of shaping, its just memory size is the real main thing and the speed of it. But yes, they are capable.
VH And the programming presumably would be awkward but…
Well, the programming, yep, because the newest computers obviously don’t programme the old machines so you have to do it the old way which is the long-hand way...drawn in stitch for stitch.

About modern knitwear production in the UK

There’s lots of small ones, but no big numbers. But yeh, the amount of factories, it’s all the big players that have gone.

About keeping design in the UK but production abroad

And its easier for them to do a new sample and take it straight down [to the customer in London] rather than wait for it to come over from Sri Lanka...

So the factories that you know about, that you visit, do you find that they use predominantly modern machinery or mostly older with some modern, or a balance of both. What’s their balance of plant would you say?

Its difficult, its quite spread, you go to some customers and they’re the majority old machines with just a few of the new type, then there’re some guys that have changed everything over to the new type. Erm, its quite broad spread on this, I couldn’t really say. The SES is the main machine anyway, that is the vast majority of Shima machines out there, yeh. The older machines, the 202 the SEC machines, the 202 and 214, some people still have them, they prefer them but...we stopped producing them 20 odd years ago, they’re all going off to India and people are buying more of the SES, the used market is still quite a huge market.

And what sort of things, say on the SESs, what sort of things are they making, are they making you know, high quality goods, are they making stuff for M&S are they making, you know, what sort of goods? Are they using the older machines for cheaper goods? Or does it not work like that?

It doesn’t work like that. It depends on the actual market you’re going to if, your main area OK is Manchester, Leicester, the Nottingham, Derby area. Manchester, 99% of people there have the SESs, not the short bed, they have the long bed, so they’re doing cut and sew. So they’re still doing blanket fabric, overlocking it together, so at the very low end of the market. Its cash and carry, market trader, that type of thing. Er, the other couple of percent in Manchester have kind of jumped, they’ve missed the shaping out, have gone straight from cut and sew, straight to wholegarment.

Purely as I was saying because we are able to get these machines at a better price now so. Its been a big learning curve for them.

Yeh, because they have to go from programming – I suppose the programming is a huge jump for them isn’t it?

Yeh, well to do a blanket you’ve only got a pattern that repeats across, wholegarment, you’ve have to do everything.

Everything

Everything, you’ve got to know the engineering of a garment, which is where the wholegarment, the SDS comes into it. Cos a lot of that work is already...

Yes it is...

Is built into it.

The sizing. So they’re finding that, they’re using the system heavily because of.....

Yes

...fully I suppose I mean, because of that?
R Yes, you can do basic garments in five minutes on here, but when you actually come to the technicalities of a garment, having to change sleeve shapes, and connections underarm, and shoulders etc...you need to really start knowing what you’re doing.

V And do they avoid that bit, do they just work with the basic programmes, or?

R We are actually training their people up. There’s a guy in one of the factories who, he totally understands it so he’s making good garments, yeh.

V So really, yeh, that’s quite interesting so do you think it means you’re going to see better quality, well what is there market/

R It’s better quality, the usual bad thing on a garment is the seams

V It’s the difficult bit,

R Well there isn’t any seams so...

V Who are they selling that to and what and what level of market, and what yarns are they using?

R They’re still using the lower end of the market. They’re still using 50/50 cotton acrylic, 100% acrylic, um..

V So we’re getting whole garments in acrylic, that’s fascinating isn’t it?

R Their price point is always around £20-£25,

V They’re not expensive.

R and then we’ve got another customer. Their main customer is Oasis. There you’re looking at £35-40-£60 per garment so...

**About the technician’s role**

R The key person nowadays is the technician, the sample technician.

V As opposed to the machine technician? Is there a difference?

R Well, they are more or less one and the same person, you don’t have just your mechanic anymore, there’s very few...factories like that. It’s usually the tech, the sampling technician, sample mechanic, does everything.

V And do you find that the sample mechanic, sample technician, whatever you like to call them - sample technician, do they work with designers or how?

R Yes.

V So the designer from a company would want a range, a garment would come and work with the sample technician, is that how it works?

R The, the, yeh different companies work differently, some have their own designers in house as well so they’ll all work together as a team. But you also have design houses, like Intro or Flick, or people like that who go to a factory and they give them the design and the sizing, what they want and its a case of the technician will make it, what they think, send it off and then, backwards and forwards, three or four times until its right.

V Right, which do you think works the best? In your experience?

R Well its always better if you’ve got a designer next to the technician, together, its better because its quicker, and you actually build a rapport between the two of you, you know what the other one’s thinking.

**About WideGauge® (multi gauge) machinery and needles**

R It is mainly needles, it is mainly the needles.

V So its a new type of needle?

R New type, its still a latch needle, but its the technology in the needle which allows us still to knit quite a tight fabric, its a big hook, but it allows you to knit a
tight fabric, so on the 14gge you can still get 14gge fabric, but you’ve got a half
gauge and you can put as many ends in as you can to match 7gge.
V So you half gauge it, I see, but the hooks will take the yarn?
R Its what we call a long, large hook.
V So it takes it in flat rather than round.
R Yeh
V Which is the compound needle?
R Compound needle?
V Yes
R Thats the 5gge machine, 3gge and 5gge is compound.
V Right, and is that the one that slides up inside itself?
R Its got a slide, but you’ve still got the pelerine on the side of the needle.
We’ve also got the new needle, the wholegarment needle basically which is the slider
needle.
V Thats the one I’m thinking of, I’ve seen a picture where it slides up inside,
R Yeh the compound slides, but the slider needle actually splits open, to
transfer, so when it transfers, that slide goes over the hook, opens out, the yarns
sitting on there [gestures with hands], so its going....
V Oh right. Ok, and so, is that exclusive to Shima, that needle?
R Yes its a Shima patent
V Its a Shima patent on the wholegarment one?
R Slide needle
V And the one thats on the new machine is the ..
R SSG/SIG?
V Yes, is that a Shima patent?
R Shima patent, yeh, yeh.
V So other companies, like Stoll or whatever, you say they do multigauge,
they have different methods of doing it?
R They have a different method of doing it, yeh. I don’t know what
V Its just interesting to know that there are different methods, because
obviously technology is going in so many different ways, there’s that sort of
technology, but there’s also the mechanics, which I suppose its engineering isn’t it?
Really precise engineering.
R Thats it. But it must be pretty similar how they’re doing it because there’s no
other way to do it really.

About the capabilities of Wholegarment®
So if we talk about wholegarment. Why have Shima produced another equivalent, or
the next version of the SES - the SSG and the SIG if wholegarment is so
successful? What, do they still see there is potential in flat knitting?
R In flat knitting, yeh, wholegarments can’t do everything,
V Ok, what can’t wholegarments do then?
R Er..lots of colours, jacquards, you can but you end up putting a lot of hand
finishing back into the garments, you’re not really gaining anything from
that. Intarsias, not really a wholegarment thing either.
V OK
R Its basic stripes you can do wholegarment, no problem, we do now an air-
splicer which means you can put eight colours into one yarns feeder, so it
chops and changes the colour as it goes alone.
But yeh, there’s still the, the biggest market is still shaped, shaped garments.

V Shaped on flat machines?

R Flat machines, yeah. Fashioned, shall I say?

**About the first widespread use of V-bed shaping on commercial knitwear**

Well in the UK, it became big well, ah, when this machine came, its we used to do shaping on the old machines, C.V. Knitwear or Mansfield Hosiery and they used to be called, they used to use the old machines for shaping.

V Right, so when are we talking?

R 80s?

V 80s..

R Then during the 90s when these machines really took off, I think it were around 93,94 in the UK especially, thats when it really took off. And we were using them for doing that in the Uk, whereas people had these around the world and they weren’t using them.

V So they were using them as the old machines/

R Yeh, so we kind of led the way with them again. We had the machines and we were making them do things that Japan said, ‘you can’t do that’..

**About the SES machine and complete garment technologies**

R Um, it is difficult really, cos if you look at like the wholegarment, you get designers find it hard to design for the machine.

V Do they?

R SES, which basically you can do anything, you can do anything you want on an SES, wheras with wholegarment you can’t. So its trying to, you know you’re trying to and you can’t do that and you can’t do this, and its..’what can the machines do?’, thats what you get. Rather than getting them to think, to think wholegarment, think that way, design for the machine, rather than designing...

V What you’ve always designed?

R Yeh

V So really in that case, that is technology is leading the way isn’t it?

R Yes it is in that. But on the other side, on the SSG/SIG, its all there for the designer to come on up with what they want, you know.

V So thats actually two quite distinct themes there aren’t there?

R Yes, thats why you’re best to keep both technologies.

**About ‘seamless’ versus ‘complete garment’ knitting**

Whats the last really big thing in knitwear?

R Wholegarment, its got to be the wholegarment.

V I thought you’d say that.

R You see with the SSG/SIG as opposed to the SES, its, there’s developments on the machine that make them faster, they are about 15-20% faster like for like, so I suppose thats a big impact if you want to look at it that way, but...

V Thats more from productivity than..

R It is. Air-splicer? 8 colour air splicer, its not really took off yet..Wholegarment, the slide needle..

V Hang on which is the slide needle? The one that splits?

R The split needle, yeh

V Do you think the future lies in V bed machines rather that circulars?
Well yeah, with 3 dimensional pieces, things that are actually shaped, seamless, seamfree, garments, not garments that they say are seamless, but have got seams. I can’t quite get my head around that one.
3.1 Definitions of larger figure types used in the online survey

Frontal silhouettes

Type A - apple
Type B - small pear
Type C - pear
Type D - potato (or Ovoid)
Type E - large potato (supersize) (or Large Ovoid)
Type F - peanut (tall)
Side Silhouettes
3.2 Survey questionnaire

This Questionnaire is part of a
Doctoral research project
into knitwear for larger women's body shape.
If you would like to participate,
please select one box from the following multiple choice questions.

<table>
<thead>
<tr>
<th>What is the nearest standard size to your upper body size? (please use UK sizes, click here for comparison chart)</th>
<th>What is the nearest standard size to your lower body size? (please use UK sizes, click here for a comparison chart)</th>
</tr>
</thead>
<tbody>
<tr>
<td>○ 8</td>
<td>○ 8</td>
</tr>
<tr>
<td>○ 10</td>
<td>○ 10</td>
</tr>
<tr>
<td>○ 12</td>
<td></td>
</tr>
<tr>
<td>○ 14</td>
<td>○ 14</td>
</tr>
<tr>
<td>○ 16</td>
<td>○ 16</td>
</tr>
<tr>
<td>○ 22</td>
<td>○ 20</td>
</tr>
<tr>
<td>○ 24 and over</td>
<td>○ 22</td>
</tr>
<tr>
<td></td>
<td>○ 24 and over</td>
</tr>
</tbody>
</table>

From the following pictures, choose the silhouettes nearest to your body shape and stance and pick them from the drop down lists below.
Front views

