

1 Abstract

2

3 **Background:** Professional bus drivers report a high prevalence of upper quadrant
4 musculoskeletal pain which could be associated with scapular dyskinesis (SD). However, the
5 evidence for valid and reliable screening methods for this condition is limited as SD among
6 bus drivers is an emerging area of research. Therefore, the main aim of study was to
7 investigate the reliability of dynamic scapular motion test (DSMT) using video analysis as an
8 accurate method to evaluate scapular dyskinesis (SD) and to identify patterns of SD among
9 bus drivers.

10 **Methods:** Thirty-two bus drivers from a private bus company with unilateral upper quadrant
11 musculoskeletal pain participated in the study. The DSMT was conducted and the SD was
12 captured in the video during shoulder flexion-abduction movements. Two investigators
13 analysed the video recordings and identified the patterns of SD. The intra- and inter-rater
14 reliability were determined using the percentage of agreement and Weighted Kappa
15 coefficients (Kw). Descriptive analysis was used to examine the patterns of SD.

16 **Findings:** The intra- and inter-rater reliability of DSMT using video analysis were excellent
17 (Kw coefficient 0.762 – 0.878 and 0.87 – 1.00, respectively). About 56.2% and 53.1% of bus
18 drivers presented SD with the shoulder flexion and abduction movements during DSMT.
19 Medial border prominence (Type II pattern of SD) was identified as the common pattern of SD.

20 **Conclusion/Application to practice:** The DSMT using video analysis showed excellent intra
21 and inter-rater reliability to evaluate SD. Occupational health practitioners can consider DSMT
22 using video analysis to identify SD among people with upper quadrant musculoskeletal pain
23 at the workplace.

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1 **Original research article**

2 **A clinical evaluation of scapular dyskinesis among professional bus drivers with**
3 **unilateral upper quadrant musculoskeletal pain**

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5 **Background:**

6 Scapular dyskinesis (SD) is a condition characterized by abnormal dynamic scapular
7 control during shoulder movements and functional tasks (Burn et al., 2016). The scapula plays
8 an important role in the upper quadrant region which involves the shoulder complex joints and
9 cervical spine (Cools et al., 2014). The position and motor control of the scapula contributes
10 to both mobility and stability of the neck and shoulder region (Cools et al., 2014). In clinical
11 practice, the SD is identified by the presence of the prominence of the border of scapula which
12 includes superior, medial or inferior borders, and loss of scapula control during the bi-planar
13 arm movements (Huang et al., 2015; Maor et al., 2017). Current clinical evidence suggests a
14 strong relationship between SD with chronic neck and shoulder pain (Kibler et al., 2013;
15 Hickey et al., 2018). A recent meta-analysis reported that individuals with SD had 43% greater
16 risk of developing shoulder pain than those without SD (Hickey et al., 2018). Therefore, the
17 clinical identification and therapeutic management of SD is important for the rehabilitation of
18 individuals with chronic upper quadrant musculoskeletal pain (Panagiotopoulos & Crowther.,
19 2019).

20 Occupations such as professional bus driving involves repetitive neck and shoulder
21 movements (Rugbeer et al., 2016). The occupational tasks of bus drivers are stressful and
22 have changed little over the decades (Golinko et al., 2020). It demands significant repetitive
23 actions on the upper quadrant joints such as bending arms to control steering and frequent
24 twisting of neck which can cause musculoskeletal stress to neck and shoulder regions
25 resulting in significant occupational health hazards to the bus drivers (Golinko et al., 2020). A
26 recent literature review found that a high prevalence of upper quadrant musculoskeletal pain
27 in the neck (42.4%) and shoulder regions (39.2%) respectively among professional bus drivers
28 which was higher than the global 12-month prevalence of shoulder pain the in the general

1 public (36.7%) (Joseph et al., 2020). This finding along with other studies indicated that
2 professional bus drivers are at a high risk of developing upper quadrant musculoskeletal pain
3 (Joseph et al., 2020, Geete et al., 2013). However, to date no studies have investigated the
4 patterns of SD among professional bus drivers.

