Elsevier Editorial System(tm) for Manual Therapy

Manuscript Draft

Manuscript Number: YMATH-D-15-00243R3

Title: Reliability, Agreement, and Diagnostic Accuracy of the Modified Lateral Scapular Slide Test

Article Type: Original Article

Keywords: diagnostic accuracy, Lateral Scapular Slide Test, reliability, scapular asymmetry, scapular position.

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Abstract: Background: The Lateral Scapular Slide Test (LSST) is a static test used in practice to assess linear inferior scapular angle displacement and scapular asymmetry at three different degrees of shoulder joint abduction; However, there is no evidence in the literature about the reliability and diagnostic accuracy of a modified LSST (arm elevation in scaption with loading) in a symptomatic population.
Objective: To assess reliability and diagnostic accuracy of the MLSST in subjects with and without shoulder symptoms. A new test position is examined, in which the arm is held in 90° of elevation in scaption with 1 kg load.
Design: Within day intra-and inter rater reliability, agreement, and diagnostic accuracy study.
Method: Participants included 25 (42±2.7 years) subjects with shoulder symptoms and 25 (40±2.1years) asymptomatic control subjects. Two raters measured the distance between the inferior scapular angle and T7 at arms by the side, hands on hips and 90° of arm elevation in the scapular plane with 1 kg load. Measurements were performed twice, bilaterally. Intraclass correlation coefficient (ICC), minimal detectable change (MDC95%) and diagnostic accuracy were calculated.
Results: The ICCs for intra- and inter-rater reliability were good to high in both groups. The MDC95% in symptomatic and asymptomatic group ranged 0.67-1.40 cm and .60-1.52cm respectively. Positive and negative likelihood ratios ranged 1.07-5.50 and 0.81-1.11, respectively.
Conclusion: The MLSST had good reliability and agreement properties to assess scapular position in both groups. However, no test position had clinical utility as a diagnostic criterion for shoulder pathology.

TITLE PAGE

Reliability, Agreement, and Diagnostic Accuracy of the Modified Lateral Scapular Slide Test

ABSTRACT

Background: The Lateral Scapular Slide Test is a static test used in clinical settings to assess medio-lateral inferior angle displacement and scapular asymmetry at three different degrees of shoulder abduction. However, there is no evidence in the literature about the reliability and diagnostic accuracy of a modified LSST (arm elevation in the scapular plane with loading) in a symptomatic population.

Objective: To assess the intra- and inter-rater reliability, agreement, and diagnostic accuracy of the MLSST in subjects with and without shoulder symptoms. A new test position is examined, in which the arm is held in 90º of elevation in the scapular plane with 1 kg load.

Design: Within day intra- and inter-rater reliability, agreement, and diagnostic accuracy study.

Method: Participants included 25 (42±2.7 years) subjects with shoulder symptoms and 25 (40±2.1years) asymptomatic control subjects. Two raters, blinded to each other's outcomes, measured the distance between the inferior scapular angle and T7 at arms by the side, hands on hips and 90º of arm elevation in the scapular plane with 1 kg load. Measurements were performed twice, bilaterally. Intraclass correlation coefficient (ICC), minimal detectable change ($MDC_{95\%}$) and diagnostic accuracy were calculated.

Results: The ICCs for intra- and inter-rater reliability were good to high in both shoulders of symptomatic and asymptomatic groups. The $MDC_{95\%}$ in the symptomatic group ranged between 0.67 – 1.40 cm in the symptomatic shoulder and 0.72 – 1.16 cm in the asymptomatic shoulder. The asymptomatic group presented a $MDC_{95\%}$ ranging between 0.63 – 1.52cm in the dominant and 0.60 – 1.41cm in the non dominant shoulder. Positive and negative likelihood ratios ranged between 0.67 – 5.50 and 0.81 – 1.11, respectively.

Conclusion: The MLSST had good reliability and agreement properties to assess scapular position in both groups. However, no test position had clinical utility as a diagnostic criterion for shoulder pathology.

Keywords: diagnostic accuracy, Lateral Scapular Slide Test, reliability, scapular asymmetry, scapular position.

INTRODUCTION

Shoulder joint function may be affected by changes in scapular position and motion. Several studies have shown that altered scapular position and motion, commonly termed scapular dyskinesis, can significantly impact on shoulder joint stability (Mueller et al., 2013), muscles' force generation (Kebaetse et al., 1999; Kibler & McMullen, 2003; Kibler et al., 2006) and length tension capacities (Borstad, 2006), range of motion (Kebaetse et al., 1999), and quality of movement (Ludewig & Reynolds, 2009). Any muscle imbalance affecting the shoulder complex may change scapular kinematics and the symmetry of shoulder motions. Thus, scapular asymmetry is often considered as a related factor to the development or perpetuation of shoulder pain and disability and used as a diagnostic criterion to identify patients at risk of developing shoulder symptoms (Lukasiewicz et al., 1999; Hebert et al., 2002; Uhl et al., 2009; Kawasaki et al., 2012; Klintberg et al., 2015). However, there is controversy and debate among clinicians and researchers regarding whether scapular asymmetry does predispose the shoulder to pathology (McClure et al., 2009; Kibler et al., 2013; Morais & Pascoal, 2013; Hosseinimehr et al., 2015).