![Silhouette Options](ORIGINAL IN COLOUR)
### 3.3 Survey data

<table>
<thead>
<tr>
<th>ref</th>
<th>upper body</th>
<th>lower body</th>
<th>front</th>
<th>side</th>
<th>bra cup</th>
<th>age group</th>
<th>stomach</th>
<th>bottom</th>
<th>internet shopper</th>
<th>custom clothing</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>24+</td>
<td>type C</td>
<td>lordosis</td>
<td>B</td>
<td>45-55</td>
<td>rounded</td>
<td>very rounded</td>
<td>occasionally</td>
<td>maybe</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>24+</td>
<td>type C</td>
<td>lordosis</td>
<td>C</td>
<td>45-55</td>
<td>rounded</td>
<td>very rounded</td>
<td>often</td>
<td>maybe</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>24+</td>
<td>type C</td>
<td>lordosis</td>
<td>D</td>
<td>45-55</td>
<td>rounded</td>
<td>never</td>
<td>maybe</td>
<td>maybe</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>24+</td>
<td>type C</td>
<td>upright</td>
<td>E</td>
<td>45-55</td>
<td>rounded</td>
<td>rounded</td>
<td>occasionally</td>
<td>maybe</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>20</td>
<td>type C</td>
<td>upright</td>
<td>F</td>
<td>45-55</td>
<td>rounded</td>
<td>rounded</td>
<td>never</td>
<td>maybe</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>24+</td>
<td>type D</td>
<td>upright</td>
<td>G</td>
<td>45-55</td>
<td>rounded</td>
<td>rounded</td>
<td>never</td>
<td>maybe</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>22</td>
<td>type C</td>
<td>kyphosis</td>
<td>H</td>
<td>45-55</td>
<td>rounded</td>
<td>rounded</td>
<td>never</td>
<td>maybe</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>22</td>
<td>type A</td>
<td>kyphosis</td>
<td>I</td>
<td>45-55</td>
<td>rounded</td>
<td>rounded</td>
<td>never</td>
<td>maybe</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>22</td>
<td>type C</td>
<td>kyphosis</td>
<td>J</td>
<td>45-55</td>
<td>rounded</td>
<td>rounded</td>
<td>never</td>
<td>maybe</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>22</td>
<td>type D</td>
<td>kyphosis</td>
<td>K</td>
<td>45-55</td>
<td>rounded</td>
<td>rounded</td>
<td>never</td>
<td>maybe</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>20</td>
<td>type C</td>
<td>upright</td>
<td>L</td>
<td>45-55</td>
<td>rounded</td>
<td>rounded</td>
<td>occasional</td>
<td>maybe</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>20</td>
<td>type C</td>
<td>upright</td>
<td>M</td>
<td>45-55</td>
<td>rounded</td>
<td>rounded</td>
<td>never</td>
<td>maybe</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>20</td>
<td>type C</td>
<td>upright</td>
<td>N</td>
<td>45-55</td>
<td>rounded</td>
<td>rounded</td>
<td>never</td>
<td>maybe</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>20</td>
<td>type C</td>
<td>upright</td>
<td>O</td>
<td>45-55</td>
<td>rounded</td>
<td>never</td>
<td>maybe</td>
<td>maybe</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>20</td>
<td>type C</td>
<td>upright</td>
<td>P</td>
<td>45-55</td>
<td>rounded</td>
<td>never</td>
<td>maybe</td>
<td>maybe</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>20</td>
<td>type C</td>
<td>upright</td>
<td>Q</td>
<td>45-55</td>
<td>rounded</td>
<td>never</td>
<td>maybe</td>
<td>maybe</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>20</td>
<td>type C</td>
<td>upright</td>
<td>R</td>
<td>45-55</td>
<td>rounded</td>
<td>rounded</td>
<td>never</td>
<td>maybe</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>20</td>
<td>type C</td>
<td>upright</td>
<td>S</td>
<td>45-55</td>
<td>rounded</td>
<td>never</td>
<td>maybe</td>
<td>maybe</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>20</td>
<td>type C</td>
<td>upright</td>
<td>T</td>
<td>45-55</td>
<td>rounded</td>
<td>rounded</td>
<td>never</td>
<td>maybe</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>20</td>
<td>type C</td>
<td>upright</td>
<td>U</td>
<td>45-55</td>
<td>rounded</td>
<td>rounded</td>
<td>never</td>
<td>maybe</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>20</td>
<td>type C</td>
<td>upright</td>
<td>V</td>
<td>45-55</td>
<td>rounded</td>
<td>rounded</td>
<td>never</td>
<td>maybe</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>20</td>
<td>type C</td>
<td>upright</td>
<td>W</td>
<td>45-55</td>
<td>rounded</td>
<td>rounded</td>
<td>never</td>
<td>maybe</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>20</td>
<td>type C</td>
<td>upright</td>
<td>X</td>
<td>45-55</td>
<td>rounded</td>
<td>rounded</td>
<td>never</td>
<td>maybe</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>20</td>
<td>type C</td>
<td>upright</td>
<td>Y</td>
<td>45-55</td>
<td>rounded</td>
<td>rounded</td>
<td>never</td>
<td>maybe</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>20</td>
<td>type C</td>
<td>upright</td>
<td>Z</td>
<td>45-55</td>
<td>rounded</td>
<td>rounded</td>
<td>never</td>
<td>maybe</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>24+</td>
<td>type C</td>
<td>lordosis</td>
<td>A</td>
<td>45-55</td>
<td>rounded</td>
<td>very rounded</td>
<td>never</td>
<td>maybe</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>24+</td>
<td>type C</td>
<td>lordosis</td>
<td>B</td>
<td>45-55</td>
<td>rounded</td>
<td>very rounded</td>
<td>never</td>
<td>maybe</td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>24+</td>
<td>type C</td>
<td>lordosis</td>
<td>C</td>
<td>45-55</td>
<td>rounded</td>
<td>very rounded</td>
<td>never</td>
<td>maybe</td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>24+</td>
<td>type C</td>
<td>lordosis</td>
<td>D</td>
<td>45-55</td>
<td>rounded</td>
<td>very rounded</td>
<td>never</td>
<td>maybe</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>24+</td>
<td>type C</td>
<td>lordosis</td>
<td>E</td>
<td>45-55</td>
<td>rounded</td>
<td>very rounded</td>
<td>never</td>
<td>maybe</td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>24+</td>
<td>type C</td>
<td>lordosis</td>
<td>F</td>
<td>45-55</td>
<td>rounded</td>
<td>very rounded</td>
<td>never</td>
<td>maybe</td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>24+</td>
<td>type C</td>
<td>lordosis</td>
<td>G</td>
<td>45-55</td>
<td>rounded</td>
<td>very rounded</td>
<td>never</td>
<td>maybe</td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>24+</td>
<td>type C</td>
<td>lordosis</td>
<td>H</td>
<td>45-55</td>
<td>rounded</td>
<td>very rounded</td>
<td>never</td>
<td>maybe</td>
<td></td>
</tr>
<tr>
<td>34</td>
<td>24+</td>
<td>type C</td>
<td>lordosis</td>
<td>I</td>
<td>45-55</td>
<td>rounded</td>
<td>very rounded</td>
<td>never</td>
<td>maybe</td>
<td></td>
</tr>
<tr>
<td>35</td>
<td>24+</td>
<td>type C</td>
<td>lordosis</td>
<td>J</td>
<td>45-55</td>
<td>rounded</td>
<td>very rounded</td>
<td>never</td>
<td>maybe</td>
<td></td>
</tr>
<tr>
<td>36</td>
<td>24+</td>
<td>type C</td>
<td>lordosis</td>
<td>K</td>
<td>45-55</td>
<td>rounded</td>
<td>very rounded</td>
<td>never</td>
<td>maybe</td>
<td></td>
</tr>
<tr>
<td>37</td>
<td>24+</td>
<td>type C</td>
<td>lordosis</td>
<td>L</td>
<td>45-55</td>
<td>rounded</td>
<td>very rounded</td>
<td>never</td>
<td>maybe</td>
<td></td>
</tr>
<tr>
<td>38</td>
<td>24+</td>
<td>type C</td>
<td>lordosis</td>
<td>M</td>
<td>45-55</td>
<td>rounded</td>
<td>very rounded</td>
<td>never</td>
<td>maybe</td>
<td></td>
</tr>
<tr>
<td>39</td>
<td>24+</td>
<td>type C</td>
<td>lordosis</td>
<td>N</td>
<td>45-55</td>
<td>rounded</td>
<td>very rounded</td>
<td>never</td>
<td>maybe</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>24+</td>
<td>type C</td>
<td>lordosis</td>
<td>O</td>
<td>45-55</td>
<td>rounded</td>
<td>very rounded</td>
<td>never</td>
<td>maybe</td>
<td></td>
</tr>
<tr>
<td>41</td>
<td>24+</td>
<td>type C</td>
<td>lordosis</td>
<td>P</td>
<td>45-55</td>
<td>rounded</td>
<td>very rounded</td>
<td>never</td>
<td>maybe</td>
<td></td>
</tr>
<tr>
<td>42</td>
<td>24+</td>
<td>type C</td>
<td>lordosis</td>
<td>Q</td>
<td>45-55</td>
<td>rounded</td>
<td>very rounded</td>
<td>never</td>
<td>maybe</td>
<td></td>
</tr>
<tr>
<td>43</td>
<td>24+</td>
<td>type C</td>
<td>lordosis</td>
<td>R</td>
<td>45-55</td>
<td>rounded</td>
<td>very rounded</td>
<td>never</td>
<td>maybe</td>
<td></td>
</tr>
<tr>
<td>44</td>
<td>24+</td>
<td>type C</td>
<td>lordosis</td>
<td>S</td>
<td>45-55</td>
<td>rounded</td>
<td>very rounded</td>
<td>never</td>
<td>maybe</td>
<td></td>
</tr>
<tr>
<td>45</td>
<td>24+</td>
<td>type C</td>
<td>lordosis</td>
<td>T</td>
<td>45-55</td>
<td>rounded</td>
<td>very rounded</td>
<td>never</td>
<td>maybe</td>
<td></td>
</tr>
<tr>
<td>46</td>
<td>24+</td>
<td>type C</td>
<td>lordosis</td>
<td>U</td>
<td>45-55</td>
<td>rounded</td>
<td>very rounded</td>
<td>never</td>
<td>maybe</td>
<td></td>
</tr>
<tr>
<td>47</td>
<td>24+</td>
<td>type C</td>
<td>lordosis</td>
<td>V</td>
<td>45-55</td>
<td>rounded</td>
<td>very rounded</td>
<td>never</td>
<td>maybe</td>
<td></td>
</tr>
<tr>
<td>48</td>
<td>24+</td>
<td>type C</td>
<td>lordosis</td>
<td>W</td>
<td>45-55</td>
<td>rounded</td>
<td>very rounded</td>
<td>never</td>
<td>maybe</td>
<td></td>
</tr>
<tr>
<td>49</td>
<td>24+</td>
<td>type C</td>
<td>lordosis</td>
<td>X</td>
<td>45-55</td>
<td>rounded</td>
<td>very rounded</td>
<td>never</td>
<td>maybe</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>24+</td>
<td>type C</td>
<td>lordosis</td>
<td>Y</td>
<td>45-55</td>
<td>rounded</td>
<td>very rounded</td>
<td>never</td>
<td>maybe</td>
<td></td>
</tr>
<tr>
<td>51</td>
<td>24+</td>
<td>type C</td>
<td>lordosis</td>
<td>Z</td>
<td>45-55</td>
<td>rounded</td>
<td>very rounded</td>
<td>never</td>
<td>maybe</td>
<td></td>
</tr>
<tr>
<td>Page</td>
<td>Column</td>
<td>Type</td>
<td>Bending</td>
<td>Lumbar</td>
<td>Pelvis</td>
<td>Sacrum</td>
<td>Thigh</td>
<td>Tarsus</td>
<td>Ankle</td>
<td>Foot</td>
</tr>
<tr>
<td>------</td>
<td>--------</td>
<td>------</td>
<td>---------</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
<td>-------</td>
<td>--------</td>
<td>-------</td>
<td>------</td>
</tr>
<tr>
<td>64</td>
<td>18</td>
<td>20</td>
<td>upright</td>
<td>C</td>
<td>55-65</td>
<td>rounded</td>
<td>rounded</td>
<td>never</td>
<td>maybe</td>