5 There are three different types of scapular examination techniques to detect SD
6 namely observation, semi-dynamic examination and dynamic examination (Uhl et al., 2009;
7 Kibler et al., 2002). The observation test involves visual evaluation and measurement of
8 scapular displacement from the trunk. However, it is highly challenging to observe the motions
9 of the scapula beneath the muscle and overlying soft tissues. The semi-dynamic test involves
10 static evaluation of scapula in a fixed plane of movement but it provides only a static
11 assessment of scapula position at one point in space. Therefore, the current recommendation
12 for clinical assessment of SD advocates the use of dynamic scapular motion tests (DSMT)
13 (Kibler et al., 2013). However, the reliability of the DSMT has not been tested in the population
14 of professional bus drivers. Most of the evidence on DSMT to date has been with athletes
15 with no reported studies examining SD among bus drivers population using DSMT. Thus, the
16 reliability of the DSMT had to be established prior to the application of this test to investigate
17 the patterns of SD among the bus drivers. Therefore, the main aims of the study were 1) to
18 investigate the intra and inter-rater reliability of the DST and 2) to investigate the patterns of
19 SD among professional bus drivers with unilateral upper quadrant musculoskeletal pain.

20 **Methods**

21 The sample for this study consisted of bus drivers who were recruited from one bus company
22 in Thailand. The bus company was randomly selected from a pool of three bus companies
23 which had participated in the Sustained Model of Assessment and Rehabilitation Training
24 (SMART) Drive project (Apirati et al., in press; Joseph et al., 2020). Bus drivers were recruited
25 through an approved advertisement displayed at the bus depot. Eligibility criteria included
26 presence of unilateral upper quadrant pain for the past 12 months, at least a year working 5
27 or more hours per day as a full-time professional bus driver and working for a minimum of 5
28 days per week. The exclusion criteria included history of any injuries to the upper extremity

1 that prevented them from working, bilateral upper quadrant musculoskeletal pain and inability
2 to perform shoulder flexion and abduction more than 120 degrees. The bus drivers who
3 participated in the study were driving both automatic buses and buses with gears, and used
4 both types of buses interchangeably. The drivers worked in different routes as per their duty
5 schedule and usually operated without a bus conductor. The study was conducted in the
6 natural work setting of drivers in the bus depot during the period between August, 2019 and
7 August, 2020. All participants received information about the study and signed the written
8 informed consent forms before the commencement of the study. The study was approved by
9 the Human Experimental Committee, Faculty of Associated Medical Sciences, Chiang Mai
10 University, Thailand (Ethical approval number-(AMSEC-62EX-007).

11 ***Participant characteristics***

12 Demographic characteristics including age in years, height in inches and weight in pounds
13 were collected using a self-administered questionnaire. Similarly, characteristics including
14 daily driving duration (in hours), daily driving distance (in miles) and number of years
15 experience were collected on the questionnaire. The numerical rating scale (NRS), a
16 commonly used and broadly validated tool was used to measure the intensity of pain in the
17 shoulder or upper back regions (Karcioglu et al., 2018). The participant rated their pain
18 intensity on a scale ranging from 0 to 10, with 0 indicating no pain and 10 indicating the worst
19 possible pain. A score of 1-3 indicates minimum pain, 4-6 indicates moderate intensity of pain
20 and 7-10 as severe intensity of pain. Along with pain intensity, the duration of the pain was
21 also collected.

22 ***Dynamic scapula motion test***

23 The participants elevated their arms to 120 degrees in the frontal and scapular plans
24 with and without holding weights (Larsen et al., 2020; Kibler et al., 2002). A scapular motion
25 was considered as normal when the motion presents with bilateral posterior tilting, external
26 rotation, and slight superior translation during arm elevation and reversal of these during
27 lowering relative to the opposite side (Larsen et al., 2020). If the scapular motion was not
28 normal, then the clinician observed the scapula for the presence of any of the four patterns of

1 SD. The four patterns of SD were Type I pattern (prominence of the inferior medial scapular
2 angle and would be associated with excessive anterior tilting of the scapula), Type II pattern
3 (prominence of the entire medial border and would be associated with excessive scapular
4 internal rotation), Type III pattern (prominence of the superior scapular border and would be
5 associated with excessive upward translation of the scapula) and finally Type IV pattern
6 (characterized as “normal,” indicating that no asymmetries were identified and no prominence
7 of the medial or superior border was observed) (Larsen et al., 2020; Kibler et al., 2002).

8 ***Procedure of DSMT***

9 The DSMT was performed according to a protocol developed by McClure (McClure et
10 al., 2009). The DSMT was conducted with participants in the sitting position with both the arms
11 hanging at the sides of the body with the elbow straight and shoulder in neutral position. The
12 sitting position was controlled with their first metatarsophalangeal joint aligned with a marker
13 on the floor to standardize the video recording. As a familiarization procedure, the participants
14 were instructed to perform bilateral active movements of shoulder flexion and abduction in the
15 sagittal and frontal planes carrying mini weights in the hand. The participants carried 1.5 kg if
16 they weighed less than 68.1 kg and 2.5 kg if they weighed 68.1 kg or more.

