Contribution of lumbar spine and hip movement during the palms to floor test in individuals with diagnosed hypermobility syndrome

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The ability to place the hands to the floor forms part of the assessment of joint hypermobility. The test may be symptom free, or in the case of joint hypermobility syndrome, may be associated with pain in the spine, hip, and knee. The aim of this study was to identify the relative amount of movement at the lumbar spine and hip during this test in people with asymptomatic and symptomatic hypermobility compared with a control group. Thirty-six female subjects (10 asymptomatic hypermobility, 13 symptomatic hypermobility, and 13 control) ranging between 18 and 60 years of age participated in the investigation. Measurements were made by using digital photography and inclinometers. Measurement reliability was established prior to the investigation. There was a significant difference (p<0.05) between hip flexion range in the two hypermobility groups compared to the control group; there was no significant difference in lumbar spine movement between the three groups. The findings suggest that people with asymptomatic or symptomatic hypermobility perform the hand to floor test with the same relative contribution from the lumbar spine and hip joints. Both groups perform the hands to floor test and with a greater relative hip flexion range than a control group.

Introduction

There is emerging evidence that joint hypermobility in some people may be responsible for distressing and disabling symptoms (Grahame, 2003; Grahame and Bird, 2001). Hypermobility is defined as an increase in the range of movement (ROM) at a joint beyond the accepted norm (Keer, 2003), and generalised hypermobility is present when a certain number of joints in the body have an increased ROM (Gannon and Bird, 1999). Hypermobility may be due to genetic influences in collagen structure (Zweers, Hakim, Grahame, and Schalkwijk, 2004) or maybe acquired through sport or training (Grahame, 2003; Zemek and Magee, 1996). Hypermobility per se need not be associated with symptoms (Safran et al, 2001).

The diagnostic term joint hypermobility syndrome (JHS) is applied when hypermobility is associated with musculoskeletal symptoms in the absence of any systemic disease (Kirk, Ansell, and Bywaters, 1967). There is no definitive explanation why symptoms develop in some individuals with hypermobility and not in others. Hypotheses have included joint micro- trauma in inherently weak collagen tissue (Russek, 2000), overstimulation of sensory nerve endings as a result of stretching (Child, 1986), inherent collagen tissue weakness (Kirk, Ansell, and Bywaters, 1967), a higher percentage of weaker type III collagen fibrils that are less able to stabilise joints (Child, 1986), and over-stimulated sensory nerves that are overstretched due to the poorer quality collagen framework supporting them (Child, 1986), autonomic dys-function (Gazit, Nahir, Grahame, and Jacob, 2003), and lack of joint control of hypermobile joints (Keer, 2003). Ongoing research is required to better understand why some hypermobile people remain asymptomatic and others go on to develop JHS.

Hypermobility may be assessed in a number of ways. One method, the Beighton scale (Beighton, Solomon, and Soskolne, 1973), is a commonly used index for measuring hypermo-bility. The scale involves measuring nine move-ments. Four of the measurements are performed bilaterally. The ninth and final measurement assesses if the patient can actively place the palms of the hands flat on the floor without the need to bend the knees.

The Beighton scale was originally introduced for use in epidemiological studies to identify JHS in populations by visual inspection without the need for equipment. Although well suited for this task, it may be a less appropriate tool for clinicians to use to diagnose hypermobility in individuals because of the limited joints being assessed, with six of the nine joints tested being located in the upper limb. Furthermore, the scale does not include the glenohumeral joint, which has been reported to be hypermobile in many patients (Keer, 2003). Finally, it gives no indication of the degree of hypermobility as it is an ‘all-or-nothing’ test.

Because of these deficiencies, Grahame, Bird, and Child (2000) have suggested an alternative assessment for measuring JHS. This set of measurements includes the Beighton scale and includes an additional set of major and minor criteria. The clinical diagnosis of JHS is made when two major criteria, or one major criteria and two minor criteria, or four minor criteria are present. This method of measuring hypermobi-lity is known as the Revised (Brighton, 1998) criteria for the diagnosis of JHS (Grahame, Bird, and Child, 2000).