<td></td>
</tr>
<tr>
<td>66</td>
<td>22</td>
<td>22</td>
<td>sway</td>
<td>C</td>
<td>55-65</td>
<td>rounded</td>
<td>flat</td>
<td>occasionally</td>
<td>maybe</td>
<td></td>
</tr>
<tr>
<td>67</td>
<td>24+</td>
<td>24+</td>
<td>lordosis D</td>
<td>55-65</td>
<td>rounded</td>
<td>very rounded</td>
<td>very rounded</td>
<td>occasionally</td>
<td>maybe</td>
<td></td>
</tr>
<tr>
<td>68</td>
<td>22</td>
<td>18</td>
<td>upright</td>
<td>E</td>
<td>45-55</td>
<td>very rounded</td>
<td>flat</td>
<td>occasionally</td>
<td>maybe</td>
<td></td>
</tr>
<tr>
<td>69</td>
<td>22</td>
<td>22</td>
<td>kyphosis D</td>
<td>45-55</td>
<td>very rounded</td>
<td>rounded</td>
<td>occasionally</td>
<td>maybe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>70</td>
<td>24+</td>
<td>24+</td>
<td>lordosis F</td>
<td>35-45</td>
<td>very rounded</td>
<td>very rounded</td>
<td>occasionally</td>
<td>maybe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>71</td>
<td>22</td>
<td>24+</td>
<td>upright</td>
<td>C</td>
<td>35-45</td>
<td>very rounded</td>
<td>rounded</td>
<td>often</td>
<td>maybe</td>
<td></td>
</tr>
<tr>
<td>72</td>
<td>18</td>
<td>18</td>
<td>lordosis C</td>
<td>20-35</td>
<td>rounded</td>
<td>rounded</td>
<td>occasional</td>
<td>maybe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>73</td>
<td>20</td>
<td>18</td>
<td>upright</td>
<td>F</td>
<td>55-65</td>
<td>rounded</td>
<td>flat</td>
<td>never</td>
<td>maybe</td>
<td></td>
</tr>
<tr>
<td>74</td>
<td>22</td>
<td>24+</td>
<td>lordosis D</td>
<td>45-55</td>
<td>very rounded</td>
<td>rounded</td>
<td>never</td>
<td>maybe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>75</td>
<td>20</td>
<td>20</td>
<td>upright</td>
<td>C</td>
<td>35-45</td>
<td>rounded</td>
<td>rounded</td>
<td>occasionally</td>
<td>maybe</td>
<td></td>
</tr>
<tr>
<td>76</td>
<td>20</td>
<td>20</td>
<td>lordosis D</td>
<td>45-55</td>
<td>rounded</td>
<td>rounded</td>
<td>occasionally</td>
<td>maybe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>77</td>
<td>18</td>
<td>18</td>
<td>upright</td>
<td>C</td>
<td>55-65</td>
<td>rounded</td>
<td>rounded</td>
<td>occasionally</td>
<td>maybe</td>
<td></td>
</tr>
<tr>
<td>78</td>
<td>22</td>
<td>24+</td>
<td>kyphosis C</td>
<td>45-55</td>
<td>rounded</td>
<td>very rounded</td>
<td>occasionally</td>
<td>maybe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>79</td>
<td>24+</td>
<td>24+</td>
<td>lordosis A</td>
<td>45-55</td>
<td>very rounded</td>
<td>very rounded</td>
<td>occasionally</td>
<td>maybe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>80</td>
<td>22</td>
<td>24+</td>
<td>upright</td>
<td>D</td>
<td>45-55</td>
<td>very rounded</td>
<td>rounded</td>
<td>never</td>
<td>maybe</td>
<td></td>
</tr>
<tr>
<td>81</td>
<td>20</td>
<td>22</td>
<td>upright</td>
<td>D</td>
<td>55-65</td>
<td>very rounded</td>
<td>rounded</td>
<td>never</td>
<td>already</td>
<td></td>
</tr>
<tr>
<td>82</td>
<td>24+</td>
<td>24+</td>
<td>upright</td>
<td>F</td>
<td>20-35</td>
<td>rounded</td>
<td>rounded</td>
<td>often</td>
<td>maybe</td>
<td></td>
</tr>
<tr>
<td>84</td>
<td>24+</td>
<td>24+</td>
<td>upright</td>
<td>E</td>
<td>35-45</td>
<td>very rounded</td>
<td>rounded</td>
<td>often</td>
<td>maybe</td>
<td></td>
</tr>
<tr>
<td>85</td>
<td>14</td>
<td>18</td>
<td>upright</td>
<td>C</td>
<td>20-35</td>
<td>rounded</td>
<td>rounded</td>
<td>never</td>
<td>maybe</td>
<td></td>
</tr>
<tr>
<td>86</td>
<td>24+</td>
<td>24+</td>
<td>kyphosis D</td>
<td>55-65</td>
<td>very rounded</td>
<td>rounded</td>
<td>occasionally</td>
<td>maybe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>87</td>
<td>24+</td>
<td>24+</td>
<td>upright</td>
<td>D</td>
<td>45-55</td>
<td>very rounded</td>
<td>rounded</td>
<td>rounded</td>
<td>maybe</td>
<td></td>
</tr>
<tr>
<td>88</td>
<td>24+</td>
<td>24+</td>
<td>sway</td>
<td>C</td>
<td>35-45</td>
<td>very rounded</td>
<td>flat</td>
<td>occasionally</td>
<td>maybe</td>
<td></td>
</tr>
<tr>
<td>89</td>
<td>14</td>
<td>20</td>
<td>upright</td>
<td>D</td>
<td>35-45</td>
<td>rounded</td>
<td>rounded</td>
<td>often</td>
<td>maybe</td>
<td></td>
</tr>
<tr>
<td>90</td>
<td>18</td>
<td>14</td>
<td>upright D</td>
<td>65+</td>
<td>rounded</td>
<td>flat</td>
<td>occasional</td>
<td>maybe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>91</td>
<td>24+</td>
<td>24+</td>
<td>kyphosis E</td>
<td>45-55</td>
<td>very rounded</td>
<td>rounded</td>
<td>occasionally</td>
<td>maybe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>92</td>
<td>24+</td>
<td>24+</td>
<td>upright</td>
<td>D</td>
<td>55-65</td>
<td>rounded</td>
<td>rounded</td>
<td>occasionally</td>
<td>maybe</td>
<td></td>
</tr>
<tr>
<td>93</td>
<td>22</td>
<td>22</td>
<td>upright</td>
<td>D</td>
<td>35-45</td>
<td>very rounded</td>
<td>rounded</td>
<td>never</td>
<td>maybe</td>
<td></td>
</tr>
<tr>
<td>94</td>
<td>24+</td>
<td>24+</td>
<td>upright E</td>
<td>65+</td>
<td>very rounded</td>
<td>very rounded</td>
<td>never</td>
<td>never</td>
<td></td>
<td></td>
</tr>
<tr>
<td>95</td>
<td>24+</td>
<td>24+</td>
<td>kyphosis E</td>
<td>45-55</td>
<td>very rounded</td>
<td>very rounded</td>
<td>occasionally</td>
<td>maybe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>96</td>
<td>24+</td>
<td>24+</td>
<td>upright D</td>
<td>45-55</td>
<td>rounded</td>
<td>rounded</td>
<td>never</td>
<td>maybe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>97</td>
<td>24+</td>
<td>24+</td>
<td>lordosis FF</td>
<td>65+</td>
<td>very rounded</td>
<td>very rounded</td>
<td>often</td>
<td>maybe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>98</td>
<td>24+</td>
<td>24+</td>
<td>upright E</td>
<td>65+</td>
<td>very rounded</td>
<td>very rounded</td>
<td>never</td>
<td>maybe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>99</td>
<td>24+</td>
<td>24+</td>
<td>lordosis C</td>
<td>55-65</td>
<td>very rounded</td>
<td>very rounded</td>
<td>never</td>
<td>maybe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>100</td>
<td>24+</td>
<td>24+</td>
<td>upright D</td>
<td>45-55</td>
<td>very rounded</td>
<td>flat</td>
<td>never</td>
<td>never</td>
<td></td>
<td></td>
</tr>
<tr>
<td>101</td>
<td>22</td>
<td>24+</td>
<td>lordosis C</td>
<td>45-55</td>
<td>rounded</td>
<td>very rounded</td>
<td>occasionally</td>
<td>maybe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>102</td>
<td>24+</td>
<td>24+</td>
<td>sway    B</td>
<td>45-55</td>
<td>very rounded</td>
<td>rounded</td>
<td>occasionally</td>
<td>maybe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>103</td>
<td>24+</td>
<td>24+</td>
<td>lordosis C</td>
<td>45-55</td>
<td>very rounded</td>
<td>very rounded</td>
<td>occasionally</td>
<td>maybe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>104</td>
<td>24+</td>
<td>24+</td>
<td>lordosis E</td>
<td>45-55</td>
<td>very rounded</td>
<td>rounded</td>
<td>never</td>
<td>maybe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>106</td>
<td>18</td>
<td>18</td>
<td>upright F</td>
<td>55-65</td>
<td>very rounded</td>
<td>very rounded</td>
<td>never</td>
<td>maybe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>107</td>
<td>24+</td>
<td>24+</td>
<td>kyphosis C</td>
<td>45-55</td>
<td>very rounded</td>
<td>rounded</td>
<td>often</td>
<td>already</td>
<td></td>
<td></td>
</tr>
<tr>
<td>108</td>
<td>22</td>
<td>22</td>
<td>kyphosis C</td>
<td>20-35</td>
<td>rounded</td>
<td>rounded</td>
<td>occasionally</td>
<td>maybe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>109</td>
<td>20</td>
<td>18</td>
<td>upright FF</td>
<td>20-35</td>
<td>rounded</td>
<td>flat</td>
<td>often</td>
<td>maybe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>110</td>
<td>18</td>
<td>14</td>
<td>upright FF</td>
<td>65+</td>
<td>rounded</td>
<td>flat</td>
<td>never</td>
<td>maybe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>111</td>
<td>24+</td>
<td>24+</td>
<td>upright B</td>
<td>45-55</td>
<td>very rounded</td>
<td>very rounded</td>
<td>never</td>
<td>maybe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>112</td>
<td>18</td>
<td>18</td>
<td>upright D</td>
<td>45-55</td>
<td>rounded</td>
<td>rounded</td>
<td>occasionally</td>
<td>maybe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>113</td>
<td>24+</td>
<td>24+</td>
<td>sway    E</td>
<td>45-55</td>
<td>very rounded</td>
<td>very rounded</td>
<td>occasionally</td>
<td>maybe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>114</td>
<td>24+</td>
<td>24+</td>
<td>upright D</td>
<td>45-55</td>
<td>very rounded</td>
<td>rounded</td>
<td>after</td>
<td>maybe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>115</td>
<td>24+</td>
<td>24+</td>
<td>lordosis E</td>
<td>20-35</td>
<td>rounded</td>
<td>rounded</td>
<td>occasionally</td>
<td>maybe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>116</td>
<td>20</td>
<td>24+</td>
<td>upright E</td>
<td>45-55</td>
<td>very rounded</td>
<td>rounded</td>
<td>after</td>
<td>maybe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>117</td>
<td>24+</td>
<td>24+</td>
<td>kyphosis D</td>
<td>45-55</td>
<td>very rounded</td>
<td>rounded</td>
<td>occasionally</td>
<td>maybe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>118</td>
<td>24+</td>
<td>24+</td>
<td>lordosis D</td>
<td>45-55</td>
<td>very rounded</td>
<td>very rounded</td>
<td>often</td>
<td>maybe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>119</td>
<td>10</td>
<td>12</td>
<td>upright B</td>
<td>20-35</td>
<td>rounded</td>
<td>rounded</td>
<td>occasionally</td>
<td>maybe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>120</td>
<td>24+</td>
<td>24+</td>
<td>lordosis F</td>
<td>20-35</td>
<td>very rounded</td>
<td>flat</td>
<td>occasional</td>
<td>maybe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>121</td>
<td>22</td>
<td>24+</td>
<td>upright E</td>
<td>20-35</td>
<td>rounded</td>
<td>rounded</td>
<td>occasionally</td>
<td>maybe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>122</td>
<td>24+</td>
<td>24+</td>
<td>upright E</td>
<td>35-45</td>
<td>rounded</td>
<td>rounded</td>
<td>occasionally</td>
<td>maybe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>123</td>
<td>22</td>