The Lateral Scapular Slide Test (LSST) is proposed as a practical, quantitative method for assessing medio-lateral inferior angle displacement and recognizing scapular symmetry in clinical settings (Kibler, 1998). Side to side comparison is done between the

distances of the thoracic spine to the inferior angle of the scapulae and performed in 3 different arm positions: one, arms by the side; two, hands on hips; three, 90º of shoulder abduction with the thumbs pointing downwards (maximal internal rotation of the shoulders). Although this is a relatively simple test to perform, the literature shows conflicting results in the measurement properties of the LSST to identify scapular asymmetry. While some authors have reported reasonable reliability and agreement, and recommend its use in clinical practice (Gibson et al., 1995; McKenna et al., 2004), others found less adequate compatibility in this regard (Gibson et al., 1995; Odom et al., 2001; Shadmehr et al., 2010; Ozunlu et al., 2011). Moreover, the clinical utility of the LSST remains inconclusive. Several studies using the LSST as a diagnostic criterion for determining scapular asymmetry in subjects with and without shoulder pain, found that the ability of this test to differentiate between symptomatic and asymptomatic shoulders is questionable (Odom et al., 2001; Koslow et al., 2003; Nijs et al., 2005; Shadmehr et al., 2010). Asymmetry in scapular position between sides is often assumed as pathological. However, asymmetrical scapular position is reported in both symptomatic and asymptomatic populations confounding the interpretation (Uhl et al., 2009; Seitz et al., 2012b; Morais & Pascoal, 2013; Hosseinimehr et al., 2015).

Considering that dynamic scapular stability and mobility strongly depends on the contribution of the muscular system, a modified LSST (MLSST) is proposed to load the shoulder muscles to assess if this modification further highlights side to side differences in scapular position between symptomatic and asymptomatic shoulders (Struyf et al., 2009). The MLSST introduces 2 variations to the original LSST: one, in 90º of shoulder abduction a load of 1kg is added; and two, a further position is added of unloaded arm abduction to 180º. Struyf et al., (2009) recommend the modifications when testing populations with shoulder symptoms to refine the measurement and clinometric properties of the LSST. Shadmehr et al., (2014) further proposed that the MLSST be done with the arm in the scapular plane instead of the coronal plane because this position was more reflective of the neuromuscular control of the scapula whereas the coronal plane could be more reflective of glenohumeral joint capsule and ligamentous restrains. Additionally, abnormal scapular position and motion may be better recognized during arm elevation performed in the scapular plane (scaption) when compared with the coronal plane (shoulder abduction) (Giphart et al., 2013).

Thus, the aim of this study was to determine the reliability, agreement and clinical utility of the MLSST, particularly the new test position, 90º of shoulder abduction in scaption

with 1 kg load, to rule in or rule out scapular asymmetry as a factor related with the presence of shoulder pathology.

MATERIALS AND METHODS

Study design

This was a two groups, two assessors, repeated measures study. Intra- and inter-rater reliability and agreement, and diagnostic accuracy were investigated. The intra- and inter-rater reliability and agreement study was performed following the Guidelines for Reporting Reliability and Agreement studies (GRRAS) (Kottner et al., 2011). For the diagnostic accuracy study, the Standards for Reporting of Diagnostic Accuracy (STARD) was used (Bossuyt et al., 2003).

Subjects

Twenty-five (n = 25) subjects complaining of shoulder pain were recruited from two private physical therapy clinics and one outpatient physical therapy division of a general hospital. During the same period, a general announcement among hospital personnel was held to recruit subjects free from symptoms. The aims and procedures of the study were explained, and prior to participation, volunteers had to sign an informed consent form. Subjects then underwent clinical examination by an orthopedic surgeon, complemented with diagnostic imaging (MRI and ultrasonography imaging) on both shoulders to screen for abnormalities, such as partial rotator cuff tears or tendinopathy. The orthopedic surgeon then established and reported the final diagnosis, taking into account both clinical and imaging findings, and referred the subjects to the research team. This study was approved by the ethics committee.

Inclusion criteria

All recruited subjects had to be between 18 and 65 years old and be able to actively perform 90º of shoulder abduction in scaption with maximal internal rotation while holding 1kg weight in their hands. Subjects in the symptomatic group had to be diagnosed with unilateral shoulder pathology by an orthopedic surgeon.

Exclusion criteria

Subjects were excluded if they had any of the following conditions: regular engagement in unilateral overhead sports or professional activities, previous shoulder surgery, history of systemic disease or neuromuscular disorder, limited cervical motion, fracture of the upper limb, leg length discrepancy, deformities of the vertebral column (e.g., scoliosis), and body mass index (BMI) equal or greater than 29.9 (obesity). Obesity would

make it difficult to identify body landmarks by means of palpation. Subjects were also excluded if they showed abnormal MRI or ultrasound images (e.g., partial rotator cuff tears) in their asymptomatic shoulder (symptomatic group) or shoulders (asymptomatic group) and if they complained of bilateral shoulder pain or pain that was triggered by provocative maneuvers at the neighboring anatomic regions (e.g., cervical spine) during physical examination (Manske & Ellenbecker, 2013).

Instruments

A digital Vernier caliper with an accuracy of 0.01mm (Mitotuyo Company,Japan),a goniometer (Lafayette Company, USA) and 1kg weight were used in this study.

Raters

Two physical therapists with 10 years of clinical experience in the assessment and intervention of musculoskeletal conditions of the upper body quadrant performed all measurements. Before study initiation, they underwent familiarization with the standardized measurement procedures of the study and took a practice trial on 10 subjects for over approximately 2 hours. The outcomes of the two independent raters were used to test inter-rater reliability. For the intra-rater reliability component of the study, one of the examiners repeated the test 30 minutes later.