17 A video camera (Canon 700D, Japan) was mounted on a tripod fixed at the level of
18 scapula and was placed 204 cm away at the back of the participant to record the movements
19 (Figure 1). After the familiarization procedure, the participants performed 5 repetitions of the
20 shoulder flexion and abduction movements with the weights. All the movements were video
21 recorded and used for analysis. All the trials were conducted by a trained investigator. After
22 the trials, the video recordings were reviewed by two investigators (junior and senior
23 investigator) and chosen the single most predominant pattern of SD. If any patterns of SD was
24 observed, it was marked as “yes” and the type of SD was noted. If a normal scapular motion
25 was observed, it was noted as Type IV and then, it was relabelled as “no” (Larsen et al., 2020).
26 If the mixed patterns of scapular prominence were found during shoulder flexion and abduction
27 movement, the investigators identified the SD as mixed patterns (i.e. Type I + II, Type II + III,
28 Type I + III or Type I + II + III) (Huang et al., 2015). The two investigators rated the patterns of

1 SD independently and no discussion was permitted during the rating procedure. The
2 investigators were permitted to view the video second time if necessary and required. The
3 same videotapes were reviewed again at seven days later and the patterns of SD were
4 assessed again by the senior investigator.

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6 **Statistical analysis**

7 The sample size calculation for the study was prepared using G*power sample size
8 calculator with a power of 0.8 and an effect size of 0.5. Thus, a sample size of 32 participants
9 was considered appropriate for the study to evaluate the patterns of SD among professional
10 bus drivers. In addition, prior to evaluation of patterns of SD, 10 participants were recruited in
11 the study to investigate the reliability of the DSMT using video analysis. The statistical analysis
12 was performed using the SPSS version 23.0 for Windows. The intra- and inter-rater reliability
13 of the DSMT were determined using percentage of agreement and Weighted Kappa
14 coefficients (K). The K coefficient were set as follows; 0.81-1.00 excellent, 0.61-0.80
15 substantial, 0.41-0.60 moderate, 0.21-0.40 fair, 0-0.20 slight and less than zero as poor. The
16 statistical significance was considered at an alpha level of p-value < 0.05 with 95% confidence
17 intervals. Descriptive statistics were used to describe the demographic characteristics of
18 participants and the patterns of SD among the study participants.

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20 **Findings**

21 Thirty-two long-distance professional bus drivers between 30 and 50 years old
22 participated in the study. The mean age of the professional bus drivers in this study was 43.97
23 \pm 5.20 years. The bus drivers reported a moderate intensity of unilateral upper quadrant
24 musculoskeletal pain (NRS 5.34 \pm 1.29). Table 1 shows the demographic and work
25 characteristics of participants.

26 Table 2 shows the results of the reliability analysis for the DSMT using the video
27 analysis to identify patterns of SD among the professional bus drivers with unilateral upper
28 quadrant musculoskeletal pain. A total of ten participants (age 43.20 \pm 5.75 yrs.; weight 71.60

1 ± 9.20 kg.; height 166.00 ± 4.21 cm.) participated in the reliability study. The results of intra-
2 rater reliability of the DSMT using the video analysis to detect the patterns of SD among the
3 professional bus drivers showed excellent reliability with 100 and 90 percentage of
4 agreements in shoulder flexion and abduction with a Kappa coefficient of 1.00 and 0.878 for
5 shoulder flexion and abduction respectively ($p < 0.001$). The inter-rater reliability results
6 between the two investigators presented substantial reliability for shoulder abduction and
7 excellent reliability for shoulder flexion with Kappa coefficients of 0.762 to 0.878 respectively
8 ($p < 0.001$).

9 The patterns of the SD presented among the bus drivers with unilateral upper quadrant
10 musculoskeletal pain are shown in Table 3. A symmetrical scapular motion (Type IV) was
11 observed in all the participants in the non-painful side during both shoulder flexion and
12 abduction movements. In the painful side, 56.2% (N=18) of the bus drivers presented with SD
13 during the shoulder flexion movement, while 53.1% (N=17) presented with SD during the
14 shoulder abduction movement. Type II was the common pattern of SD observed among the
15 bus drivers during shoulder flexion (41%, N=13) and abduction (38%, N=12) movements.
16 Figure 2 shows a Type II pattern of SD observed among the bus drivers. Also, a mixed pattern
17 of SD (Type I + II) was observed in 6% (N=4) of the bus drivers.