<td>22</td>
<td>lordosis E</td>
<td>20-35</td>
<td>rounded</td>
<td>rounded</td>
<td>occasional</td>
<td>maybe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>124</td>
<td>14</td>
<td>14</td>
<td>lordosis F</td>
<td>45-55</td>
<td>rounded</td>
<td>rounded</td>
<td>never</td>
<td>never</td>
<td></td>
<td></td>
</tr>
<tr>
<td>125</td>
<td>18</td>
<td>18</td>
<td>upright FF</td>
<td>35-40</td>
<td>rounded</td>
<td>rounded</td>
<td>occasional</td>
<td>maybe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>127</td>
<td>24+</td>
<td>24+</td>
<td>lordosis C</td>
<td>35-45</td>
<td>very rounded</td>
<td>very rounded</td>
<td>never</td>
<td>maybe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>128</td>
<td>24+</td>
<td>24+</td>
<td>lordosis F</td>
<td>35-45</td>
<td>very rounded</td>
<td>flat</td>
<td>occasional</td>
<td>maybe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>129</td>
<td>24+</td>
<td>24+</td>
<td>lordosis C</td>
<td>35-45</td>
<td>very rounded</td>
<td>very rounded</td>
<td>never</td>
<td>maybe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>130</td>
<td>24+</td>
<td>24+</td>
<td>lordosis D</td>
<td>65+</td>
<td>very rounded</td>
<td>very rounded</td>
<td>occasional</td>
<td>maybe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>131</td>
<td>24+</td>
<td>24+</td>
<td>lordosis B</td>
<td>65+</td>
<td>very rounded</td>
<td>very rounded</td>
<td>occasional</td>
<td>maybe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>132</td>
<td>24+</td>
<td>24+</td>
<td>lordosis F</td>
<td>55-65</td>
<td>very rounded</td>
<td>very rounded</td>
<td>often</td>
<td>maybe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>133</td>
<td>24+</td>
<td>24+</td>
<td>lordosis E</td>
<td>55-65</td>
<td>very rounded</td>
<td>never</td>
<td>maybe</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>203</td>
<td>20</td>
<td>22</td>
<td>type C</td>
<td>kyphosis</td>
<td>D</td>
<td>45-55</td>
<td>rounded</td>
<td>rounded</td>
<td>occasionally</td>
<td>maybe</td>
</tr>
<tr>
<td>204</td>
<td>8</td>
<td>12</td>
<td>type B</td>
<td>kyphosis</td>
<td>B</td>
<td>20-35</td>
<td>rounded</td>
<td>rounded</td>
<td>occasionally</td>
<td>maybe</td>
</tr>
<tr>
<td>205</td>
<td>10</td>
<td>12</td>
<td>type C</td>
<td>kyphosis</td>
<td>C</td>
<td>35-45</td>
<td>very rounded</td>
<td>very rounded</td>
<td>never</td>
<td>abstained</td>
</tr>
<tr>
<td>206</td>
<td>18</td>
<td>18</td>
<td>type B</td>
<td>upright</td>
<td>E</td>
<td>45-55</td>
<td>rounded</td>
<td>flat</td>
<td>occasionally</td>
<td>maybe</td>
</tr>
<tr>
<td>207</td>
<td>8</td>
<td>10</td>
<td>type C</td>
<td>upright</td>
<td>B</td>
<td>20-35</td>
<td>rounded</td>
<td>rounded</td>
<td>never</td>
<td>already</td>
</tr>
<tr>
<td>208</td>
<td>22</td>
<td>24+</td>
<td>type C</td>
<td>lordosis</td>
<td>D</td>
<td>55-65</td>
<td>rounded</td>
<td>rounded</td>
<td>often</td>
<td>maybe</td>
</tr>
<tr>
<td>209</td>
<td>24+</td>
<td>24+</td>
<td>type C</td>
<td>lordosis</td>
<td>E</td>
<td>35-45</td>
<td>rounded</td>
<td>very rounded</td>
<td>never</td>
<td>maybe</td>
</tr>
<tr>
<td>210</td>
<td>24+</td>
<td>24+</td>
<td>type E</td>
<td>sway</td>
<td>C</td>
<td>20-35</td>
<td>very rounded</td>
<td>flat</td>
<td>never</td>
<td>maybe</td>
</tr>
<tr>
<td>211</td>
<td>24+</td>
<td>20</td>
<td>type B</td>
<td>upright</td>
<td>FF</td>
<td>45-55</td>
<td>rounded</td>
<td>very rounded</td>
<td>never</td>
<td>maybe</td>
</tr>
<tr>
<td>212</td>
<td>8</td>
<td>8</td>
<td>type A</td>
<td>upright</td>
<td>A</td>
<td>16-20</td>
<td>flat</td>
<td>flat</td>
<td>occasionally</td>
<td>maybe</td>
</tr>
<tr>
<td>213</td>
<td>20</td>
<td>20</td>
<td>type C</td>
<td>kyphosis</td>
<td>C</td>
<td>45-55</td>
<td>rounded</td>
<td>rounded</td>
<td>occasionally</td>
<td>maybe</td>
</tr>
<tr>
<td>214</td>
<td>20</td>
<td>22</td>
<td>type C</td>
<td>lordosis</td>
<td>D</td>
<td>20-35</td>
<td>rounded</td>
<td>rounded</td>
<td>even</td>
<td>maybe</td>
</tr>
<tr>
<td>215</td>
<td>14</td>
<td>12</td>
<td>type A</td>
<td>upright</td>
<td>D</td>
<td>20-35</td>
<td>rounded</td>
<td>rounded</td>
<td>occasionally</td>
<td>maybe</td>
</tr>
<tr>
<td>216</td>
<td>16</td>
<td>20</td>
<td>type C</td>
<td>upright</td>
<td>C</td>
<td>35-45</td>
<td>rounded</td>
<td>rounded</td>
<td>often</td>
<td>maybe</td>
</tr>
<tr>
<td>217</td>
<td>14</td>
<td>16</td>
<td>type C</td>
<td>lordosis</td>
<td>C</td>
<td>20-35</td>
<td>rounded</td>
<td>rounded</td>
<td>occasionally</td>
<td>maybe</td>
</tr>
<tr>
<td>218</td>
<td>16</td>
<td>22</td>
<td>type D</td>
<td>kyphosis</td>
<td>B</td>
<td>35-45</td>
<td>very rounded</td>
<td>rounded</td>
<td>occasionally</td>
<td>maybe</td>
</tr>
<tr>
<td>219</td>
<td>24+</td>
<td>24+</td>
<td>type E</td>
<td>upright</td>
<td>FF</td>
<td>45-55</td>
<td>very rounded</td>
<td>rounded</td>
<td>often</td>
<td>maybe</td>
</tr>
<tr>
<td>220</td>
<td>16</td>
<td>20</td>
<td>type C</td>
<td>upright</td>
<td>B</td>
<td>20-35</td>
<td>rounded</td>
<td>rounded</td>
<td>occasionally</td>
<td>maybe</td>
</tr>
<tr>
<td>221</td>
<td>22</td>
<td>20</td>
<td>type D</td>
<td>upright</td>
<td>D</td>
<td>45-55</td>
<td>rounded</td>
<td>flat</td>
<td>never</td>
<td>maybe</td>
</tr>
<tr>
<td>222</td>
<td>16</td>
<td>20</td>
<td>type E</td>
<td>lordosis</td>
<td>B</td>
<td>45-55</td>
<td>very rounded</td>
<td>very rounded</td>
<td>often</td>
<td>maybe</td>
</tr>
<tr>
<td>223</td>
<td>20</td>
<td>20</td>
<td>type A</td>
<td>lordosis</td>
<td>E</td>
<td>45-55</td>
<td>very rounded</td>
<td>flat</td>
<td>often</td>
<td>maybe</td>
</tr>
<tr>
<td>224</td>
<td>16</td>
<td>14</td>
<td>type D</td>
<td>upright</td>
<td>C</td>
<td>45-55</td>
<td>rounded</td>
<td>flat</td>
<td>never</td>
<td>maybe</td>
</tr>
<tr>
<td>225</td>
<td>10</td>
<td>12</td>
<td>type B</td>
<td>lordosis</td>
<td>B</td>
<td>20-35</td>
<td>rounded</td>
<td>very rounded</td>
<td>never</td>
<td>never</td>
</tr>
<tr>
<td>226</td>
<td>18</td>
<td>18</td>
<td>type A</td>
<td>upright</td>
<td>D</td>
<td>35-45</td>
<td>rounded</td>
<td>flat</td>
<td>occasionally</td>
<td>already</td>
</tr>
<tr>
<td>227</td>
<td>24+</td>
<td>24+</td>
<td>type C</td>
<td>kyphosis</td>
<td>FF</td>
<td>35-45</td>
<td>very rounded</td>
<td>rounded</td>
<td>often</td>
<td>maybe</td>
</tr>
<tr>
<td>228</td>
<td>18</td>
<td>20</td>
<td>type C</td>
<td>kyphosis</td>
<td>E</td>
<td>35-45</td>
<td>rounded</td>
<td>rounded</td>
<td>occasionally</td>
<td>maybe</td>
</tr>
<tr>
<td>229</td>
<td>20</td>
<td>24+</td>
<td>type C</td>
<td>lordosis</td>
<td>E</td>
<td>55-65</td>
<td>rounded</td>
<td>very rounded</td>
<td>often</td>
<td>maybe</td>
</tr>
<tr>
<td>230</td>
<td>24+</td>
<td>24+</td>
<td>type C</td>
<td>lordosis</td>
<td>E</td>
<td>35-45</td>
<td>very rounded</td>
<td>rounded</td>
<td>occasionally</td>
<td>maybe</td>
</tr>
<tr>
<td>231</td>
<td>18</td>
<td>18</td>
<td>type D</td>
<td>kyphosis</td>
<td>C</td>
<td>55-65</td>
<td>rounded</td>
<td>rounded</td>
<td>occasionally</td>
<td>maybe</td>
</tr>
<tr>
<td>232</td>
<td>14</td>
<td>14</td>
<td>type B</td>
<td>lordosis</td>
<td>O</td>
<td>35-45</td>
<td>rounded</td>
<td>very rounded</td>
<td>never</td>
<td>maybe</td>
</tr>
<tr>
<td>233</td>
<td>24+</td>
<td>24+</td>
<td>type D</td>
<td>kyphosis</td>
<td>C</td>
<td>35-45</td>
<td>very rounded</td>
<td>rounded</td>
<td>often</td>
<td>maybe</td>
</tr>
<tr>
<td>234</td>
<td>24+</td>
<td>24+</td>
<td>type C</td>
<td>lordosis</td>
<td>FF</td>
<td>45-55</td>
<td>very rounded</td>
<td>very rounded</td>
<td>often</td>
<td>already</td>
</tr>
<tr>
<td>235</td>
<td>20</td>
<td>20</td>
<td>type C</td>
<td>lordosis</td>
<td>F</td>
<td>35-45</td>
<td>very rounded</td>
<td>rounded</td>
<td>never</td>
<td>maybe</td>
</tr>
<tr>
<td>236</td>
<td>18</td>
<td>18</td>
<td>type D</td>
<td>kyphosis</td>
<td>E</td>
<td>45-55</td>
<td>rounded</td>
<td>flat</td>
<td>occasionally</td>
<td>maybe</td>
</tr>
<tr>
<td>237</td>
<td>24+</td>
<td>24+</td>
<td>type C</td>
<td>kyphosis</td>
<td>D</td>
<td>35-45</td>
<td>very rounded</td>
<td>rounded</td>
<td>occasionally</td>
<td>maybe</td>
</tr>
<tr>
<td>238</td>
<td>8</td>
<td>8</td>
<td>type B</td>
<td>upright</td>
<td>D</td>
<td>35-45</td>
<td>rounded</td>
<td>rounded</td>
<td>often</td>
<td>maybe</td>
</tr>
<tr>
<td>239</td>
<td>8</td>
<td>8</td>
<td>type B</td>
<td>upright</td>
<td>D</td>
<td>35-45</td>
<td>rounded</td>
<td>rounded</td>
<td>often</td>
<td>maybe</td>
</tr>
<tr>
<td>240</td>
<td>24+</td>
<td>24+</td>
<td>type C</td>
<td>kyphosis</td>
<td>D</td>
<td>35-45</td>
<td>very rounded</td>
<td>rounded</td>
<td>occasionally</td>
<td>maybe</td>
</tr>
<tr>
<td>241</td>
<td>18</td>
<td>18</td>
<td>type D</td>
<td>upright</td>
<td>C</td>
<td>45-55</td>
<td>rounded</td>
<td>rounded</td>
<td>occasionally</td>
<td>maybe</td>
</tr>
<tr>
<td>242</td>
<td>10</td>
<td>10</td>
<td>type D</td>
<td>upright</td>
<td>B</td>
<td>15-20</td>
<td>rounded</td>
<td>rounded</td>
<td>never</td>
<td>maybe</td>
</tr>
<tr>
<td>243</td>
<td>20</td>
<td>20</td>
<td>type D</td>
<td>lordosis</td>
<td>E</td>
<td>20-35</td>
<td>very rounded</td>
<td>rounded</td>
<td>occasionally</td>
<td>maybe</td>
</tr>
<tr>
<td>244</td>
<td>16</td>
<td>16</td>
<td>type D</td>
<td>upright</td>
<td>D</td>
<td>55-65</td>
<td>rounded</td>
<td>rounded</td>
<td>occasionally</td>
<td>maybe</td>
</tr>
<tr>
<td>245</td>
<td>16</td>
<td>16</td>
<td>type C</td>
<td>lordosis</td>
<td>D</td>
<td>20-35</td>
<td>rounded</td>
<td>rounded</td>
<td>never</td>
<td>maybe</td>
</tr>
<tr>
<td>246</td>
<td>14</td>
<td>16</td>
<td>type C</td>
<td>kyphosis</td>
<td>B</td>
<td>45-55</td>
<td>rounded</td>
<td>flat</td>
<td>occasionally</td>
<td>maybe</td>
</tr>
<tr>
<td>247</td>
<td>24+</td>
<td>24+</td>
<td>type B</td>
<td>lordosis</td>
<td>O</td>
<td>35-45</td>
<td>rounded</td>
<td>rounded</td>
<td>occasionally</td>
<td>maybe</td>
</tr>
<tr>
<td>248</td>
<td>20</td>
<td>24+</td>
<td>type D</td>
<td>upright</td>
<td>FF</td>
<td>45-55</td>
<td>rounded</td>
<td>flat</td>
<td>never</td>
<td>maybe</td>
</tr>
<tr>
<td>249</td>
<td>16</td>
<td>16</td>
<td>type D</td>
<td>upright</td>
<td>C</td>
<td>45-55</td>