The ‘hands to floor test’ forms part of the assessment for JHS. This test may be per- formed as a symptom-free movement in subjects who are hypermobile and asymptomatic. How- ever, in people with JHS, this procedure may be associated with substantial pain and discomfort in a variety of areas including the lumbar spine, thoracic spine, hips, knees, shoulders, and upper limb. One possible explanation is that people with and without symptoms who are hypermo- bile perform the ‘hand to floor’ movement dif-ferently. For example, there may be differences in the speed of the movement, the muscle activity during the movement, the overall coor-dination of the movement, or the amount of movement at different regions. In the latter case, this might mean that the various joints may have a distinctly different contribution to the overall movement. One of these possible differences may be differing contributions from the lumbar spine and hip joints. In addition, hamstrings length and its potential influence on hip ROM may also be a contributing factor (Esola, McClure, Fitzgerald, and Siegler, 1996; Li, McClure, and Pratt, 1996; Wong and Lee, 2004).

The aim of this study was to investigate if any differences existed in the range of lumbar flex-ion, hip flexion, and hamstrings length in three separate groups: group 1: subjects with hyper-mobility and no symptoms; group 2: subjects with JHS; and group 3: control group subjects with no symptoms who were unable to reach the floor when performing the hand to floor test. Differences or similarities in the three groups could then be compared.

Methods

Subjects

Subjects with and without symptoms were recruited by placing an advertisement on the Hypermobility Syndrome Web page (http://www.hypermobility.org) requesting volunteers. Additional subjects were recruited through advertising posters at the U.K. hospital where the investigation was conducted and through word of mouth requests. Hypermobility is more common in females than males (Birrell, Adebajo, Hazleman, and Silman, 1994), and to investigate a homogeneous population, only female subjects were recruited.

Each potential subject was provided with an information booklet explaining the purpose of the study. Subjects who voluntarily agreed to participate who fulfilled the inclusion criteria signed informed consent documentation and were aware of their right to withdraw from the study at any stage.

Subjects with JHS were diagnosed according to the criteria of the Revised (Brighton, 1998) criteria for the diagnosis of Benign JHS (Grahame, Bird, and Child, 2000). All subjects had their diagnosis confirmed by a consultant rheumatologist.

Once recruited, a convenient time for each subject was organised for them to attend the clinic where demographic information was taken and the postural measurements were made.

Demographic information pertaining to the three groups is detailed in Table 1. There were no significant baseline differences between any of the groups for the variables of age, height, and weight. No subject in the control group could reach the floor in the hand to floor test. All subjects in the hypermobile and JHS groups could reach the floor in the hand to floor test.

The mean Beighton score for the control group was 1.2 (SD 1.5) out of a possible maximum score of 9. The mean scores for the subjects without symptoms who were hypermobile was 6.0 (SD 1.5) and 5.5 (SD 1.4) for subjects with JHS.

Group inclusion/exclusion criteria

Subjects were divided into one of the three diagnostic categories: hypermobile without symptoms, hypermobile with symptoms (JHS), and the control subjects.

Hypermobile subjects without symptoms were defined as those who had a minimum score of 5/9 on the Beighton scale (Beighton, Solomon, and Soskolne, 1973). For the purposes of this study, at least one of these points must have come from being able to place the palms of the hand flat on the floor without bending the knees. Subjects in this group were included if they had no current or previous musculoskeletal or neural symptoms.

Subjects with JHS (hypermobile with symptoms) were diagnosed according to the criteria of the Revised (Brighton, 1998) criteria for the

Table 1. Demographic information pertaining to the three groups of subjects.

	Height (cm) range and mean (SD)	Weight (kg) range and mean (SD)	Age (yr) range and mean (SD)	Number of subjects who could reach the floor	Areas of symptoms (pain)
Control group	160.0–182.0	50.9–68.0	23.0–47.0	0	No symptoms
N ¼ 13	170.2 (6.6)	59.9 (5.5)	30.5 (5.6)		
Hypermobile group	152.0–183.0	58.0–76.0	18.0–60.0	10	No symptoms
N ¼ 10	166.0 (8.7)	63.9 (6.0)	31.6 (11.6)		
JHS group	158.0–175.0	52.0–80.0	26.0–56.0	13	Lumbar (9 subjects)
N ¼ 13	163.9 (5.3)	67.4 (8.3)	35.6 (7.4)		Thoracic (4 subjects)
					Cervical (4 subjects)
					Shoulder (5 subjects)
					Elbow (1 subject)
					Hand (2 subjects)
					Knee (6 subjects)

SD: standard deviation; N: number; JHS: joint hypermobility syndrome; cm: centremeter; kg: kilogram. All symptoms were those of pain.

diagnosis of benign JHS. The minimum score of 5/9 was chosen because this is the recommen- dation from the Revised (Brighton, 1998) cri- teria for the diagnosis of benign JHS (Grahame, Bird, and Child, 2000).