Procedures

Each rater identified and marked the spinous process of the 7^{th} thoracic vertebra (T7). This started by identifying the spinous process of the 7^{th} cervical vertebra (C7) as described by da Costa, et al. (2010). After identifying C7, raters palpated the spinous processes of the vertebrae down to T7 and then marked it with a tag. Then, they measured the distance between the inferior angle of the scapulae and the spinous process of T7 in 3 different arm positions. The first position was with the arms by the side. The second was with the subject's hands on the hips, and the third was with the arms elevated to 90º of shoulder abduction in scaption with maximal internal rotation and 1kg load hold in their hands (Figure 1). The order of measurements considering side, arm positions and raters was randomized.

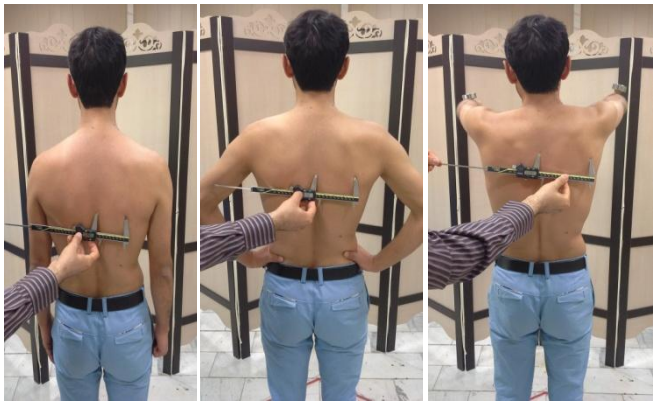

Figure 1: Three positions of the MLSST

To measure the scaption angle (40º from the frontal plane), we set the fixed goniometer arm on the body axis in the frontal plane and put the axis of one goniometer on the acromion tip and the mobile arm parallel to subject arm axis. Since there may be some differences in subjects' upper extremity length, we extended the extendable mobile arm of the goniometer up to the wall and marked it with a cross. This was performed separately at 90º of scaption in both upper extremities. All subjects were asked to keep their fingertips in line with the marked wall cross during measurement capture (Figure2).

Figure 2: 90º of scaption

All measurements were captured bilaterally in less than 60 seconds. Subjects were given as much rest time between measurements as they required. No more than 30 seconds was generally necessary. The caliper was set to zero by an independent researcher after each measurement in order to secure raters' blinding to the measurement values. When one examiner obtained a complete set of measurements on a subject, the tags marking the spinous process were removed. Skin movement distortion was a concern, hence, a method

recommended by the International Society for the Advancement of Kinanthropometry (ISAK, 2001)**,** whereby the landmark is identified, skin released and relocated, marked then rechecked for skin displacement was used to reduce measurement error potentially related to markers positioning. The same procedures were repeated with the other rater. The interval time between raters' measurements was 2 minutes.

The Visual Analog scale (VAS) was used to assess the severity of shoulder pain at rest and during the MLSST (Jensen et al., 1986). To qualify pain, metric 0 was set as equal to no pain, whereas 10 meant worst pain ever felt.

Data Analysis

All data were analyzed using SPSS version 17 for Windows (SPSS Inc., Chicago, Illinois, USA). Descriptive statistics are reported as mean and standard deviation (SD) unless otherwise stated.

Reliability and agreement properties

Two models of intraclass correlation coefficients (ICC), were used to examine the intra- and inter-rater reliability of the MLSST, respectively $ICC_{2,1}$ and $ICC_{3,1}$. Using SPSS software, $ICC_{2,1}$ was computed by selecting the options 2-way random, single measure, and absolute agreement, and $ICC_{3,1}$ by selecting average measure, and absolute agreement. Standard error of the measurement (1SEM or simply SEM), two-standard error of the measurement ($2SEM = 2SD* \sqrt{1 - ICC}$) and minimal detectable change with 95% confidence intervals ($MDC_{95\%} = SEM*1.96 * .\sqrt{2}$) were calculated in the 3 different arm testing positions (Weir, 2005). The ICCs were classified as follow: <0.69, poor correlation; 0.70-0.79, fair correlation; 0.80-0.89 good correlation; 0.90-1.00 high correlation (Blesh, 1974). 1SEM and 2SEM were calculated from the two ICC models used in this study, $ICC_{2,1}$ and $ICC_{3,1}$, respectively. With 1SEM clinicians may be 68% certain that the true measurement value lies within its value. 2SEM provides the clinician with 95% of confidence (McKenna et al., 2004). Reliability was calculated based on 25 symptomatic shoulders and 25 asymptomatic shoulders in the symptomatic group and 50 asymptomatic shoulders in the asymptomatic group, separately.

Diagnostic accuracy

For estimation of the diagnostic accuracy of the MLSST, a side to side difference greater than 1.5cm was the criterion used to consider asymmetry (Kibler, 1998). Sensitivity, specificity, positive and negative likelihood ratios were computed in 25 symptomatic

shoulders and 25 asymptomatic shoulders in the symptomatic group and 50 asymptomatic shoulder in the asymptomatic group, separately (Fritz & Wainner, 2001).