<td>rounded</td>
<td>rounded</td>
<td>occasionally</td>
<td>maybe</td>
</tr>
<tr>
<td>250</td>
<td>24+</td>
<td>24+</td>
<td>type C</td>
<td>upright</td>
<td>D</td>
<td>45-55</td>
<td>very rounded</td>
<td>very rounded</td>
<td>occasionally</td>
<td>maybe</td>
</tr>
<tr>
<td>251</td>
<td>8</td>
<td>8</td>
<td>type D</td>
<td>upright</td>
<td>B</td>
<td>20-35</td>
<td>flat</td>
<td>rounded</td>
<td>never</td>
<td>maybe</td>
</tr>
<tr>
<td>252</td>
<td>14</td>
<td>14</td>
<td>type B</td>
<td>upright</td>
<td>D</td>
<td>20-35</td>
<td>very rounded</td>
<td>rounded</td>
<td>never</td>
<td>maybe</td>
</tr>
<tr>
<td>253</td>
<td>16</td>
<td>14</td>
<td>type D</td>
<td>upright</td>
<td>B</td>
<td>20-35</td>
<td>rounded</td>
<td>rounded</td>
<td>never</td>
<td>maybe</td>
</tr>
<tr>
<td>254</td>
<td>20</td>
<td>16</td>
<td>type D</td>
<td>upright</td>
<td>D</td>
<td>35-45</td>
<td>rounded</td>
<td>rounded</td>
<td>occasionally</td>
<td>already</td>
</tr>
<tr>
<td>255</td>
<td>10</td>
<td>0</td>
<td>type C</td>
<td>kyphosis</td>
<td>B</td>
<td>20-35</td>
<td>rounded</td>
<td>rounded</td>
<td>never</td>
<td>maybe</td>
</tr>
<tr>
<td>256</td>
<td>16</td>
<td>16</td>
<td>type D</td>
<td>lordosis</td>
<td>H</td>
<td>35-45</td>
<td>very rounded</td>
<td>rounded</td>
<td>never</td>
<td>maybe</td>
</tr>
<tr>
<td>257</td>
<td>18</td>
<td>18</td>
<td>type D</td>
<td>kyphosis</td>
<td>C</td>
<td>45-55</td>
<td>rounded</td>
<td>rounded</td>
<td>often</td>
<td>maybe</td>
</tr>
<tr>
<td>258</td>
<td>20</td>
<td>20</td>
<td>type C</td>
<td>upright</td>
<td>D</td>
<td>20-35</td>
<td>rounded</td>
<td>very rounded</td>
<td>never</td>
<td>maybe</td>
</tr>
<tr>
<td>259</td>
<td>24+</td>
<td>24+</td>
<td>type C</td>
<td>upright</td>
<td>B</td>
<td>45-55</td>
<td>very rounded</td>
<td>very rounded</td>
<td>occasionally</td>
<td>already</td>
</tr>
<tr>
<td>260</td>
<td>18</td>
<td>20</td>
<td>type F</td>
<td>upright</td>
<td>FF</td>
<td>55-65</td>
<td>rounded</td>
<td>rounded</td>
<td>often</td>
<td>maybe</td>
</tr>
<tr>
<td>261</td>
<td>16</td>
<td>20</td>
<td>type E</td>
<td>kyphosis</td>
<td>C</td>
<td>55-65</td>
<td>very rounded</td>
<td>rounded</td>
<td>never</td>
<td>maybe</td>
</tr>
<tr>
<td>262</td>
<td>18</td>
<td>18</td>
<td>type B</td>
<td>upright</td>
<td>B</td>
<td>20-35</td>
<td>rounded</td>
<td>rounded</td>
<td>occasionally</td>
<td>maybe</td>
</tr>
<tr>
<td>263</td>
<td>16</td>
<td>16</td>
<td>type C</td>
<td>kyphosis</td>
<td>E</td>
<td>20-35</td>
<td>very rounded</td>
<td>very rounded</td>
<td>never</td>
<td>maybe</td>
</tr>
<tr>
<td>264</td>
<td>16</td>
<td>16</td>
<td>type F</td>
<td>swallow</td>
<td>D</td>
<td>20-35</td>
<td>very rounded</td>
<td>rounded</td>
<td>never</td>
<td>maybe</td>
</tr>
<tr>
<td>265</td>
<td>10</td>
<td>12</td>
<td>type B</td>
<td>upright</td>
<td>C</td>
<td>16-20</td>
<td>rounded</td>
<td>rounded</td>
<td>never</td>
<td>maybe</td>
</tr>
<tr>
<td>134</td>
<td>24+</td>
<td>20</td>
<td>type D</td>
<td>upright</td>
<td>D</td>
<td>55-65</td>
<td>very rounded</td>
<td>flat</td>
<td>occasionally</td>
<td>maybe</td>
</tr>
<tr>
<td>135</td>
<td>24+</td>
<td>24+</td>
<td>type D</td>
<td>lordosis</td>
<td>D</td>
<td>55-65</td>
<td>very rounded</td>
<td>very rounded</td>
<td>often</td>
<td>already</td>
</tr>
<tr>
<td>136</td>
<td>24+</td>
<td>20</td>
<td>type D</td>
<td>kyphosis</td>
<td>FF</td>
<td>45-55</td>
<td>very rounded</td>
<td>flat</td>
<td>occasionally</td>
<td>maybe</td>
</tr>
<tr>
<td>137</td>
<td>14</td>
<td>34</td>
<td>type C</td>
<td>kyphosis</td>
<td>E</td>
<td>65+</td>
<td>rounded</td>
<td>rounded</td>
<td>never</td>
<td>maybe</td>
</tr>
<tr>
<td>138</td>
<td>20</td>
<td>22</td>
<td>type D</td>
<td>upright</td>
<td>C</td>
<td>55-65</td>
<td>very rounded</td>
<td>flat</td>
<td>often</td>
<td>already</td>
</tr>
<tr>
<td>139</td>
<td>20</td>
<td>26</td>
<td>type A</td>
<td>kyphosis</td>
<td>C</td>
<td>45-55</td>
<td>very rounded</td>
<td>flat</td>
<td>never</td>
<td>maybe</td>
</tr>
<tr>
<td>140</td>
<td>24+</td>
<td>24+</td>
<td>type C</td>
<td>kyphosis</td>
<td>F</td>
<td>45-55</td>
<td>very rounded</td>
<td>very rounded</td>
<td>occasionally</td>
<td>maybe</td>
</tr>
<tr>
<td>141</td>
<td>24+</td>
<td>24+</td>
<td>type E</td>
<td>kyphosis</td>
<td>C</td>
<td>35-45</td>
<td>very rounded</td>
<td>very rounded</td>
<td>never</td>
<td>maybe</td>
</tr>
<tr>
<td>142</td>
<td>24+</td>
<td>24+</td>
<td>type F</td>
<td>kyphosis</td>
<td>C</td>
<td>35-45</td>
<td>very rounded</td>
<td>very rounded</td>
<td>never</td>
<td>maybe</td>
</tr>
<tr>
<td>143</td>
<td>18</td>
<td>38</td>
<td>type C</td>
<td>kyphosis</td>
<td>FF</td>
<td>20-35</td>
<td>rounded</td>
<td>flat</td>
<td>occasionally</td>
<td>maybe</td>
</tr>
<tr>
<td>144</td>
<td>24+</td>
<td>24+</td>
<td>type E</td>
<td>lordosis</td>
<td>D</td>
<td>55-65</td>
<td>very rounded</td>
<td>very rounded</td>
<td>often</td>
<td>maybe</td>
</tr>
<tr>
<td>145</td>
<td>22</td>
<td>24+</td>
<td>type C</td>
<td>kyphosis</td>
<td>D</td>
<td>45-55</td>
<td>very rounded</td>
<td>very rounded</td>
<td>occasionally</td>
<td>maybe</td>
</tr>
<tr>
<td>146</td>
<td>24+</td>
<td>24+</td>
<td>type C</td>
<td>lordosis</td>
<td>D</td>
<td>20-35</td>
<td>very rounded</td>
<td>rounded</td>
<td>never</td>
<td>maybe</td>
</tr>
<tr>
<td>147</td>
<td>20</td>
<td>22</td>
<td>type D</td>
<td>lordosis</td>
<td>D</td>
<td>55-65</td>
<td>very rounded</td>
<td>very rounded</td>
<td>occasionally</td>
<td>maybe</td>
</tr>
<tr>
<td>148</td>
<td>18</td>
<td>22</td>
<td>type C</td>
<td>kyphosis</td>
<td>C</td>
<td>20-35</td>
<td>rounded</td>
<td>very rounded</td>
<td>occasionally</td>
<td>maybe</td>
</tr>
<tr>
<td>149</td>
<td>18</td>
<td>20</td>
<td>type D</td>
<td>upright</td>
<td>B</td>
<td>35-45</td>
<td>very rounded</td>
<td>rounded</td>
<td>never</td>
<td>maybe</td>
</tr>
<tr>
<td>150</td>
<td>20</td>
<td>21</td>
<td>type B</td>
<td>kyphosis</td>
<td>D</td>
<td>45-55</td>
<td>rounded</td>
<td>rounded</td>
<td>occasionally</td>
<td>never</td>
</tr>
<tr>
<td>151</td>
<td>18</td>
<td>20</td>
<td>type C</td>
<td>upright</td>
<td>C</td>
<td>55-65</td>
<td>rounded</td>
<td>rounded</td>
<td>never</td>
<td>already</td>
</tr>
<tr>
<td>152</td>
<td>20</td>
<td>20</td>
<td>type C</td>
<td>upright</td>
<td>E</td>
<td>20-35</td>
<td>rounded</td>
<td>rounded</td>
<td>occasionally</td>
<td>maybe</td>
</tr>
<tr>
<td>153</td>
<td>20</td>
<td>22</td>
<td>type C</td>
<td>lordosis</td>
<td>D</td>
<td>20-35</td>
<td>very rounded</td>
<td>rounded</td>
<td>occasionally</td>
<td>maybe</td>
</tr>
<tr>
<td>154</td>
<td>22</td>
<td>24+</td>
<td>type E</td>
<td>lordosis</td>
<td>D</td>
<td>45-55</td>
<td>very rounded</td>
<td>rounded</td>
<td>never</td>
<td>maybe</td>
</tr>
<tr>
<td>155</td>
<td>24+</td>
<td>24+</td>
<td>type D</td>
<td>upright</td>
<td>F</td>
<td>45-55</td>
<td>very rounded</td>
<td>flat</td>
<td>never</td>
<td>maybe</td>
</tr>
<tr>
<td>156</td>
<td>24+</td>
<td>24+</td>
<td>type E</td>
<td>kyphosis</td>
<td>D</td>
<td>45-55</td>
<td>very rounded</td>
<td>rounded</td>
<td>occasionally</td>
<td>maybe</td>
</tr>
<tr>
<td>157</td>
<td>24+</td>
<td>24+</td>
<td>type E</td>
<td>lordosis</td>
<td>FF</td>
<td>35-45</td>
<td>very rounded</td>
<td>rounded</td>
<td>occasionally</td>
<td>maybe</td>
</tr>
<tr>
<td>158</td>
<td>24+</td>
<td>24+</td>
<td>type E</td>
<td>kyphosis</td>
<td>D</td>
<td>45-55</td>
<td>very rounded</td>
<td>very rounded</td>
<td>occasionally</td>
<td>maybe</td>
</tr>
<tr>
<td>159</td>
<td>24+</td>
<td>24+</td>
<td>type D</td>
<td>upright</td>
<td>D</td>
<td>45-55</td>
<td>very rounded</td>
<td>rounded</td>
<td>rounded</td>
<td>occasionally</td>
</tr>
<tr>
<td>160</td>
<td>20</td>
<td>20</td>
<td>type E</td>
<td>kyphosis</td>
<td>D</td>
<td>35-45</td>
<td>very rounded</td>
<td>very rounded</td>
<td>occasionally</td>
<td>maybe</td>
</tr>
<tr>
<td>161</td>
<td>21</td>
<td>21</td>
<td>type A</td>
<td>upright</td>
<td>D</td>
<td>65+</td>
<td>very rounded</td>
<td>rounded</td>
<td>occasionally</td>
<td>maybe</td>
</tr>
<tr>
<td>162</td>
<td>20</td>
<td>20</td>
<td>type C</td>
<td>kyphosis</td>
<td>C</td>
<td>45-55</td>
<td>rounded</td>
<td>rounded</td>
<td>rounded</td>
<td>occasionally</td>
</tr>
<tr>
<td>163</td>
<td>24+</td>
<td>24+</td>
<td>type C</td>
<td>lordosis</td>
<td>E</td>
<td>55-65</td>
<td>very rounded</td>
<td>rounded</td>
<td>often</td>
<td>already</td>
</tr>
<tr>
<td>164</td>
<td>18</td>
<td>20</td>
<td>type D</td>
<td>kyphosis</td>
<td>C</td>
<td>45-55</td>
<td>rounded</td>
<td>rounded</td>
<td>occasionally</td>
<td>already</td>
</tr>
<tr>
<td>165</td>
<td>18</td>
<td>16</td>
<td>type E</td>
<td>upright</td>
<td>C</td>
<td>55-65</td>
<td>very rounded</td>
<td>flat</td>
<td>occasionally</td>
<td>maybe</td>
</tr>
<tr>
<td>166</td>
<td>18</td>
<td>18</td>
<td>type D</td>
<td>kyphosis</td>
<td>C</td>
<td>55-65</td>
<td>rounded</td>
<td>very rounded</td>
<td>never</td>
<td>maybe</td>
</tr>
<tr>
<td>167</td>
<td>24+</td>
<td>20</td>
<td>type D</td>
<td>upright</td>
<td>D</td>
<td>55-65</td>
<td>very rounded</td>
<td>flat</td>
<td>occasionally</td>
<td>maybe</td>
</tr>
<tr>
<td>168</td>
<td>24+</td>
<td>24+</td>
<td>type D</td>
<td>lordosis</td>
<td>D</td>
<td>55-65</td>
<td>very rounded</td>
<td>very rounded</td>
<td>often</td>
<td>maybe</td>
</tr>
<tr>
<td>169</td>
<td>24+</td>
<td>20</td>
<td>type D</td>
<td>kyphosis</td>
<td>FF</td>
<td>45-55</td>
<td>very rounded</td>
<td>flat</td>
<td>occasionally</td>
<td>maybe</td>
</tr>
<tr>
<td>170</td>
<td>14</td>
<td>34</td>
<td>type C</td>
<td>kyphosis</td>
<td>E</td>
<td>65+</td>
<td>rounded</td>
<td>rounded</td>
<td>never</td>
<td>maybe</td>
</tr>
<tr>
<td>171</td>
<td>20</td>
<td>22</td>
<td>type D</td>
<td>upright</td>
<td>C</td>
<td>55-65</td>
<td>very rounded</td>
<td>flat</td>
<td>often</td>
<td>already</td>
</tr>
<tr>
<td>172</td>
<td>20</td>
<td>18</td>
<td>type A</td>
<td>kyphosis</td>
<td>C</td>
<td>45-55</td>
<td>very rounded</td>
<td>flat</td>
<td>never</td>
<td>maybe</td>
</tr>
<tr>
<td>173</td>
<td>24+</td>
<td>24+</td>
<td>type E</td>
<td>kyphosis</td>
<td>F</td>
<td>45-55</td>
