African Journal for Physical Ativity and Health Sciences (AJPHES), Vol. 22 (1:1), March 2016, pp. 107-117.

Assessment of scapular position in patients suffering from shoulder dysfunction

E. KORKIE, A.J. VAN ROOIJEN, A.M. MARAIS AND P.J. BECKER

Department of Physiotherapy, Faculty of Health Sciences, University of Pretoria, Pretoria, Gauteng, South Africa.
E-mail: Elzette.Korkie@up.ac.za

(Submitted: 22 January 2016; Revision accepted: 04 March 2016)

Abstract

Shoulder dysfunction inhibits 80% of competitive swimmers from performing optimally. The most common contributing factor to shoulder dysfunction is an altered scapula position. A standard for the distance between T4 and the medial border of the scapula is lacking. Measurements of the distance between T4 and the root of the scapula were made and the relationship of the distance and the function of trapezius middle fibres at resting length was tested. A Vernier caliper® (ICC 0.94) was used to measure the distance from T4 to the medial border of the scapula. Exercises and stretches to retrain and strengthen the middle fibres of the trapezius specifically were performed twice a week, scheduled around the swimmers' regular training and strengthening sessions, for six weeks. The results showed that palpation of the scapula to measure the distance between T4 and the spinal root is reliable and valid. A normalisation index should be used to adjust for body build and posture. Furthermore, the distance between the thoracic spine and the scapula did not change, regardless of the statistical improvement in the function of trapezius middle fibres ($p < 0.05$). The research results are of importance for clinical practice, evaluation and treatment programmes for physiotherapists. The data obtained from this study can serve as a baseline for further studies.

Keywords: Scapula position, shoulder dysfunction, trapezius muscle, competitive swimming.

How to cite this article:
Korkie, E., Van Rooijen, A.J., Marais, A.M. & Becker, P.J. (2016). Assessment of scapular position in patients suffering from shoulder dysfunction. *African Journal for Physical Activity and Health Sciences*, 22(1:1), 107-117.

Introduction

Shoulder function is an essential element in high-performance swimming. However, 80% of competitive swimmers suffer from some type of shoulder dysfunction during their careers (Nijs, Roussel, Struyf, Mottram & Meeusen, 2007; Sein, Walton, Linklater, Appleyard, Kirkbride, Kuah & Murrell, 2010; Riemann, Witt & Davies, 2011). The most common contributing factor to shoulder dysfunction is an altered scapula position, either resting or dynamic (Kibler & Sciascia, 2010; McClure, Greenberg, Kreha, 2012; Struyf et al., 2012b). Specialised assessment methods have been described, but are not feasible due to the expensiveness of the instruments which are often not available at all swimming schools.

Effective assessment of the scapular position must be cost-effective, clinically applicable, valid and reliable (Nijs et al., 2007). Evaluation of the resting scapula position was widely investigated, and surface palpation is a valid indicator of the scapula position (Lewis & Valentine, 2007). In clinical practice, the scapular position is evaluated by specific bony landmarks. Landmarks on the scapula must correspond to landmarks on the thoracic wall (Mottram, 1997; Nijs et al., 2007; Haneline, Cooperstein, Young & Ross, 2008; Struyf, Nijs, Mottram, Roussel, Cools & Meeusen, 2012b).

A method to determine the resting position of the scapula is to measure the distance from the thoracic spine (T4) to the medial border of the scapula. A distance less than five centimetres is indicative of a resting position of the scapula in adduction, and more than six centimetres is indicative of a resting position of the scapula in abduction (Host, 1995). Sobush, Simoneau, Dietz, Levene, Grossman and Smith (1996) first described this point of reference, and gave clinical guidelines on interpreting the results; however, this information was based on a single case report. According to Host (1995), the distance between T4 and the medial border of the scapula should be 5.08 cm. In a study conducted on 15 female students (aged 19–21), it was found that the distance between the thoracic spine and superior angle of the scapula was 8.76 cm; between the thoracic spine and root of the scapular spine it was 8.81 cm and from the thoracic spine to the inferior angle of the scapula (Nijs, Roussel, Vermeulen & Souvereyns, 2005), it was 8.72 cm (Sobush et al., 1996). No statistical difference was found between the dominant and non-dominant sides of the body ($p > 0.01$) (Sobush et al., 1996).

In another study conducted on patients who presented with shoulder pain (19 female, 10 male, aged 42–70), it was reported that the distance between the medial border of the scapula and T4 varied between symptomatic subjects (6.15 cm) and asymptomatic subjects (6 cm) (Nijs et.al., 2005). The intra- and inter-tester reliability of this test was good (0.64–0.86) (Sobush et al., 1996) and (0.7-0-0.9) (Nijs et al., 2005).