The inclusion criteria for the control group subjects were a Beighton score of 4/9 or less, an inability to reach the floor with their hands (with the knees remaining straight), and no current or previous musculoskeletal or neural symptoms. The aim of this investigation was to determine if the range of hip and lumbar flexion move- ment in subjects who were hypermobile without symptoms and those with JHS was different when performing the hands to floor test. In addition to this, the ratios of these movements would be calculated. A control group of asymp- tomatic subjects who were not hypermobile (i.e., under the 4/9 Beighton threshold) and who were unable to reach the floor was included so their range of movements (and ratios) could be com- pared with the two hypermobile groups.

A total of 36 female subjects were recruited to this study: 13 subjects who had a diagnosis of JHS, 10 subjects without symptoms who were hyper- mobile, and 13 subjects without symptoms who were not hypermobile. Although it proved difficult to recruit 13 subjects without symptoms who were hypermobile, the number recruited (*n* ¼ 10) satis- fied the numbers of subjects needed in each group determined from the power analysis. Of the subjects with JHS, seven had three separate areas of symptoms, five had two separate areas of symptoms, and one subject had only one area of symptoms. All symptoms were those of pain. Subject information is detailed in Table 1.

Ethical approval for the investigation was approved by the local ethics committee at the teaching hospital where the data were collected (Riverside Research and Ethics Committee).

Measurements

In addition to the Beighton score, the other measurements that were taken in this investiga- tion included hamstrings length, hip flexion angle, and lumbar flexion range.

To protect the subject's modesty, all data were collected in a quiet and private room. Subjects were asked to undress down to their underwear to expose the spine, hips, and legs.

Hamstring length was measured in supine and for the right leg only. The knee of the left leg was flexed and supported on pillows until the spine was flat against the plinth in an attempt to reduce spinal movement. An inclinometer (Isomed Inc., Portland, OR, USA) was cali- brated to zero when placed on the tibia of the right leg in a horizontal position. The right leg was then passively lifted with the knee in full extension (straight leg raise) until the pelvis was observed to rotate. The angle at the point the pelvis started to rotate was recorded.

The subject then performed the palm to floor test, keeping their knees straight. Lumbar flex- ion and hip flexion range were measured in standing. Lumbar flexion range was measured by using two inclinometers. Hip flexion angles were measured by using digital photography. A series of anatomical landmarks were used as reference points to produce these measurements. These anatomical landmarks were identified by palpation with the subjects in standing and once identified were marked by attaching nontoxic adhesive markers (6-mm diameter). The land- marks included the twelfth thoracic (T12), fourth lumbar (L4), and second sacral (S2) spi- nous processes (SP). The S2 SP was identified as the SP corresponding with the horizontal level of the posterior inferior iliac spine. The L4 SP was identified as the SP corresponding with the horizontal level of the superior margin of the iliac crest. The T12 SP was identified by count- ing upward on the SPs from the L4 SP.

In addition, an adhesive marker was placed on the iliac crest at the midpoint of the posterior and anterior superior iliac spines. The midpoint was determined by using a nonstretch tape measure once these points were identified. Additional markers were placed 2 cm below the greater trochanter according to recommenda- tions made by Tully and Stillman (1997), and the final marker was placed on the lateral femoral condyle midway between anterior and posterior edges of the iliotibial tract at the level of the superior edge of the patella with the knee straight (Tully and Stillman, 1997). All these markers were placed on the right side of the body of all subjects.

Hip flexion angles were calculated from two digital photographs using a Kodak DX450 5 megapixel camera with 3 x optical zoom and a 38-114 retinar lens (Eastman Kodak Company, Hemel Hempstead, Hertfordshire, UK). The first photograph was taken with the patient upright in a comfortable and natural standing position, and the second was taken after the subjects were instructed to bend forward as far as possible (knees straight) with minimal strain. To standardise the photographs, the lens of the camera was positioned 2 meters from the sub- ject. The camera was mounted on a tripod, and the lens height was adjusted to the height of the greater trochanter marker. To reduce parallax, the front of the camera was adjusted to be par- allel to the thigh. Marker placements and the method the hip flexion angle was derived are illustrated in Figure 1.

To calculate the hip angles, the digital photos were printed on A4 size paper, and the angles were measured with a protractor. This was similar to hip measurement angles reported previously (Kippers and Parker, 1987; Tully and Stillman, 1997).

The lumbar spinal angles were measured with one inclinometer placed on the marked T12 spinal level and on the marked S2 spinal level. As recommended in the Isomed guidelines (Isomed Inc., Portland, OR, USA), the lumbar angle was determined by subtracting the sacral measurement from the thoracic measurement. A negative result would indicate lumbar exten- sion and a positive result greater than 01 would indicate lumbar flexion. These measurements were made in the same positions and at the same time as the hip flexion measurements were made.