<td>very rounded</td>
<td>very rounded</td>
<td>occasionally</td>
<td>maybe</td>
</tr>
<tr>
<td>174</td>
<td>24+</td>
<td>24+</td>
<td>type C</td>
<td>kyphosis</td>
<td>C</td>
<td>35-45</td>
<td>very rounded</td>
<td>very rounded</td>
<td>never</td>
<td>maybe</td>
</tr>
<tr>
<td>175</td>
<td>24+</td>
<td>24+</td>
<td>type E</td>
<td>kyphosis</td>
<td>C</td>
<td>35-45</td>
<td>very rounded</td>
<td>very rounded</td>
<td>never</td>
<td>maybe</td>
</tr>
<tr>
<td>176</td>
<td>18</td>
<td>18</td>
<td>type C</td>
<td>kyphosis</td>
<td>FF</td>
<td>20-35</td>
<td>rounded</td>
<td>flat</td>
<td>occasionally</td>
<td>maybe</td>
</tr>
<tr>
<td>177</td>
<td>24+</td>
<td>24+</td>
<td>type E</td>
<td>lordosis</td>
<td>D</td>
<td>55-65</td>
<td>very rounded</td>
<td>very rounded</td>
<td>often</td>
<td>maybe</td>
</tr>
<tr>
<td>178</td>
<td>22</td>
<td>24+</td>
<td>type C</td>
<td>lordosis</td>
<td>D</td>
<td>45-55</td>
<td>very rounded</td>
<td>very rounded</td>
<td>occasionally</td>
<td>maybe</td>
</tr>
<tr>
<td>179</td>
<td>24+</td>
<td>24+</td>
<td>type E</td>
<td>lordosis</td>
<td>D</td>
<td>20-35</td>
<td>very rounded</td>
<td>rounded</td>
<td>never</td>
<td>maybe</td>
</tr>
<tr>
<td>180</td>
<td>22</td>
<td>22</td>
<td>type D</td>
<td>kyphosis</td>
<td>C</td>
<td>55-65</td>
<td>very rounded</td>
<td>very rounded</td>
<td>occasionally</td>
<td>maybe</td>
</tr>
<tr>
<td>181</td>
<td>20</td>
<td>20</td>
<td>type D</td>
<td>upright</td>
<td>E</td>
<td>20-35</td>
<td>rounded</td>
<td>rounded</td>
<td>occasionally</td>
<td>maybe</td>
</tr>
<tr>
<td>182</td>
<td>22</td>
<td>22</td>
<td>type D</td>
<td>lordosis</td>
<td>D</td>
<td>20-35</td>
<td>very rounded</td>
<td>rounded</td>
<td>occasionally</td>
<td>maybe</td>
</tr>
<tr>
<td>183</td>
<td>24+</td>
<td>24+</td>
<td>type E</td>
<td>lordosis</td>
<td>D</td>
<td>55-65</td>
<td>very rounded</td>
<td>very rounded</td>
<td>never</td>
<td>maybe</td>
</tr>
<tr>
<td>184</td>
<td>22</td>
<td>24+</td>
<td>type E</td>
<td>kyphosis</td>
<td>D</td>
<td>45-55</td>
<td>very rounded</td>
<td>rounded</td>
<td>occasionally</td>
<td>maybe</td>
</tr>
<tr>
<td>185</td>
<td>24+</td>
<td>24+</td>
<td>type C</td>
<td>lordosis</td>
<td>FF</td>
<td>35-45</td>
<td>very rounded</td>
<td>rounded</td>
<td>occasionally</td>
<td>maybe</td>
</tr>
<tr>
<td>186</td>
<td>24+</td>
<td>24+</td>
<td>type E</td>
<td>kyphosis</td>
<td>D</td>
<td>45-55</td>
<td>very rounded</td>
<td>very rounded</td>
<td>occasionally</td>
<td>maybe</td>
</tr>
<tr>
<td>187</td>
<td>24+</td>
<td>24+</td>
<td>type D</td>
<td>upright</td>
<td>D</td>
<td>45-55</td>
<td>very rounded</td>
<td>rounded</td>
<td>occasionally</td>
<td>maybe</td>
</tr>
<tr>
<td>188</td>
<td>20</td>
<td>20</td>
<td>type E</td>
<td>kyphosis</td>
<td>D</td>
<td>35-45</td>
<td>very rounded</td>
<td>very rounded</td>
<td>never</td>
<td>maybe</td>
</tr>
<tr>
<td>189</td>
<td>22</td>
<td>22</td>
<td>type A</td>
<td>upright</td>
<td>D</td>
<td>65+</td>
<td>very rounded</td>
<td>rounded</td>
<td>occasionally</td>
<td>maybe</td>
</tr>
<tr>
<td>190</td>
<td>20</td>
<td>20</td>
<td>type E</td>
<td>kyphosis</td>
<td>C</td>
<td>45-55</td>
<td>rounded</td>
<td>rounded</td>
<td>occasionally</td>
<td>maybe</td>
</tr>
<tr>
<td>191</td>
<td>24+</td>
<td>24+</td>
<td>type C</td>
<td>lordosis</td>
<td>E</td>
<td>55-65</td>
<td>rounded</td>
<td>rounded</td>
<td>never</td>
<td>already</td>
</tr>
<tr>
<td>192</td>
<td>20</td>
<td>20</td>
<td>type D</td>
<td>kyphosis</td>
<td>C</td>
<td>45-55</td>
<td>rounded</td>
<td>rounded</td>
<td>occasionally</td>
<td>already</td>
</tr>
<tr>
<td>193</td>
<td>18</td>
<td>16</td>
<td>type E</td>
<td>upright</td>
<td>C</td>
<td>55-65</td>
<td>very rounded</td>
<td>flat</td>
<td>occasionally</td>
<td>maybe</td>
</tr>
<tr>
<td>194</td>
<td>18</td>
<td>22</td>
<td>type C</td>
<td>kyphosis</td>
<td>C</td>
<td>55-65</td>
<td>rounded</td>
<td>very rounded</td>
<td>never</td>
<td>maybe</td>
</tr>
<tr>
<td>No.</td>
<td>Race</td>
<td>Sex</td>
<td>Age</td>
<td>Degree</td>
<td>Shape</td>
<td>Roundness</td>
<td>Orientation</td>
<td>Posture</td>
<td>Occasional</td>
<td>More</td>
</tr>
<tr>
<td>-----</td>
<td>------</td>
<td>-----</td>
<td>-----</td>
<td>--------</td>
<td>-------</td>
<td>-----------</td>
<td>-------------</td>
<td>---------</td>
<td>------------</td>
<td>------</td>
</tr>
<tr>
<td>275</td>
<td>10</td>
<td>12</td>
<td>D</td>
<td>35-45</td>
<td>rounded</td>
<td>rounded</td>
<td>occasionally</td>
<td>maybe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>276</td>
<td>16</td>
<td>18</td>
<td>C</td>
<td>35-45</td>
<td>very rounded</td>
<td>rounded</td>
<td>occasionally</td>
<td>maybe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>277</td>
<td>22</td>
<td>22</td>
<td>D</td>
<td>20-35</td>
<td>very rounded</td>
<td>very rounded</td>
<td>occasionally</td>
<td>maybe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>278</td>
<td>14</td>
<td>18</td>
<td>C</td>
<td>20-35</td>
<td>rounded</td>
<td>very rounded</td>
<td>never</td>
<td>maybe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>279</td>
<td>22</td>
<td>20</td>
<td>E</td>
<td>45-55</td>
<td>flat</td>
<td>flat</td>
<td>occasionally</td>
<td>never</td>
<td></td>
<td></td>
</tr>
<tr>
<td>280</td>
<td>8</td>
<td>10</td>
<td>B</td>
<td>55-65</td>
<td>rounded</td>
<td>rounded</td>
<td>never</td>
<td>maybe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>281</td>
<td>12</td>
<td>18</td>
<td>A</td>
<td>15-20</td>
<td>rounded</td>
<td>very rounded</td>
<td>never</td>
<td>never</td>
<td></td>
<td></td>
</tr>
<tr>
<td>282</td>
<td>12</td>
<td>18</td>
<td>C</td>
<td>15-20</td>
<td>rounded</td>
<td>very rounded</td>
<td>never</td>
<td>never</td>
<td></td>
<td></td>
</tr>
<tr>
<td>283</td>
<td>16</td>
<td>18</td>
<td>D</td>
<td>55-65</td>
<td>very rounded</td>
<td>rounded</td>
<td>never</td>
<td>already</td>
<td></td>
<td></td>
</tr>
<tr>
<td>284</td>
<td>12</td>
<td>16</td>
<td>B</td>
<td>20-35</td>
<td>rounded</td>
<td>rounded</td>
<td>never</td>
<td>maybe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>285</td>
<td>16</td>
<td>18</td>
<td>C</td>
<td>20-35</td>
<td>rounded</td>
<td>rounded</td>
<td>occasionally</td>
<td>maybe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>286</td>
<td>14</td>
<td>16</td>
<td>B</td>
<td>45-55</td>
<td>flat</td>
<td>rounded</td>
<td>never</td>
<td>never</td>
<td></td>
<td></td>
</tr>
<tr>
<td>287</td>
<td>16</td>
<td>20</td>
<td>D</td>
<td>55-65</td>
<td>very rounded</td>
<td>rounded</td>
<td>never</td>
<td>maybe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>288</td>
<td>16</td>
<td>16</td>
<td>A</td>
<td>45-55</td>
<td>rounded</td>
<td>rounded</td>
<td>often</td>
<td>maybe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>289</td>
<td>10</td>
<td>10</td>
<td>B</td>
<td>15-20</td>
<td>flat</td>
<td>rounded</td>
<td>never</td>
<td>maybe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>290</td>
<td>16</td>
<td>18</td>
<td>D</td>
<td>35-45</td>
<td>rounded</td>
<td>very rounded</td>
<td>never</td>
<td>maybe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>291</td>
<td>12</td>
<td>18</td>
<td>C</td>
<td>45-55</td>
<td>rounded</td>
<td>very rounded</td>
<td>occasionally</td>
<td>maybe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>292</td>
<td>14</td>
<td>14</td>
<td>B</td>
<td>45-55</td>
<td>rounded</td>
<td>rounded</td>
<td>occasionally</td>
<td>maybe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>293</td>
<td>16</td>
<td>18</td>
<td>B</td>
<td>35-45</td>
<td>rounded</td>
<td>very rounded</td>
<td>never</td>
<td>maybe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>294</td>
<td>12</td>
<td>12</td>
<td>C</td>
<td>15-20</td>
<td>rounded</td>
<td>very rounded</td>
<td>never</td>
<td>maybe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>295</td>
<td>12</td>
<td>12</td>
<td>B</td>
<td>20-35</td>
<td>rounded</td>
<td>very rounded</td>
<td>never</td>
<td>maybe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>296</td>
<td>24+</td>
<td>24+</td>
<td>B</td>
<td>45-55</td>
<td>very rounded</td>
<td>occasionally</td>
<td>maybe</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>300</td>
<td>22</td>
<td>24+</td>
<td>C</td>
<td>45-55</td>
<td>very rounded</td>
<td>rounded</td>
<td>never</td>
<td>maybe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>301</td>
<td>12</td>
<td>14</td>
<td>D</td>
<td>20-35</td>
<td>rounded</td>
<td>very rounded</td>
<td>occasionally</td>
<td>maybe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>302</td>
<td>16</td>
<td>16</td>
<td>B</td>
<td>20-35</td>
<td>rounded</td>
<td>very rounded</td>
<td>never</td>
<td>maybe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>303</td>
<td>18</td>
<td>16</td>
<td>D</td>
<td>35-45</td>
<td>very rounded</td>
<td>flat</td>
<td>never</td>
<td>never</td>
<td></td>
<td></td>
</tr>
<tr>
<td>304</td>
<td>24+</td>
<td>24+</td>
<td>D</td>
<td>55-65</td>
<td>very rounded</td>
<td>very rounded</td>
<td>often</td>
<td>maybe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>305</td>
<td>8</td>
<td>10</td>
<td>F</td>
<td>15-20</td>
<td>flat</td>
<td>flat</td>
<td>never</td>
<td>maybe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>306</td>
<td>18</td>
<td>18</td>
<td>C</td>
<td>55-65</td>
<td>rounded</td>
<td>rounded</td>
<td>never</td>
<td>maybe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>307</td>
<td>24+</td>
<td>24+</td>
<td>E</td>
<td>15-20</td>
<td>very rounded</td>
<td>very rounded</td>
<td>occasionally</td>
<td>maybe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>308</td>
<td>8</td>
<td>10</td>
<td>D</td>
<td>20-35</td>
<td>rounded</td>
<td>rounded</td>
<td>occasionally</td>
<td>already</td>
<td></td>
<td></td>
</tr>
<tr>
<td>309</td>
<td>16</td>
<td>16</td>
<td>B</td>
<td>20-35</td>
<td>rounded</td>
<td>flat</td>
<td>occasionally</td>
<td>maybe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>310</td>
<td>24+</td>
<td>24+</td>
<td>C</td>
<td>35-45</td>
<td>very rounded</td>
<td>rounded</td>
<td>often</td>
<td>already</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
3.4 Selected survey responses