RESULTS

Subjects

Thirty asymptomatic subjects (n = 30) volunteered to participate in the study, however, 5 were excluded due to the presence of spinal misalignments (n = 3) and partial rotator cuff tears (n = 2). The final sample was then composed by 25 asymptomatic subjects (40±2.1years). The symptomatic group consisted of 25 subjects (42±2.7 years) diagnosed by the orthopedic surgeon as having unilateral subacromial pain syndrome both on clinical presentation and confirmed by diagnostic imaging. The mean pain score at rest was 3±0.4 and 5±0.3 during MLSST. Socio-demographic characteristics of the sample are summarized in Table 1.

Reliability and agreement properties

The intra- and inter -rater ICCs were good to high in both asymptomatic and symptomatic groups (Tables 2 and 3). Intra- and inter-rater agreement estimations (SEM and $MDC_{95\%}$ values) were notably low in the symptomatic group, with the positions arms by the side (P1) and hands on hips (P2) showing the narrower estimative. The 2SEM results, according to $ICC_{2,1}$, ranged from 0.44 cm to 1.10 cm for asymptomatic group and from 0.48 cm to 1.06 cm for the symptomatic group.

Diagnostic accuracy

The sensitivity of the MLSST at all arm positions varied between 11% and 30%, whereas the specificity was relatively high (80%–95%). Positive likelihood ratio ranged from 1.07 to 5.5 and negative likelihood ratio from 0.84 to 1.11. Individual values per rater and testing positions are shown in Table 4.

DISCUSSION

This study found good to high intra- and inter-rater reliability of the MLSST in both subjects with and without shoulder symptoms and pathology. Furthermore, the intra- and inter-rater SEM and $MDC_{95\%}$ of the MLSST appear to be sufficiently narrow in all testing positions, suggesting reasonable agreement for its use in clinical practice.

The SEMs estimated in this study (< 0.56cm) were, in general, lower than those estimated by others that have also investigated the 90º of shoulder abduction in scaption test

position [da Costa, et al. (2010) SEM < 1.17 cm and Shadmehr, et al. (2014) SEM < 1.09 cm]. This suggests a better precision, possibly related to instrumentation, caliper [this and Shadmehr et al.'s (2014) study] versus palpation meter (da Costa et al., 2010), explaining the overall improvement in reliability. There are other simple instruments in the literature that have also shown low measurement error when measuring scapular position, such as specialized wooden instruments (Plafcan et al., 1997) or scoliometers (Curtis & Roush, 2006). However, which instrument offers the best measurement quality to assess scapular position at the lowest cost is currently unknown and deserves to be investigated in the future.

In addition to the instrumentation factor, the relatively low SEMs observed in this study at 90º of shoulder abduction in scaption were possibly related with the 1kg load added to the subjects' hands. It has been shown that increasing loads to the 90º of shoulder abduction in scaption position reduces measurement error and improves reliability (Shadmehr et al., 2014). Since this study was not intended to measure and compare loaded and unloaded conditions in the 90º of shoulder abduction in scaption position such justification can only be speculative at the moment but should be clarified in the future. It is particularly important for this to be investigated in symptomatic populations because increased neuromuscular drive and coordination of the scapular muscles are unlikely to be the same in symptomatic and asymptomatic populations (Shadmehr et al., 2014). Moreover, optimal secure loads have not been established for populations with shoulder pathology. Further research into these topics is therefore warranted.

A more prominent inferior angle of the scapula when the arm is moved in scaption, rather than in the coronal plane, may be another reason why reliability in this and another study (Shadmehr et al., 2014) was greater compared to other studies using the 90º of arm elevation position (Gibson et al., 1995; Odom et al., 2001; Struyf et al., 2009; Shadmehr et al., 2010; Ozunlu et al., 2011). When the plane of arm elevation is closer to the sagittal plane (e.g., the scapular plane), for the same degree of arm elevation the scapula tends to be in a more anteriorly tilted position (Chu et al., 2012; Roren et al., 2015), making it easier to track and palpate its inferior angle. Other factors that may have had some influence on this are training and expertise of the raters (Lluch et al., 2014) and low to moderate thickness of the subcutaneous tissue of the subjects (Lewis et al., 2002), estimated by means of BMI in this study.

The observed 2SEM and $MDC_{95\%}$ in our study was within the 1.5cm threshold which may suggest that the cut off recommended by Kibler (1998) to differentiate between normal and abnormal scapular asymmetry was optimal to test the diagnostic accuracy of the MLSST. Using that diagnostic criterion, the MLSST showed low sensitivity, high specificity and poor positive and negative likelihood ratios (Table 4). These findings indicate that, although reliability and agreement parameters of the MLLST may be reasonably robust to identify possible asymmetries, it is unlikely that this test is capable of differentiating between subjects with and without shoulder symptoms or determining the risk of predisposition to pathology. Previous studies reporting the diagnostic accuracy of the LSST had similar conclusions. In a sample composed by 20 subjects being treated for shoulder impairments and 26 subjects without shoulder impairments, Odom, et al. (2001) reported low sensitivity (28%–53%) and specificity (34%–56%) of the LSST. Shadmehr, et al. (2010) in a study conducted in 27 subjects with and 30 subjects without shoulder pain, verified high sensitivity (80%–96%), low specificity (4%–26%) and poor positive (0.94–1.22) and negative (0.21–2.5) likelihood ratios of the LSST. Differences in samples characteristics, instruments used, modified versus traditional LSST, and training of raters may explain some of the dissimilarities in the measures of accuracy among studies.