Both the hip flexion angles and the lumbar flexion angles were calculated by determining the difference between the two measurements (standing and end range flexion).

Following this the subjects were asked to stand up and walk around the room for 1 minute, and then the photograph and inclinometer measurements were repeated. Floor markings ensured that the subjects returned to the same position between measurements. This process was repeated on three occasions in total.

Reliability

The intratester reliability of the lumbar and hip measurements and the hamstrings length measurement was determined in a previous study on 10 asymptomatic subjects recruited by the senior investigator (TC). The subjects were

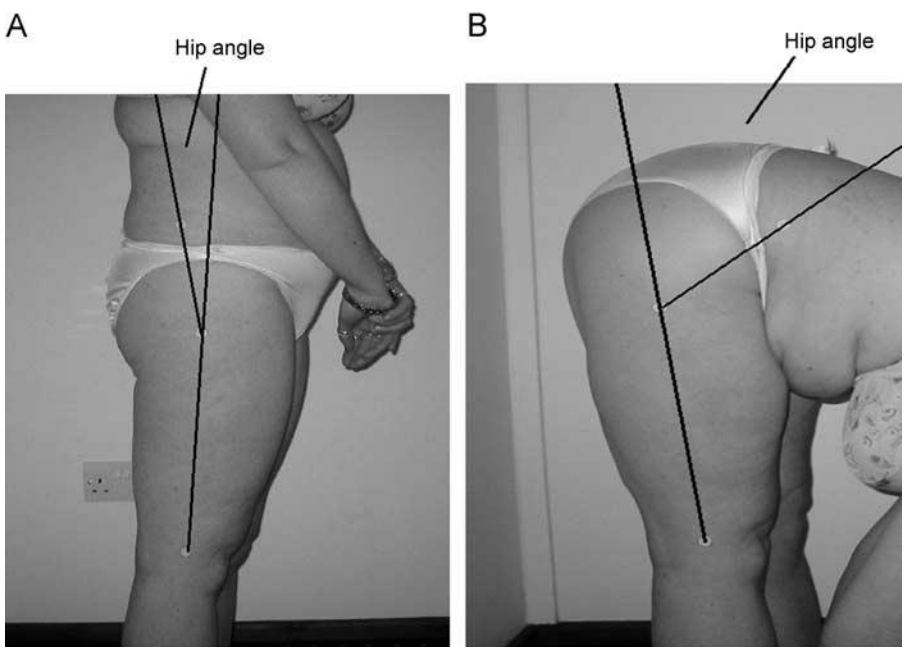

Figure 1. Marker placement and the hip flexion angle in standing (A) and at the end of the ‘hands to the floor’ movement (B).

of varying heights and body shapes. On one occasion, three measurements were made of each movement and then on a second occasion (1 week later) a second set of three measurements were made. The reliability of the measurements was determined by using intraclass correlation coefficients (ICC, model 3,k), standard error of measurements (SEM), and 95% confidence intervals (95% CI). The ICC (3,k), 95% CI, and SEM results for the measurement of lumbar flexion were 0.85, 0.35–0.96, and 2.21, respec- tively. The corresponding results for the mea- surement of hip flexion were 0.92, 0.71–0.98, and 2.91, and for the hamstrings length measurement were 0.87, 0.56–0.97, and 3.41.

The ICC (model 3,k) results and the 95% CI for the reliability study suggested the measurement techniques used to measure lumbar flexion and hip flexion show good reliability (Portney and Watkins, 1983). Of clinical relevance the results for the standard error of measurement suggest that measurements of less than or equal to 31 should be considered as measurement error when measuring lumbar flexion and hip flexion and less than or equal to 41 for hamstrings length, using the methods outlined.

Although the results suggest that the method used in this study to measure the hip flexion angle was reliable, it is acknowledged that it is not used as a standard method for measuring this range. Placing a skin marker halfway between the ASIS and PSIS allowed for a stan- dardized photographic measurement of hip flexion that would not have been possible if the ASIS had been obstructed by skin and body tissues. However, the validity of this method is not known.