18

19 **Discussion**

20 To our knowledge, this study is the first study to examine the patterns of SD observed
21 among professional bus drivers with upper quadrant musculoskeletal pain. The clinical
22 consensus statement from a scapular summit suggests that the treatment strategies for SD
23 can be effectively implemented by evaluation of the SD and recommends a comprehensive
24 rehabilitation program to address SD (Kibler et al., 2013). Therefore, it was important to
25 conduct the current study as it helped to establish a reliable clinical method and an
26 understanding on the patterns of SD among bus drivers with upper quadrant musculoskeletal
27 pain.

1 The findings from the current study demonstrated a reliable clinical method using video
2 analysis of the scapula to identify patterns of SD among people involved in an occupations
3 such as bus driving. The excellent reliability of the DSMT using video analysis for both inter-
4 rater reliability ($Kw = 0.762 - 0.878$) and intra-rater reliability ($Kw = 0.878 - 1.00$) suggested
5 that the clinical method to investigate the patterns of SD was scientifically acceptable. The
6 reliability findings of dynamic scapular motion test in this study were similar to a previous study
7 (Kibler et al., 2002; McClure et al., 2009). Currently, some of the measurement techniques to
8 evaluate SD requires sophisticated equipment and procedures such as electromagnetic
9 tracking device, 3-dimentional motion analysis systems and inclinometers (Nijs et al., 2007;
10 Watson et al., 2005). These dynamic assessments to identify SD are expensive, require
11 specialized equipment (laboratory methods) and specialized training limiting their usefulness
12 in clinical practice. (Nijs et al., 2007). Furthermore, it is challenging to establish clinical
13 assessment criteria to define SD especially when the scapula is moving in two planes.
14 Therefore, video recording and analysis are more appropriate and reliable. Although the
15 DSMT in this study was performed by physiotherapists, the procedure could easily be
16 administered by health care professionals. Thus, the clinical assessment of SD using the
17 DSMT through the video analysis presented in this study could be useful for clinicians in
18 practice because it is a highly reliable, easy to perform and affordable method

19 In the current study, approximately 56.2% and 53.1% of the professional bus drivers
20 who had unilateral upper quadrant musculoskeletal pain demonstrated alterations of scapular
21 movement during the flexion and abduction movements of the DSMT with Type II pattern was
22 identified as the common pattern of SD among the bus drivers. On the other hand, a
23 symmetrical scapular motion was observed in all the participants in the non-painful side during
24 both shoulder flexion and abduction movements. The abnormal motions of the scapula during
25 SD is hypothesized to increase the angulation of the humerus on the glenoid and decrease
26 the subacromial space, leading to MSP and shoulder pathology (Edmonds & Dengerink.,
27 2014). Furthermore, the alterations in the scapula motions and abnormal patterns of SD may
28 lead to a decrease in the performance of neck and shoulder movements (Kibler et al., 2012).

1 The nature of the professional bus drivers work involves driving buses for long
2 distances potentially resulting in overuse and repetitive neck and shoulder movements which
3 may result in SD and upper quadrant MSP. Therefore, the study findings suggest a need to
4 develop appropriate management strategies such as a health awareness program, possibly a
5 screening for upper quadrant musculoskeletal pain, and appropriate referrals for early
6 diagnostic testing. Evidence based exercises designed by a trained physical therapist could
7 also be considered to alleviate the potential for injury and to manage early symptoms. The
8 study findings also highlight the need for further research to prevent SD and musculoskeletal
9 pain. For example, factors such as driving tasks, equipment used by the drivers, types of
10 buses with and without gears, working hours, and rest breaks need to be studied in the context
11 of SD to explore other risk factors and how they could be prevented. Also, the current study
12 focused only on the scapular kinematics and the kinetic measures such as strength, motor
13 control of the scapular muscles were not considered. Therefore, further studies that
14 comprehensively analyse both quantitative and qualitative evaluation of upper quadrant
15 musculoskeletal pain and SD among bus drivers are needed.

16 The study has some limitations. The examination of patterns of SD among the bus
17 drivers was conducted from only one bus company from a specific geographic location, hence
18 the wider applications of the study findings on the bus drivers needs to be interpreted with
19 caution. The small sample size of the study was another limitation. Further studies that
20 investigate SD in a larger population of professional drivers are required. The current study
21 did not control for the types of buses, steering components and the driving conditions of the
22 bus drivers. The drivers from the bus company used both types of buses with and without
23 gears, driving them interchangeably as allocated by their shift managers and it was possible
24 that the different models of buses might have different engineering features. It needs to be
25 acknowledged that it was challenging to control the types of bus and related variables
26 especially in developing countries where the bus companies and drivers were delivering
27 services to society in spite of the socioeconomic challenges which influence the conditions of
28 the busses used by drivers.