It seems plausible that the low diagnostic ability of the (M)LSST found in this and other studies (Odom et al., 2001; Shadmehr et al., 2010) could be related to the fact that asymmetrical scapular position between sides may be a normal finding in both symptomatic and asymptomatic populations, posing difficulties in establishing a robust threshold value for diagnostic purposes (Uhl et al., 2009; Seitz et al., 2012b; Morais & Pascoal, 2013; Hosseinimehr et al., 2015). Additionally, there is a general belief among clinicians that pain, particularly pain as significant as in this sample (VAS 3–5), may contribute to muscle imbalances of the shoulder-neck region and to altered kinematic patterns of the scapula, further aggravating asymmetry between sides during arm elevation (Kibler, 1998; Roche et al., 2015). However, not all patients with shoulder symptoms may develop asymmetric scapular position and motion (Uhl et al., 2009), presumably because each individual may develop a protective motor strategy and adaptation (e.g., co-contraction of agonist-antagonist muscles, or increased activity of synergistic muscles) to pain provocation movements that is unique based on experience, anthropometrics, posture or task (Hodges, 2011). As patients in

these study were engaged at different stages of a rehabilitation program that included motor control exercises of the scapula, postural correction and conditioning of the scapular muscles, it is likely that diagnostic accuracy measures might have been influenced by the effects of therapy on scapular position and motion on those patients who were in a more advanced stage. Longitudinal research is needed to more definitely discern the clinical value of side to side differences in scapular position and motion to identify patients at risk of developing or perpetuating shoulder pathology and symptoms. In addition, further exploratory research is recommended to understand whether scapular asymmetry detected during MLSST positions are, for instance, related with pathomechanics of the glenohumeral joint region, such as compression and friction of the rotator cuff tendons against the acromial arch, and pain. Some authors have proposed that scapular position influences the subacromial space (Solem-Bertoft et al., 1993; Silva et al., 2010), yet no clear picture exists on this subject. While some authors reported decrease in acromio-humeral distance (AHD) in subjects with scapular dyskinesis (Silva et al., 2010), others found no link between observed scapular dyskinesis and AHD (Seitz et al., 2012a). Therefore, combining linear measurements of the scapular position with ultrasonography of the glenohumeral region and 3-dimensional shoulder kinematics in subjects with and without complains of subacromial pain would be decisive in future research to help clarifying the value of the MLSST.

There are some limitations in this study that must be acknowledged. The MLLST is a simple clinical measure that may only assess scapular positioning in one or two planes at most. However, scapular position alterations in patients with shoulder pain and pathology are highly variable and multidirectional (Ratcliffe et al., 2013), hence, possible side to side scapular asymmetries in several patients in this study may not have been detected by the MLSST, lowering diagnostic accuracy measures. Methodologies that use three-dimensional analysis of bilateral scapular position and orientation are preferable to detect asymmetry (Uhl et al., 2009). Blinding raters to the subject group identity is recommended in diagnostic accuracy studies (Bossuyt et al., 2003). But because the asymptomatic group of subjects had no pain on testing and the symptomatic group did, raters may have been aware of subject group identity, thus their expectations may have influenced their judgment and measurement skills. Nevertheless, reliability and agreement measures were not noticeably different between symptomatic and asymptomatic groups, thus the impact on diagnostic accuracy measures might have been negligible. Two trained and experienced raters collected the data in this study; therefore, reliability of the technique cannot be extrapolated to less experienced clinicians conducting MLSST. Finally, the present study was conducted on non-athletic

individuals, who may have less muscle bulk when compared to the athletic population, and on patients who reported difficulties holding static positions with loading due to pain. Therefore, these factors do not allow direct generalization of findings to athletic populations with shoulder symptoms.

CONCLUSION

The MLSST had good reliability and agreement properties to assess scapular position in both groups. However, no test position had clinical utility as a diagnostic criterion for shoulder pathology.

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Table 1: Demographic data of participants

Demographic data	Symptomatic group (n = 25) Mean (SD)	Asymptomatic group (n=25) Mean (SD)
Age (years)	42 (2.7)	40 (2.1)
Gender	12 male, 13 female	15 male, 10 female
Body mass index (kg/m^2)	26.8	27.0

Table 2: Intra- and inter-rater $ICCs_{2,1}$, SEMs, and $MDC_{95\%}$ in asymptomatic (n = 50 shoulders) and symptomatic subjects (n = 25 symptomatic shoulders, n = 25 asymptomatic shoulders)

		Intra Rater Reliability				Inter Rater Reliability			
Position	Side	ICC	SEM (cm)	2SEM (cm)	$MDC_{95\%}$ (cm)	ICC	SEM (cm)	2SEM (cm)	$MDC_{95\%}$ (cm)

P1	D	0.90	0.36	0.72	1.00	0.96	0.23	0.46	0.63
	ND	0.89	0.32	0.64	0.89	0.95	0.22	0.44	0.60
P2	D	0.93	0.31	0.62	0.85	0.94	0.28	0.56	0.79
	ND	0.93	0.31	0.62	0.86	0.96	0.24	0.48	0.65
P3	D	0.86	0.55	1.10	1.52	0.91	0.44	0.88	1.22
	ND	0.82	0.51	1.02	1.41	0.92	0.34	0.68	0.94
		Intra Rater Reliability				Inter Rater Reliability			
Position	Side	ICC	SEM (cm)	2SEM (cm)	$MDC_{95\%}$ (cm)	ICC	SEM (cm)	2SEM (cm)	$MDC_{95\%}$ (cm)
P1	S	0.88	0.34	0.68	0.95	0.94	0.24	0.48	0.67
	AS	0.89	0.30	0.60	0.84	0.92	0.26	0.52	0.72
P2	S	0.90	0.47	0.94	1.29	0.89	0.49	0.98	1.36
	AS	0.91	0.37	0.74	1.03	0.94	0.30	0.60	0.84
P3	S	0.81	0.53	1.06	1.46	0.88	0.42	0.84	1.16
	AS	0.88	0.41	0.82	1.14	0.91	0.36	0.72	0.99