Power analysis

From the pilot study, the standard deviations for the measurements for lumbar flexion, hip flexion, and hamstrings length (using the measuring methods used in this investigation) were 5.51, 10.11, and 9.51, respectively. The standard error of measurements were 2.21, 2.91, and 3.41, respectively. Based on these results and clinical observations using these methods to measure the ranges of movement of interest, the authors considered that it was clinically relevant to detect a minimum difference of 101 for lumbar flexion, 151 for hip flexion, and 101 for hamstrings length between the groups. Based on these results and for a power of 0.8 and a level of significance of 5%, the minimum number of subjects required in each group was calculated to be 6 for lumbar flexion, 7 for hip flexion, and 10 for hamstrings length. Because 10 was the minimum number for hamstrings length, the number was increased by 30% to 13 in each group in case of subject withdrawal from the study, an underestimation of the subjects needed, or loss of subject data.

Statistical analysis

Data for the reliability investigation were analysed by using Intraclass Correlation Coefficients (model 3,k), 95% confidence intervals, and standard error or measurement. For the main investigation the descriptive statistics were compiled and then analysed. Each of the measurements of interest was made three times in succession. The mean of these three measure- ments was used in the analysis. The descriptive statistics were compiled and then analysed. A one-way ANOVA and post hoc Tukey's multiple comparison tests were used to analyse the three dependent variables (lumbar ROM, hip ROM, and hamstrings length). In addition to this the ratio of the lumbar spine ROM to hip ROM during the palms to floor movement was calculated for the three groups. Correlations between hamstrings length and hip flexion range were analysed by using the Pearson Correlation Coefficient. The critical level of statistical sig- nificance was set at *p*r0.05.

Results

Demographic information pertaining to the three groups is detailed in Table 1. Table 2 details the angular measurements for the lumbar spine in standing, in the 'palms to floor' position, and the total excursion angle from standing to the 'palms to floor' position. The mean lumbar spine angles in standing for the control group, hypermobile group, and JHS group were, respectively, -26.81, -28.51, and -27.41. The corresponding values in the 'palms to floor' position were 17.41, 16.21, and 12.81.

Table 3 details the measurements for the hip angle in standing, in the 'palms to floor' position, and the total excursion angle from standing to the 'palms to floor' position. The mean hip angles in standing for the control group, hypermobile group, and JHS group were, respectively -21.31, -16.31, and -15.71. The corresponding values in the 'palms to floor' position were 30.41, 49.91, and 51.21.

The mean hamstrings length, measured as a function of the straight leg raise angle for the three groups was 76.51 (SD 7.71) for the control group, 92.41 (SD 6.41) for the hypermobile subjects without symptoms, and 97.41 (SD 11.01) for the subjects with JHS. There was no significant difference ($p>0.05$) between the hypermobile subjects without symptoms and the subjects with JHS. There were significant differences between both groups of subjects who were hypermobile and the control group subjects who were not hypermobile ($p<0.05$).

In addition to this, no significant difference was found between the lumbar spine ROM (from standing to the 'hands to floor' position) between all the groups. No significant difference was found in the hip flexion ROM (from standing to the 'hands to floor' position) between the two groups of hypermobile subjects. A significant difference in hip ROM was found between the two groups of hypermobile subjects and the control subjects who were not hypermobile ($p<0.05$).

The ratio of the lumbar spine ROM to hip ROM during the palms to floor movement was calculated for the three groups. The ratio for the control group was determined to be 0.65 (SD 0.4), for the hypermobile group was 0.32 (SD 0.1), and the ratio for the JHS group was 0.26 (SD 0.2). Because all the ratios were less than 1.0, this finding indicates that the majority

Table 2. Angular measurements for the lumbar spine for the three groups.

	Mean lumbar spine angle (degrees) in standing (SD1)	Mean lumbar spine angle (degrees) in the 'palms to floor' position (SD1)	Total excursion angle of lumbar spine (degrees) from standing to the 'palms to floor' position (SD1)
Control group	-26.81 (4.5)	17.4 (9.2)	45.5 (7.2)
Hypermobile group	-28.51 (5.8)	16.2 (12.8)	46.1 (4.9)
JHS group	-27.4 (7.2)	12.8 (9.7)	40.9 (11.2)

The mean lumbar spine angles are presented in standing and in the palms to floor position. In addition the total excursion angle of the lumbar spine between these two positions are presented.
SD: standard deviation; JHS: joint hypermobility syndrome.

Table 3. Measurements for the hip angle for the three groups.