From ages 1 to 20 my clothes were customed made by my father. After he died I was forced to by RTW and was shocked & dismayed at how badly they fit. 30 years later and a body that has "settled" I bought Pattern Master and am learning how to sew. I want something that fits properly - you CAN'T get that in RTW. I'm small boned, small breasted with lots of fluff below the rib cage. I haven't been able to buy a 1 piece dress in 15 years - can't fit both the top and the bottom. Sweaters are a problem being small chested but large as%% Sooo I'm teaching myself to knit then I'll use PM patterns, convert them into knitting patterns, and go from there. Honestly, I can't afford to pay someone a fair price for custom sewing/fit so I'll have to do it myself, but I'm sure there are 1,000s of ladies who can afford it and probably would. I've never me a line of clothing who used a pattern/fitting model that came anywhere close to my body shape. 18

I find that the arms of RTW are often too narrow - on knits they stretch the pattern so it looks odd, and on woven fabrics they are too tight and I need to either buy a size which is way too wide in the body to get a sleeve which is wide enough around the tops of my arms, or I need to alter the garment and add an insert in the arm. I make a lot of my own clothes!

Also, big ladies often have have fantastic cleavages and like low cut garments to show them off!

Sleeveless garments often have shoulders which are narrow - same width as normal sized clothes, and they dont hide the bra straps of larger women. I am 47 and dont like showing bra straps, even tho the teens and 20s do it. But I like to look trendy and sexy. I am about a dress size 24/26 depending on the cut and where buy from

I know this is anonymous, but my name is Liz and my e-mail is parkinsonliz@hotmail.com

Good luck, this is a very worthwhile thesis you are doing! 39

Trouble finding pants and shorts..the legs are always way too big..my legs are heavy only for my size..not extremely heavy..also the seat of my pants are usually too big. Blouses always gape at the bust. I must put a pin in between the buttons at the bust. I have a bit of a middle so would like blouses and knitwear somewhat loose below the bust. 52

I have always been overweight, but my body was in proportion (hourglass, but large overall). As I reached my late 40s, things seemed to "drop" and much more weight concentrated around my waist and especially hips and bottom. I find it impossible to buy clothing like dresses or pantsuits that must fit both my bust and hips using the same size - if it fits my bust it won't come near to covering my hips, and it if fits my hips, I'm swimming in it on top. I have been designing my own sweaters in recent years because I can remedy this situation, and produce garments that fit me well. I wish I could do this with sewing as well, but I am not good at sewing, and woven fabric cannot have the same kind of "give" that knitted fabric does. 78

My measurements are 130 cms bust, 1010 waist and 137 cms hips. My bra cup size is H. Any clothes that hit across my bust without gaping at the buttons fits me like a
sack. I dislike looking like I have no waist so I tend to buy t-shirt material tops that stretch over my breasts while going in at the waist. This is a rather bad compromise as my bust takes up a lot of fabric, making the shirts rather short. The last time I was in Marks and Spencers to search for a blouse, I ended up leaving in tears because I couldn’t find anything that fit in a flattering way. I also have problems with trousers as my waist is smaller than the standard for my hip size. The waists of my trousers gap dreadfully. Because of these fitting problems, I have very few clothes. My friends tend to remark that I have the least amount of clothes of any woman they know. 211

I consider myself to have the average female shape (large hips and bust, and smaller waist) but have terrible difficulty finding clothes that fit properly. As a result I tend to stick to stretchy materials and avoid cotton and knitwear. I have heard similar complaints from many women and am really surprised that most clothing manufacturers have yet to respond by producing more realistic clothing ranges. 259

I would absolutely consider buying custom made clothing – in fact I have saved ancient shorts and trousers precisely to cut up for pattern and get someone to make some more when I can afford it. I can never find a blouse to fit – either gaping at the chest or baggy everywhere but the chest - -I’m not a particularly freakish size as proved by there never being a bra left in my size at M&S (38B) but have broad back and shoulders which makes it very difficult. Summer is a nightmare as strappy tops make me look like a beached whale, so I spend the sunny days feeling hoe and bothered in sleeved t’s. Everything light and soft and girly and pretty and AFFORDABLE seems to be created for less generously proportioned women. Or for people with a waist. Like larger versions of a size 10, which isn’t going to work on most folk, IMHO.

Why do t-shirts stop at navel length? Knitwear is difficult too as prefer things a bit loose but that only seems to come in chunky cuddly knits with don’t flatter me at all. And where’s the cotton jumpers? I get itchy in wool and mixes fibres. Shop assistants in places like Karen Millen like to snigger when you take in dresses to try on, and make bitchy comments when you’re out of earshot. I wished I could buy stuff online as changing rooms are vortexes of depression. Topshop recently told me that they didn’t have any size 16’s left as their policy was only to order two ‘specialist’ sizes in each range !!!!!!!!!! 260
Appendix F  Knitwear as fashion
The transition period of shaped underwear to outerwear occurred during the first decade of the Twentieth century. It is probable that for the majority of underwear manufacturers, the 1920s fashion change away from fully-fashioned and other knitted underwear led to surplus industrial production capacity being diversified into knitted outerwear.  

Knitted outerwear finally became highly fashionable in the 1920s and 1930s, when ‘la mode sportif’, popularised by couturiers Chanel who exploited stretch and draping - particular properties of jersey fabric and Patou whose sleekly elegant, labour intensive manually machine made jumpers introduced sweaters to high fashion. (Figure 1) An example of a Chanel-type jacket, in this relaxed, cut and sewn jersey style of dressing was found in the Hodson Shop collection. (Figure 2)

Prior to the development of electronically enabled shaped commercial fashion knitwear made on V-bed machine, which has only been widely and cheaply available since the 1980s, the majority of commercial, coloured and texturally patterned machine knitted fashion items were cut and sewn to shape from knitted fabrics. These items included men’s and women’s underwear, pullovers, jerseys and shirts made of wool and cotton, which were manufactured in Leicester and Nottingham by companies such as Wolsey, Brettles and Morley, all famous for cut and sewn production. The 1887 invention of the overlocker, which cut to shape, joined and covered a seam in one operation, made a significant contribution to the commercial progress of cut and sewn knitted goods.

---

Figure 2. Chanel-inspired jersey jacket in dark salmon coloured, fine gauge, wool jersey. c.1929-1930. The jacket has a sewn in shawl collar, front panel, and cuffs, with applied patch pockets. The garment is of cut and sewn construction with overlocking and some flat machine sewing. It has a buttoned belt. Item no. HSW 224, Hodson Shop Collection, Walsall Museum.
Shaped knitted garments did however exist as expensive underwear, and early examples of integral bust shaping formed by what were probably wale shaped gores were developed by both Pringle and I.R. Morley of Nottingham in 1895.\textsuperscript{431} This was likely to have involved an adaptation of the fully-fashioned shaping device invented by the German Albin Beyer in 1886. Today this procedure would be carried out by automatic wale transfer on an electronic knitting machine such as the Shima Seiki SES102ff used in this research.

In the 1930s, knitwear was far more highly regarded on the continent, particularly in France and Germany, than it was in the UK. It was, in Barty-King’s opinion, the influential European seasonal couture knitwear designs from, amongst others, Patou, Schiaparelli, Lanvin, Worth and Martial et Armand and the exclusively hand knitted collections by Annie Blatt and Aileen Rice that contributed to Pringle’s decision to employ the Austrian Otto Weisz as their first knitwear designer in 1934.\textsuperscript{432}

Knitwear as commercial fashion clothing was heavily influenced throughout the mid Twentieth century by the American ‘college girl’ look, which comprised largely of solid coloured, fully-fashioned, shaped cardigans and sweaters. It was not until the advent of the digitally programmed, which was after the closure of the Hodson Shop, that more complex knitwear became commercially available.

This brief history explains why the majority of knitted garments in the Hodson Shop collection, a ‘time capsule’ of mainly 1920s and 1930s ladies mass manufactured ready-to-wear clothing, were cut-and-sewn.

1.1 Analysis of knitted items, knitwear and catalogues in the Hodson Shop collection at Walsall Museum.

The Hodson Shop collection, which remained largely untouched until re-discovered in 1983, disclosed valuable information about commercial knitted clothing of this period. Although the shop was probably not a typical ‘madam’ shop of the 1920s and 30s, surviving stock nonetheless provided contemporary evidence of knitwear of this period.

Knitwear included St Margaret’s, Warwick and Gainsboro branded items which were all cut and sewn to shape. Four representative examples of knitwear from the collection that support this theory included a Corahs of Leicester, St Margaret’s branded 1927 pale blue and peach wool knit suit plated with artificial silk (see Glossary of Terms), in an all needle, double bed fabric with transfer patterns and stripes. The second was a suit from 1930 in green wool single bed knit with appliquéd flowers. The first has an integral rib, and the second one had an attached rib and could be traced to a very similar one in Wilkinson & Ridell’s 1930 wholesale catalogue.433 (Figure 3.) (Figure 4) and (Figure 5) The third example was a 1920s St Margaret’s artificial silk and wool jumper, cut from single bed jacquard knitted fabric with woven fabric edgings sewn on at neck, cuffs and pockets. (Figure 6) All three items were cut and sewn into shape at side seams, armholes and collar and none of them were well made. The last example is reminiscent of Patou’s sweaters, and the 1922 bright coloured ‘jazz jumpers’ described by Blackman as being decorated with half squares and crosses.434 This 1926, cut and sewn jumper in red artificial silk has a dark navy and red diamond appliqué pattern around the hem and at the apex of the V neck.

Although better made than the St Margaret’s garments (suggesting it was

Figure 3. St Margaret’s, blue and peach plated wool and Rayon jumper suit, 1927. Made by Corah’s of Leicester. An internal view of the body from the hem, in which can be seen the overlocked seams. The knitting is cut and overlocked to provide the shape of the garment, there is no evidence of edge shaping. The skirt of the suit is in pale blue double bed knitting in the same yarns and has a white cotton yoke with an elasticated waist. Item no. HSW 26, Hodson Shop Collection, Walsall Museum.
Figure 4. Apple green fine gauge single bed knitting jumper suit wool, c.1930. Maker unknown. Internal view of the body from the hem. The jumper has applied 2x2 ribs in bright stripes, which are cut and overlocked to the body. The side seams are overlocked. Item no.HSW27, Hodson Shop Collection, Walsall Museum.
Figure 5. Jumper from a green knitted suit from the Hodson Shop collection next to a very similar item on a page of 'Costumes and Robes' from the Wilkinson and Riddel catalogue of 1930. The Hodson Shop archive, Walsall Museum. Photograph by author.
Figure 6. St Margaret's brand cut and sewn jumper, in wool, and artificial silk. Made by Corahs of Leicester, possibly for Marks and Spencer. Dated as 1920s. Item No. HSW290.1, The Hodson Shop Collection, Wallsall Museum. Photograph by author.
Figure 7. Red artificial silk jumper c.1926. Maker unknown. The knitted fabric has been used with the courses running vertically. There are three pintucks sewn at each shoulder to give shape to the bust area. The overlocked seam at back neck and inside are faced with self fabric and sewn flat to give a neat finish. Item No HSW191, Hodson Shop Collection, Walsall Museum.
not made by Corahs) the manufacturer is unknown. (Figure 7) There were three examples of fully-fashioned knitwear in the collection, only one of which has a maker’s label. Of the unlabelled garments, the first was a size 40”, medium weight, red wool, raglan cardigan with fashioning marks on the sleeves neck and sides seams. (Figure 8) The second, labelled ‘Fully-fashioned 100% Botany Wool Empire Made’, size 38”, was an approximately 8 gauge, single bed knit turquoise cardigan, with shaped set-in sleeves and fully fashioning marks. Both had ribbon-faced front edges and sewn button holes. (Figure 9) The third was a ‘Warwick’ brand, Courtelle (acrylic) polo shirt with fully fashioning marks on the shaped raglan sleeves and armholes, but a cut and sewn collar. None of these garments were dated. However it was possible to place the first two as being made after 1950 by their style, which was similar to that of two cut and sewn garments in the collection dated to this period. A later date for the third item was indicated because Courtelle fibres were not invented until the early 1960s, and the shop closed at about the same time. In view of this it was possible that this item did not form part of the shop’s original stock.