Abbreviations: D = dominant, ND = non nominant, S = symptomatic, AS = asymptomatic, P1 = arms by the side, P2 = hands on hips, P3 = 90 º of abduction in scaption with1 kg load, SEM = standard error of the measurement, ICC = intraclass correlation coefficient, $MDC_{95\%}$ = minimal detectable change with 95% confidence in

Table 3: Intra- and inter-rater $ICCs_{3,1}$, SEMs, and $MDC_{95\%}$ in asymptomatic (n = 50 shoulders) and symptomatic subjects (n = 25 symptomatic shoulders, n = 25 asymptomatic shoulders).

		Intra Rater Reliability				Inter Rater Reliability			
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Table 4: Sensitivity, specificity, positive and negative likelihood ratios of the MLLST considering a side to side difference of 1.5 cm as threshold value to diagnose 'scapular asymmetry' (asymptomatic group, n=25; symptomatic group, n=25).

Position	Sensitivity		Specificity		Positive likelihood ratio		Negative likelihood ratio	
	Rater1	Rater2	Rater1	Rater2	Rater1	Rater2	Rater1	Rater2
P1	15%	23%	86%	95%	1.07	4.6	0.98	0.81
P2	15%	11%	86%	80%	1.07	5.5	0.98	1.11
P3	23%	30%	91%	81%	2.55	1.57	0.84	0.86

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Acknowledgments

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***Completed Reporting Guideline Checklist**

STARD checklist for reporting of studies of diagnostic accuracy

(version January 2003)

Section and Topic	Item #		On page #
TITLE/ABSTRACT/ KEYWORDS	1	Identify the article as a study of diagnostic accuracy (recommend MeSH heading 'sensitivity and specificity').	1
INTRODUCTION	2	State the research questions or study aims, such as estimating diagnostic accuracy or comparing accuracy between tests or across participant groups.	2
METHODS			
Participants	3	The study population: The inclusion and exclusion criteria, setting and locations where data were collected.	4
	4	Participant recruitment: Was recruitment based on presenting symptoms, results from previous tests, or the fact that the participants had received the index tests or the reference standard?	4
	5	Participant sampling: Was the study population a consecutive series of participants defined by the selection criteria in item 3 and 4? If not, specify how participants were further selected.	4
	6	Data collection: Was data collection planned before the index test and reference standard were performed (prospective study) or after (retrospective study)?	4
Test methods	7	The reference standard and its rationale.	5
	8	Technical specifications of material and methods involved including how and when measurements were taken, and/or cite references for index tests and reference standard.	6
	9	Definition of and rationale for the units, cut-offs and/or categories of the results of the index tests and the reference standard.	7
	10	The number, training and expertise of the persons executing and reading the index tests and the reference standard.	5
	11	Whether or not the readers of the index tests and reference standard were blind (masked) to the results of the other test and describe any other clinical information available to the readers.	7&8
Statistical methods	12	Methods for calculating or comparing measures of diagnostic accuracy, and the statistical methods used to quantify uncertainty (e.g. 95% confidence intervals).	7
	13	Methods for calculating test reproducibility, if done.	7
RESULTS			
Participants	14	When study was performed, including beginning and end dates of recruitment.	5
	15	Clinical and demographic characteristics of the study population (at least information on age, gender, spectrum of presenting symptoms).	16
	16	The number of participants satisfying the criteria for inclusion who did or did not undergo the index tests and/or the reference standard; describe why participants failed to undergo either test (a flow diagram is strongly recommended).	4
Test results	17	Time-interval between the index tests and the reference standard, and any treatment administered in between.	-
	18	Distribution of severity of disease (define criteria) in those with the target condition; other diagnoses in participants without the target condition.	4
	19	A cross tabulation of the results of the index tests (including indeterminate and missing results) by the results of the reference standard; for continuous results, the distribution of the test results by the results of the reference standard.	4&5
	20	Any adverse events from performing the index tests or the reference standard.	-
Estimates	21	Estimates of diagnostic accuracy and measures of statistical uncertainty (e.g. 95% confidence intervals).	16&17
	22	How indeterminate results, missing data and outliers of the index tests were handled.	8
	23	Estimates of variability of diagnostic accuracy between subgroups of participants, readers or centers, if done.	10
	24	Estimates of test reproducibility, if done.	8
DISCUSSION	25	Discuss the clinical applicability of the study findings.	10&11

*Author Checklist

AUTHOR CHECKLIST ***Authors of all papers reporting clinical research should submit this checklist together with their manuscript and the Reporting Guideline Checklist found on the EQUATOR site (http://www.equator-network.org/).***

This checklist identifies recognised guidelines for scientific reporting, which authors should use to prepare their manuscript *(required for systematic reviews and original research)*