	Mean hip flexion angle (degrees) in standing (SD1)	Mean hip flexion angle (degrees) in the 'palms to floor' position (SD1)	Total excursion angle of lumbar spine (degrees) from standing to the 'palms to floor' position (SD1)
Control group	-21.3 (8.2)	30.4 (10.6)	51.7 (15.9)
Hypermobile group	-16.3 (9.5)	49.9 (5.6)	79.5 (13.3)
JHS group	-15.7 (5.5)	51.2 (11.1)	78.4 (9.2)

The mean hip angles are presented in standing and in the palms to floor position. In addition the total excursion angle of the hip between these two positions are presented.
SD: standard deviation; JHS: joint hypermobility syndrome.

of the movement came from hip flexion. There was no significant difference in the lumbar spine to hip ratios between the hypermobile and JHS groups. However, both these groups had a significantly smaller lumbar spine to hip ratio than the control group (*p* ¼ 0.05). This finding suggests that for the hypermobilie and JHS group, there was a relatively greater contribution of hip flexion than in the control group.

The correlation between hamstrings length and hip flexion ROM was significant (*p* ¼ 0.05), and a moderately strong correlation was identified between hamstrings length and hip ROM in all groups (Pearson correlation Coefficient ¼ 0.59).

Discussion

The results of this study suggest that there was no significant difference in lumbar ROM between the three groups during the ‘palms to floor’ maneuver. There was a significant difference in hip ROM between the two hypermobility groups and the control group; there was no significant difference in the hip ROM between the two groups of subjects with hypermoblity.

Because of differences in study design and measuring procedures between the current study and other research in this field, it is difficult to directly compare these findings with the results of other studies that investigated dynamic motion (Rice et al, 2004) and not end range movement as in the current study.

Other investigations have reported that the hip flexion to lumbar spine flexion ratio is greater in subjects who are unable to touch the floor (Tully and Stillman, 1997). In the current study the lumbar flexion to hip flexion ratios for the hypermobile group and the JHS group were 0.32 and 0.26, respectively. A ratio less than 1 suggests that hip flexion provides a greater contribution to this movement. The ratio for the control group for the current study was 0.65. This ratio suggests that although the contribution from hip flexion is still numerically greater than the lumbar flexion component in the palms to floor maneuver, the movement available from the hips is less than in the two hypermobile groups. Tully and Stillman (1997) reported a lumbar flexion to hip flexion ratio of 0.9 in subjects who were unable to touch the floor and 0.7 in those who were able. While these figures are somewhat greater than those in the current study, the trend is the same; the difference may relate to different methods of measuring these angles. At present, there is no gold standard for measuring these movements.

Nine of the 13 subjects (70%) with JHS experienced lumbar pain as part of their pattern of symptoms. In this investigation this was the most common region where symptoms were experienced. Decreased hip mobility has been associated with low back pain (Esola, McClure, Fitzgerald, and Siegler, 1996; Shum, Crosbie, and Lee, 2005). Other studies have shown that a reduction in lumbar mobility is associated with low back pain (Shum, Crosbie, and Lee, 2005). As the spine and hips work together to produce co-ordinated movement during functional activity, it is possible that an alteration in the contributing ROM from one or both regions may be associated with low back pain symp- toms. Previous research has shown that the relationship between the lumbar spine and hips alters with lumbar spinal pain (Esola, McClure, Fitzgerald, and Siegler, 1996; Pearcy and Tibrewal, 1984). A reduction in SLR has been associated with limitations of hip and lumbar spine physiological movement (Pearcy and Tibrewal, 1984). The aim of this investigation was to investigate if an alteration in the ROM and/or an alteration in the relative contributions of range from the hips and the lumbar spine existed in subjects without symptoms who were hypermobile in comparison to those with JHS. It was hypothesised that if a difference was iden- tified, this may contribute to the body of knowledge required to further understand the cause of symptoms and contribute to knowledge that may eventually help to reduce symptoms in this condition that is associated with substantial morbidity. It was thought relevant to test this hypothesis as overstretching of one region, or a lack of mobility in another may lead to increased tissue stretch that may result in symptoms. This hypothesis was proposed previously but not tested (Child, 1986; Keer, 2003). The results of the current investigation do not support this hypothesis because no difference was found in the contribution of hip and lumbar flexion range to the hands to floor maneuver in the two groups of hypermobile subjects investigated in this study. It is acknowledged that the small number of subjects who experienced pain in the lumbar region is a limitation of the present study. Ongoing research to test this hypothesis is required to better understand why some hypermobile people remain asymptomatic and others go on to develop JHS. An additional limitation of the current research is that only hip flexion range was investigated. Other studies (Gombatto et al, 2006) have investigated the relationship of hip lateral rotation and low back pain in a population of subjects who did not exhibit hypermobility. Future research in hypermobile subjects should investigate movement patterns and other ranges of movement in the lumbar and hip regions to determine if different patterns and ranges are identifiable. Differences between the genders also require investigation.