Catalogues from the Hodson Shop archive similarly contain some fully-fashioned knitwear, although the majority was mid to lower priced cut and sewn knitted clothing. In the 1959 catalogue of the Birmingham wholesaler Bell & Nicholson three, ‘... fully-fashioned numbers from our “Shepherd” range’, were featured, priced from 24/3d to 25/9d. (Figure 10) The use of ‘fully-fashioned’ in the headlining does seem to indicate that retailers discerned the difference in manufacturing methods and recognised the cost of skilled labour involved. A cut and sewn, but embroidered cardigan in the same catalogue was priced at 25/3d, which was likely to have reflected

Figure 8. Fully fashioned red wool cardigan in single bed, 5-7 gauge knitting. No maker's label, but the surviving swing ticket reads, '100% Pure Wool' and the neck label, 'Fully Fashioned All Wool'. Size 40. The garment is fully fashioned throughout, with a linked-on neck band. The front edge has Petersham ribbon facings, and sewn buttonholes with spare buttons and yarn attached. 1950s. Item no. HSW 269. Hodson Shop Collection, Walsall Museum.
Figure 9. Fully fashioned turquoise wool cardigan, made of single bed, 8-10 gauge knitting. No maker’s label, but neck label reads, ‘Fully Fashioned 100% Botany Wool Empire Made’. Size 38. The garment is fully fashioned throughout, with a linked-on neck band. The front edge has Petersham ribbon facings and sewn button holes. 1950s. Item no. HSW 267. Hodson Shop Collection, Walsall Museum.
Figure 10. Page from Bell & Nicholson's catalogue, 1959. These fully-fashioned items were the only ones in this catalogue, although there were numerous items of cut and sewn knitwear. The clear description suggests that the retail buyers understood the difference in production methods. The Hodson Shop Archive, Wallsall Museum.
lower production cost but additional labour costs for the embellishment.436

Very little evidence of designated larger sized clothing, classified as OS (outsize), or XOS (extra outsize) was found during analysis of the Hodson Shop wholesale clothing catalogues of the 1930s. Indeed only one specified sizes by body or garment dimensions. This was on the inside cover of the Good Style catalogue of G.Strutt of Manchester for Spring/Summer 1933. The chart defined a W size, (which today would correlate to a large or possibly an extra large, as it is listed immediately before OS), as 36” bust and 43” hips, but stated that OS is ‘Made to Measure only’, despite this being labelled a ‘stock size’ chart.437

Of the thirty-seven knitted garments in the Hodson Shop collection, thirteen had sizing indication, twelve of which were to fit over a 36” (91cm). All these thirteen were from the latter period covered by the collection, which was in parallel with earlier findings; that sizing information has been found to be commonly lacking in pre-1940s knitwear. (Table 1) It was interesting to note that one of the outsize garments although labelled OS, actually only measured 38”(96.5cm) around the bust, which today would not be considered outsize. Instead, and according to the 2004 British Standard EN-3402-3:2004, this ‘Gainsboro’ brand, green wool, raglan sleeved cardigan would nowadays be categorised a UK size 16 (95-99cm) or an M (medium).438 Of the other OS items, (a sage green and a camel wool cardigan) the bust and waist measurements were smaller when compared to the corresponding measurements as specified in EN-3402-3:2004. This led to speculation as to how customers purchased knitwear pre-1940, before sizing of garments began to appear.

437 Good Style catalogue Spring Summer, G.Strutt of Manchester, 1933. Print. n.pag. Hodson Shop Collection, Walsall Museum.
<table>
<thead>
<tr>
<th>Style</th>
<th>Detail</th>
<th>Date</th>
<th>Maker</th>
<th>Fibre</th>
<th>Size</th>
<th>Equiv</th>
<th>Colour</th>
<th>Method</th>
<th>Cat. No</th>
</tr>
</thead>
<tbody>
<tr>
<td>cardigan</td>
<td>V.neck, d.bed, tuck with a rack panel inset and on b.band</td>
<td>1950s</td>
<td>Rybil</td>
<td>Orton</td>
<td>42-46&quot;</td>
<td>XXOS</td>
<td>camel</td>
<td>c&amp;s</td>
<td>HSW250</td>
</tr>
<tr>
<td>suit</td>
<td>full jaq.circ. fabric, sewn to shape</td>
<td>1950-60</td>
<td>Fashion Full Knitwear, Made in Scotland 100% wool</td>
<td>wool</td>
<td>42-44&quot;</td>
<td>XOS</td>
<td>brown/green</td>
<td>c&amp;s</td>
<td>HSW110</td>
</tr>
<tr>
<td>cardigan</td>
<td>R.neck, 'British Wool', (5g) s.bed</td>
<td>1950s</td>
<td></td>
<td>New Wool</td>
<td>40&quot;</td>
<td>OS</td>
<td>red</td>
<td>ff</td>
<td>HSW269</td>
</tr>
<tr>
<td>cardigan</td>
<td>V.neck,d.bed diamond transfer pattern, crochet trim on b.band</td>
<td>1950s</td>
<td>Made in Scotland</td>
<td>wool</td>
<td>OS</td>
<td>camel</td>
<td>c&amp;s</td>
<td>HSW237</td>
<td></td>
</tr>
<tr>
<td>cardigan</td>
<td>V.neck,transfer pattern, d.bed/s.bed</td>
<td>1950s</td>
<td>Made in England</td>
<td>wool</td>
<td>OS</td>
<td>sage</td>
<td>green</td>
<td>c&amp;s</td>
<td>HSW244</td>
</tr>
<tr>
<td>cardigan</td>
<td>V.neck,raglan, s.bed rolled edge b.band</td>
<td>1950s</td>
<td>Gainsboro</td>
<td>wool</td>
<td>OS</td>
<td>green</td>
<td>c&amp;s</td>
<td>HSW257</td>
<td></td>
</tr>
<tr>
<td>cardigan</td>
<td>R.neck s.bed (8g?)</td>
<td>1950s</td>
<td>Fully Fashioned 100% Botany Wool Empire Made</td>
<td>wool</td>
<td>38&quot;</td>
<td>WX</td>
<td>turquoise</td>
<td>ff</td>
<td>HSW267</td>
</tr>
<tr>
<td>jumper</td>
<td>V.neck, sht.slv, all needle d.bed tube fabric</td>
<td>1940-50</td>
<td>Curzonia Made in England by Howe of Curzon St</td>
<td>wool</td>
<td>38&quot;</td>
<td>WX</td>
<td>tobacco brown</td>
<td>c&amp;s</td>
<td>HSW309</td>
</tr>
<tr>
<td>jumper</td>
<td>shawl polo collar,raglan,s.bed</td>
<td>1960s</td>
<td>Warwick in Courtelle</td>
<td>courtelle</td>
<td>38&quot;</td>
<td>WX</td>
<td>white</td>
<td>ff</td>
<td>HSW305</td>
</tr>
<tr>
<td>jumper</td>
<td>V.neck,raglan, all needle d.bed tube fabric, zip @ C.B.</td>
<td>1940-50</td>
<td>Curzonia Made in England by Howe of Curzon St</td>
<td>wool</td>
<td>38&quot;</td>
<td>WX</td>
<td>beige</td>
<td>c&amp;s</td>
<td>HSW308</td>
</tr>
<tr>
<td>cardigan</td>
<td>R.collar, s.bed/d.bed ribs with smocking</td>
<td>1940s</td>
<td>Made in Scotland</td>
<td>wool</td>
<td>WX</td>
<td>38&quot;</td>
<td>mid green</td>
<td>c&amp;s</td>
<td>HSW113</td>
</tr>
<tr>
<td>twin set</td>
<td>on jumper neck, £3/17/6d</td>
<td>1950s</td>
<td>Warwick</td>
<td>wool</td>
<td>WX</td>
<td>38&quot;</td>
<td>grey/green</td>
<td>c&amp;s</td>
<td>HSW254</td>
</tr>
<tr>
<td>cardigan</td>
<td>Vneck purl patt s.bed, ripple on b.band</td>
<td>1950s</td>
<td>All Wool British Made</td>
<td>wool</td>
<td>W</td>
<td>36&quot;</td>
<td>yellow</td>
<td>c&amp;s</td>
<td>HSW242</td>
</tr>
</tbody>
</table>

**KEY**
- XXOS = 42"-46" WX = 38" bust  Size column = as on garment, Equiv = equivalent. Size codes and equivalent inches based on size chart from Good Style catalogue, G. Strutt of Manchester, 1933.
- OS = 40" bust  F = fully fashioned

Table 1. Table of larger sized knitwear from the Hodson Shop Collection analysed for this research. Sorted by size.

Trying-on can have been the only satisfactory method in view of there being such limited sizing information on the knitwear pages of the catalogues, and even on the garments themselves.
Examples of sizing variations in contemporary plus size, high street fashion knitwear (2007).

In a survey of larger sized high street knitwear in 2007 for the purpose of this research, knitwear from Debenhams specialist ‘Gorgeous’ range, and from Topshop and Wallis were tested in a size 18. This size was chosen as it was the upper body size of the model. Garments selected for testing consisted of three fully-fashioned fashion garments and two classic styled fully-fashioned garments, (a V-neck jumper and a round necked cardigan) plus one shaped ‘fashion’ cardigan. When analysing the fit of these garments, allowances were made for folds that are part of the design, and those considered postural were discounted where they appeared to be affecting the fit.439

On all but one of the garments, the shoulders were too wide to some degree, causing the sleeve head to fall off the shoulder, this in turn caused the armhole to drop and the side seams to droop on the looser garments. In those that fitted the body the dropped sleeve caused gathering under the arm. Sizing was not consistent even between items from the same range; two ‘fashion’ cardigans from Topshop, both labelled size 18 and of similar style, were different in size and fit.(Figure 11) The classic V neck jumper and cardigan from Wallis exhibited gathering under the arms, and were different in size, the cardigan being 4.5 cm bigger around the body than the jumper.

Gathering in or below the underarm of a set-in sleeve is caused by either an inadequate shoulder drop, or the shoulder seam being longer than the shoulder length. In a loose garment, spare fabric below the underarm has a tendency to droop, causing the hem to hang down at the sides and peak towards the centre front and back.

Sleeve heads are positioned differently, the orange garment’s drops off the shoulder point, and consequently the sleeve head develops lateral folds. This is also affected by the size of the armhole, which is deeper on the orange garment, measuring 28cm, as opposed to 26cm on the green garment. It is noticeable that the back armhole fits better on the green garment. The lower folds on the sleeves are ‘wearing’ and style folds.

Under the front and back armhole on the orange garment, excess fabric is gathering up, this is caused by the bust width being 5cm more on the orange garment than on the green, despite them being labelled the same size.

Figure 11. Comparison of two 'fashion' cardigans in same style, both labelled size 18. The left hand orange garment does not have the same underbust seam as the green one, and the sleeve is slightly differently styled at the cuff, but ostensibly they are the same, and were displayed side by side. Topshop, Oxford Street, April 2007.
Additional peaking, which may contribute to this effect, is caused where the garment travels over a large prominence, (usually stomach, bust or buttocks), making the surface measurement over the protuberance longer than that allowed for in the side seam length. Cut and sewn knitted items can be cut with a curved front to counteract this effect, and this is increasingly seen, but shaped knitwear is seldom, if ever, given a curved hem.

Gathering under the arms when viewed from the back may partly be attributed to the armhole having dropped, but is also because the armhole is not made round enough for the armscye of larger upper arms. Armholes are shaped with minimal (if any) bind off at the underarm, making a diagonal rather than a rounded armhole shape. When the arm of a larger woman is dropped to the side of the body any extra ‘padding’ on the upper arm and upper chest is compressed between arm and body and moves out to the sides, changing the profile of the upper arm girth. When this occurs in conjunction with a diagonal armhole shaping, the excess fabric across the diagonal in both front and back panels is gathered into an radiating folds at the underam.

The two classic fully-fashioned garments although different in size, were of similar style; the body panel was not shaped at the waist, but knitted straight from rib to armhole. The V-necked jumper, which measured the smaller of the two, was tight across the stomach, abdomen and chest, indicated by horizontal wrinkles as described by Rasband. Overall this fitted best of the two garments on the shoulders, although at the back the diagonal folds in both body and sleeve were still apparent.\textsuperscript{440} (Figure 12)

Size discrepancies found in modern plus size knitwear during this survey meant that, as in the early days of fashion knitwear, the relevant size was best found by trying-on rather than via manufacturer’s labelling.

\textsuperscript{440} Rasband and Liechty.62.
Figure 12. Comparison of two fully fashioned garments, both labelled size 18. The cardigan measured 4.5cm more around the bust. Both garment’s shoulder seam finished on the shoulder point. The cardigan’s sleeve head fitted the upper arm the better of the two. Wallis, Oxford Street, April 2007.
Appendix F - References


Blackman, Cally. "Hand knitting in Britain 1908-1939, the work of Margery Tillotson". *Textile History* 29.2. (1998): 177-200 Print


Talbot, Anne. "Sifting the Collections". *Stitchcraft*. 1933: 6-7 and 22.