Standards of reporting	The editors require that manuscripts adhere to recognised reporting guidelines relevant to the research design used. These identify matters that should be addressed in your paper. Please indicate which guidelines you have referred to. These are not quality assessment frameworks and your study need not meet all the criteria implied in the reporting guideline to be worthy of publication in the MATH. The checklists do identify essential matters that should be considered and reported upon. For example, a controlled trial may or may not be blinded but it is important that the paper identifies whether or not participants, clinicians and outcome assessors were aware of treatment assignments. **You are also required to submit a checklist from the appropriate reporting guideline (available on the EQUATOR website (http://www.equator-network.org/) together with your paper as a guide to the editors. *Reporting guidelines endorsed by MATH are listed below:*	**Guideline referred to**	**Checklist submitted****
Randomised (and quasi-randomised) controlled trial	CONSORT – Consolidated Standards of Reporting Trials http://www.equator-network.org/reporting-guidelines/consort/		
Study of Diagnostic accuracy / assessment scale	STARD Standards for the Reporting of Diagnostic Accuracy studies http://www.equator-network.org/reporting-guidelines/stard/	*	*
Systematic Review of Controlled Trials	PRISMA - Preferred Reporting Items for Systematic Reviews and Meta-Analyses http://www.equator-network.org/reporting-guidelines/prisma/		
Observational cohort, case control and cross sectional studies	STROBE **St**rengthening the **R**eporting of **Ob**servational Studies in **E**pidemiology http://www.equator-network.org/reporting-guidelines/strobe/		
Case Reports	CARE - Case Reports - http://www.care-statement.org/downloads/CAREchecklist-English.pdf		
Statistical reporting	SAMPL - guidelines for statistical reporting – *no checklist exists currently but authors are encouraged to view the guidelines on the EQUATOR website http://www.equator-network.org/reporting-guidelines/sampl/*		
	Qualitative researchers might wish to consult the guideline listed below		
Qualitative studies	COREQ: Consolidated criteria for reporting qualitative research (http://www.equator-network.org/reporting-guidelines/coreq/)		
Other (please give source)			
Not applicable (please elaborate)			

Figure

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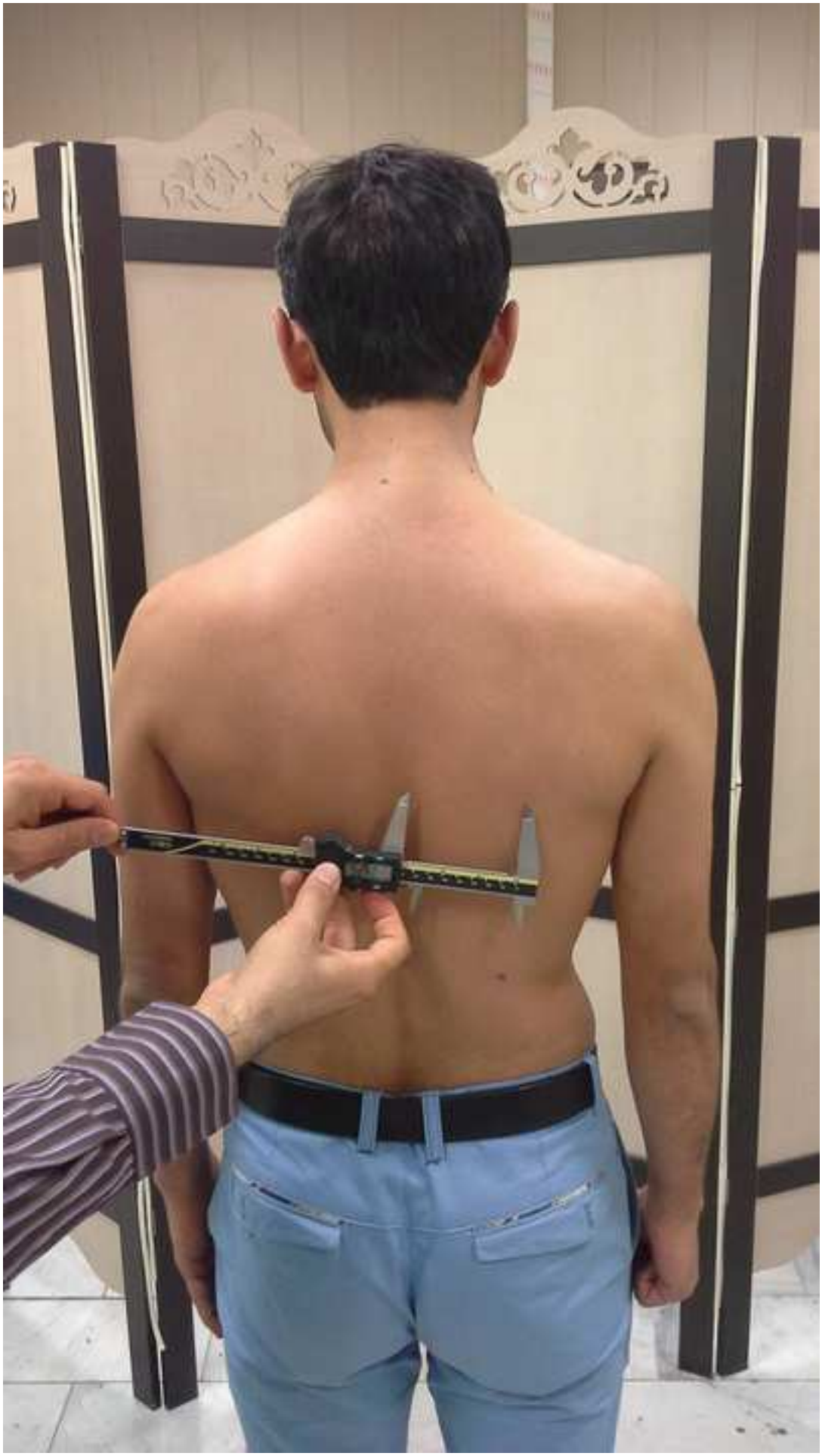