The ‘straight leg raise’ (SLR) is a clinical procedure that is often used to measure hamstrings length. However, this method may not adequately control for pelvic motion. Several publications have documented the need to control the pelvis during this movement (Cornbleets and Woolsey, 1996; Kendall, McCreary, and Provance, 1993). Bohannon, Gajdosik, and Le Veau (1985) used measured SLR on nine women and two men using cinematography. The study included three different methods of stabilising the pelvis and the contralateral leg. The authors concluded that the pelvis must be stabilised or accounted for in the measurement if it is to accurately assess hamstrings length. However, the researchers did not mention which of the three positions provided the most stabilisation. Furthermore, there was no mention of what ‘‘suitable’’ stabilisation would be or how pelvic rotation affects the hamstrings measurement. In another study, two methods of pelvic stabilisation were compared when testing the SLR with the pelvis and opposite thigh stabilised with straps or with flattening the lumbar spine by flexing the opposite knee (Gajdosik, Rieck, Sullivan, and Wightman, 1993). The results suggested that there was no significant difference between each of these methods of pelvic stability. Further research by these authors has confirmed the need for pelvic stability when using the SLR method for accurately assessing hamstrings length (Gajdosik, Rieck, Sullivan, and Wightman, 1993).

Another limitation when using the SLR to measure hamstrings length is to accurately measure the end point of range. This may be one of the reasons why the inter-observer error is higher than intraobserver error (Bierma-Zeinstra, Bohnen, Ramlal, and Riddenrikhoff, 1998). This point is dependent on the magnitude of the loads used to lift the leg, which may vary among operators (Lee and Munn, 2000) and the subjective nature on when individual clinicians feel the commencement of the resistance in the hamstrings.

Although the SLR method for measuring hamstrings length has been associated with pelvic movement (Bohannon, Gajdosik, and Le Weau, 1985), flexing the contralateral leg appears to help control for this error (Gajdosik, Rieck, Sullivan, and Wightman, 1993). However, it is acknowledged that some pelvic movement will have occurred with this clinical measurement before the point the pelvis was clinically deemed to have moved, and this is acknowledged by the authors as a limitation of the current investigation.

Piva et al (2006) investigated the intertester reliability of measuring hamstrings length, in subjects with patellofemoral pain syndrome, in a similar method that was used in the current investigation. They reported that the ICC (2,2) results were 0.92 with an associated 95% CI ranging from 0.82 to 0.96 and a SEM of 4.31. These results were comparable with the results obtained in the current investigation. Other investigations have used different assessment procedures to measure hamstrings length. These have included active knee extension (Gajdosik and Lusin, 1983) and passive knee extension (Gajdosik, Rieck, Sullivan, and Wightman, 1993).

All of these procedures have associated limitations such as lumbar stability, pelvic stability, and determination of the end point in range. There also are no available tests for accurately measuring hamstrings length with acceptable sensitivity and specificity. As such, it would be inappropriate to suggest that only the hamstrings muscles are being assessed during any of these procedures.

As in the current investigation, others (Kippers and Parker, 1987) have also used photography to assess the hands to floor mea- surement. However, it is acknowledged that the photographic method of measuring hip flexion used in the current investigation, with one reference point on the pelvis (and not as an angular measurement using a line joining the anterior superior iliac spine [ASIS] and posterior superior iliac spine [PSIS]) is not a standard method for quantifying this movement. The method used in the current study follows recommendations made by Tully and Stillman (1997), who conducted a pilot study investigating 11 marker placements. They reported that by placing a skin marker 2 cm below the greater trochanter (on the line joining the greater trochanter to the lateral line of the knee, it was possible to minimise aberrant skin motion over the greater trochanter. The decision to use the point midway between the ASIS and the PSIS was based on clinical observation and pilot studies, which revealed that in obese patients the ASIS would not be visible because of being covered by the folds of body tissue.

The results of the reliability study suggest that although the method of measuring hip flexion as used in this study achieved satisfactory reliability, it is acknowledged that the validity of this method is unknown, both in terms of its accuracy at determining the actual angle of hip flexion and confounding factors such as skin movement. Further research comparing this method with a 'gold standard' such as radiographs will help address the issue of the validity and clinical usefulness of this method.

Other investigations have reported that differing ratios may occur in subjects with chronic low back pain. Porter and Wilkinson (1997) reported that of 15 subjects with chronic low back pain and 17 subjects without symptoms, the subjects with symptoms demonstrated a reduction in the lumbar flexion range, and a subgroup of these subjects demonstrated a reduction in hip flexion range.