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2 **Implications for Occupational Health Practice**

3 The DSMT using the video analysis is a highly reliable clinical method to evaluate the
4 patterns of SD among a sample of bus drivers with upper quadrant musculoskeletal pain.
5 About half of the sample with upper quadrant musculoskeletal pain presented with SD with
6 Type II being the commonly observed pattern of SD. The study provided preliminary evidence
7 of SD among professional drivers with upper quadrant musculoskeletal pain which could serve
8 as a catalyst to design and develop appropriate clinical screening assessments and to frame
9 effective rehabilitation strategies. Practitioners who encounter bus drivers should include an
10 assessment of upper quadrant pain and make appropriate referrals if SD is suspected and if
11 exercises for musculoskeletal pain are indicated. The study provided a clear and reproducible
12 clinical method to evaluate SD which could eventually enable clinicians and occupational
13 health practitioners to apply the clinical test in a wide variety of occupational settings with
14 people with upper quadrant musculoskeletal pain. Further qualitative and quantitative studies
15 encompassing additional assessments of upper quadrant musculoskeletal pain among
16 professional bus drivers are necessary for deeper understanding of the problem in this
17 occupation.

18

Applying Research to Occupational Health Practice

Upper quadrant musculoskeletal pain is a work place health issue reported among professional bus drivers. Scapular dyskinesis was suggested to contribute to upper quadrant musculoskeletal pain. The current study presented a reliable clinical evaluation method to examine scapular dyskinesis using a video analysis technique in the work place setting. The clinical method demonstrated in the study can be translated to any occupational setting to examine scapular dyskinesis for any population who suffers with upper quadrant musculoskeletal pain. Furthermore, the study presented different patterns of scapular dyskinesis with Type II pattern being the commonly observed pattern of scapular dyskinesis. The study invites practitioners to consider a comprehensive assessment to evaluate scapular dyskinesis among people with upper quadrant musculoskeletal pain.

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Table 1 Demographic, work and pain characteristics of the professional bus drivers with unilateral upper quadrant Musculoskeletal Pain (n=32)

Variables	Participants (n = 32) (Mean ± standard deviation)
Age (years)	43.97 ± 5.20
Weight (pounds)	163.49 ± 24.03
Height (inches)	65.72 ± 1.7
Numerical rating scale for Pain; (NRS) (score)	5.34 ± 1.29
Duration of unilateral upper quadrant pain (years)	2.91 ± 2.40
Experience with bus company (years)	8.75 ± 6.49
Daily driving duration (hours/day)	7.28 ± 1.42
Daily driving distance (miles./wk)	2011.80 ± 564.34

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Table 2 Intra and inter-rater reliability analysis for the DSMT using video analysis technique to identify the pattern of SD in a sample of bus drivers (n=10)

No	Reliability analysis	Test movements	Percentage of agreement		Weighted Kappa coefficients (Kw)		p-value
			(% agreement)				
			PT _A	PT _B	PT _A	PT _B	
1	Inter-rater reliability for the patterns of SD	Shoulder flexion	90	90	0.872* (0.621-1.000)	0.878*(0.642-1.000)	0.001*
		Shoulder abduction	90	80	0.878*(0.644-1.000)	0.762*(0.449-1.000)	0.001*
2	Intra-rater reliability for the patterns of SD	Shoulder flexion	NA	100	NA	1.00 (1.000-1.000)	0.001*
		Shoulder abduction	NA	90	NA	0.878 (0.642-1.000)	0.001*

* Statistical significance at p-value < 0.001; PT_A, Physical therapist A; PT_B, Physical therapist B; NA-not applicable; DSMT-dynamic scapula motion test

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Table 3 Patterns of the scapular dyskinesis presented among the bus drivers with unilateral upper quadrant MSP (n=32)

Classification	Painful side		Non-painful side	
	n (%)		n (%)	
	Shoulder flexion	Shoulder abduction	Shoulder flexion	Shoulder abduction
Inferior angle prominence (Type I)	3 (9%)	3 (9%)	0 (0%)	0 (0%)
Medial border prominence (Type II)	13 (41%)	12 (38%)	0 (0%)	0 (0%)
Superior border prominence (Type III)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Symmetric scapular (Type IV)	14 (44%)	15 (47%)	32 (100%)	32 (100%)
Mixed patterns (Type I + II)	2 (6%)	2 (6%)	0 (0%)	0 (0%)

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Figure Legends

Figure 1: The participants sitting in normal resting posture with a camera on a tripod placed 204 cm away

Figure 2: Type II pattern of SD (Medial border of scapula prominence)

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Supplementary Materials

Any underlying research materials related to the paper will be available upon request.