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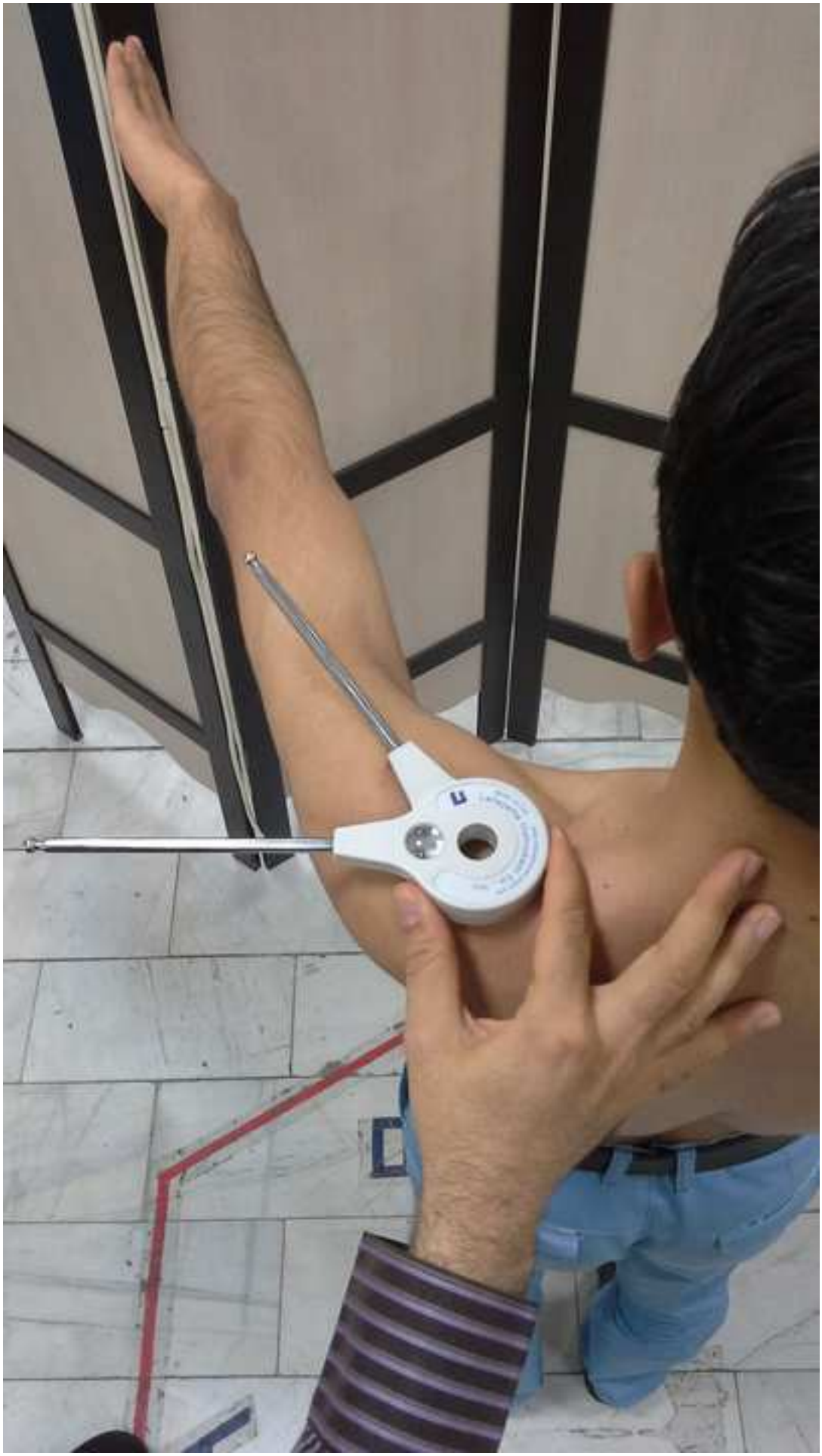

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P3	S	0.83	0.50	1.00	1.38	0.90	0.38	0.76	1.06
	AS	0.90	0.38	0.76	1.04	0.92	0.34	0.68	0.93

Abbreviations: D = dominant, ND = non dominant, S = symptomatic, AS = asymptomatic, P1 = arms by the side, P2 = hands on hips, P3 = 90 º of abduction in scaption with1 kg load, SEM = standard error of the measurement, ICC = intraclass correlation coefficient, $MDC_{95\%}$ = minimal detectable change with 95% confidence intervals

Table 4: Sensitivity, specificity, positive and negative likelihood ratios of the MLLST considering a side to side difference of 1.5 cm as threshold value to diagnose 'scapular asymmetry' (asymptomatic group, n=25; symptomatic group, n=25).

Position	Sensitivity		Specificity		Positive likelihood ratio		Negative likelihood ratio	
	Rater1	Rater2	Rater1	Rater2	Rater1	Rater2	Rater1	Rater2
P1	15%	23%	86%	95%	1.07	4.6	0.98	0.81
P2	15%	11%	86%	80%	1.07	5.5	0.98	1.11
P3	23%	30%	91%	81%	2.55	1.57	0.84	0.86

Abbreviations: P1 = arms by the side, P2 = hands on hips, P3 = 90 º of abduction in scaption with1 kg load