The findings of the current study suggest that subjects who are hypermobile who can touch the floor with their palms achieved this with increased hip range of motion and not increased lumbar spine flexion. There also does not appear to be a difference in lumbar spine flexion range to hip flexion range ratio between hypermobile subjects without symptoms and those with JHS. Although there was no significant difference between the groups with regard the total lumbar flexion range, it is noteworthy that both the control group and the hypermobilie group without symptoms had a greater mean total lumbar flexion range of 45.51 and 46.11, respectively, in comparison to the JHS group (40.91). This may be due to different movement patterns used by subjects with JHS, or this may be due to an adapted movement pattern due to kinesiophobia or due to a previous or current experience of pain. However, it should be noted that this variation may also have occurred by chance because the subject numbers in this study were relatively small. Ongoing research is needed to determine if there is any relevance in this difference in lumbar flexion range.

A limitation of this study is that it is not possible to determine the pattern of movement used by the subjects in this study given our methods of measuring movement. Previous studies have shown the movement is initiated in the lumbar spine followed by a greater contribution from the hips (Esola, McClure, Fitzgerald, and Siegler, 1996; Porter and Wilkinson, 1997). It would be useful in future research to determine if this same pattern occurs in subjects who are unable to reach the floor and in groups of hypermobile subjects with and without symptoms. Another limitation is that 4 of the 13 subjects with JHS did not have pain over their lumbosacral spine at the time of the investigation. This subgroup of subjects may have skewed the findings for the lumbar spine flexion range for the JHS group. Additional research is necessary to further determine if a difference exists in lumbar spine range in subjects with JHS when symptoms are present and when they are not currently being experienced.

Another finding of this study is that there was a moderately high correlation between hamstrings length (as measured by the SLR test) and hip ROM in all groups. Although there was no significant difference between either of the hypermobile groups, both these groups had significantly greater hamstrings length than the control group.

Other studies have also reported similar results with respect to hip ROM and hamstrings flexibility (Esola, McClure, Fitzgerald, and Siegler, 1996; Wong and Lee, 2004). Li, McClure, and Pratt (1996) reported that following hamstrings stretching exercises there was an increase in hip flexion motion in comparison to lumbar flexion movement during the movement of forward flexion. In contrast to this, other studies have shown that tightness in the hamstrings and a reduced SLR lead to a reduction in lumbar spine flexion range (Gajdosik, Albert, and Mitman, 1994; Pearcy and Tibrewal, 1984). These differences may have occurred because of different methods of measurement or different subgroup populations using different patterns of movement. In addition to this, it is not possible to implicate hamstrings muscle length in isolation during the SLR procedure. This is also the case for the forward bending movement that involves lumbar and hip flexion. The SLR procedure would also increase tension in the posterior hip capsule and ligaments and the sciatic nerve, which potentially would also limit the SLR assessment procedure. It is conceivable that the SLR test is not sensitive or specific for any one structure, and this may account for the differences reported in the studies examining the relative contribution from the lumbar spine and hip during the forward flexion movement in subjects with and without symptoms.

To reduce the pain and morbidity associated with JHS, it is important to determine the cause of the symptoms. The results of this study suggest that it would be inappropriate to implicate the contribution of hip and lumbar spine ROM used by people with JHS when they perform the movement of forward flexion because there were no significant differences in range compared with a subgroup of subjects who were hypermobile without symptoms.

Conclusion

The aim of this study was to investigate the relative contribution of lumbar spinal flexion and hip flexion during the palms to floor maneuver in three groups of subjects. No significant difference in the contribution of hip and lumbar flexion was identified between a group of hypermobile subjects without symptoms and a group of hypermobile subjects with JHS. However, both of these groups demonstrated a significantly different lumbar spine to hip contribution to the total movement than a control group of subjects who were unable to reach the floor during this movement.

A relatively strong correlation was found between hip flexion range of movement and the range of the straight leg raise, which was used in this investigation as a measure of hamstrings length. Subjects with greater straight leg raise were found to have greater range of hip flexion during the hands to floor maneuver. This study was not able to identify a mechanical difference in the way that hypermobile subjects with and without symptoms performed the palms to floor test, and further research is required to understand why some subjects who are hypermobile experience symptoms and others with similar amounts of hypermobility do not. The results of this study suggest that it is not possible to distinguish hypermobile people with and without JHS from the relative contribution of lumbar and hip flexion range when they perform the hands to floor test.

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