Consensus is lacking on the ideal distance between the thoracic spine and the medial border (Host, 1995:105; Sobush et al., 1996:44; Nijs et al., 2005). Nijs et al. (2005) demonstrated the inability of this test to differentiate between the symptomatic and asymptomatic side. The aims and clinical interpretations of this test are not clear. If the aim was to determine symmetry of the scapula positioning, the interpretation of the test is straightforward: the left side should be equal to the right side. If the aim was to determine whether the scapula is in adduction or abduction the clinical interpretation is not straightforward (Sobush et al., 1996). Consistency on the ideal distance between T4 and the medial border of the scapula is lacking (Host, 1995; Sobush et al., 1996; Nijs et al., 2005). This inconsistency makes the clinical applicability of this test untrustworthy.

Guidelines for a reliable and valid assessment of scapular position in patients suffering from painful shoulder dysfunction were lacking. In a comparative longitudinal design study conducted on competitive swimmers, data were obtained regarding the distance between T4 and the root of the scapula. The first aim of this article is to report on the measurements of the distance between T4 and the root of the scapula. The second aim is to report on the relationship of the distance between these and the function of trapezius middle fibres at resting length.

Methodology

A comparative parallel group longitudinal design was used. Two similar available groups of swimmers were included in the study. The effect of the intervention was evaluated on both groups and a comparison was executed compared over time (Brink, 2006). The study was conducted at the TuksSwim Club of the University of Pretoria.

Sampling

Swimmers (Table 2) were included if they were ranked according to SwimSA (level 2 to senior national level), aged between 13 and 23 years, and trained more than six hours per week. Swimmers were excluded if they had any respiratory infection at the time of evaluation, had any previous fractures of the shoulder girdle and if they participated in any other sport that is played with the arms above the head.

TuksSwim Club swimmers are coached by four different coaches. The swimmers of coach A and C were allocated to the intervention group. Swimmers in coaches B and D were in the control group.

Ethics approval

The Faculty of Health Sciences Research and Ethical Committee University of Pretoria (no. 163/2012) approved the research. The project was also registered at the National Department of Health (DOH.-27-0913-4521). Informed consent was obtained from swimmers 18 years and older. Swimmers younger than 18 year gave assent and were only included once their parents / guardians had given written consent. Participants who gave consent and who assented were requested to complete a personal information questionnaire

Data collection

Swimmers were contacted and the baseline and follow-up evaluations took place in the afternoons before training sessions. The evaluations were conducted before intervention, after six weeks and at the end of the swim season (five months after the intervention had started).

Throughout the study, swimmers were dressed in swimsuits. The swimmers stood with their feet hip-width apart and parallel to assure a uniform starting position. They were instructed to stand at ease (Lewis, Green, Reichard & Wright, 2002). The following anatomical landmarks were marked with a skin pencil:

- the spinous processes of following thoracic vertebrae: second (T2), third (T3), fourth (T4);
- the superior angle of the scapula and the root of the spine of the scapula.

The distance from T4 to the medial border of the scapula was measured with a Vernier caliper® (INSIZE CO., LTD, 300 mm) (Host, 1995; Sobush et al., 1996; Nijs et al., 2005; Lewis & Valentine, 2007). The testing procedure of the middle fibres of the trapezius involved a combination of muscle tests. The agonistic function of the muscle (scapula retraction) was evaluated against gravity (Kendall, McCreary, Provance, Rodgers & Romani, 2005). The quality of the muscle contraction was also evaluated.

The ability to contract the muscle through the available range of scapula retraction, to hold the inner range position without any substitution and the ability to breathe relaxed while contracting the muscle, were also tested (Comerford & Mottram, 2001; Magarey & Jones, 2003; Cuthbert & Goodheart, 2007). This combination of agonistic muscle action and the muscle's ability to contract without substitutions gives a true indication of the quality of the muscle's function. Refer to Table 1 for the validity and reliability of the measurement tools.

Table 1: The validity and reliability of the measurement tools

Measurement tool	Aim of instrument	Studies to confirm reliability and validity
Vernier calliper® (300mm) INSIZE CO., LTD	To measure the length of the pectoralis minor from the origin to the insertion.	ICC 0.94 (Borstad, 2008; Lewis and Valentine, 2007).
Measurement tape	To measure lateral costal thoracic expansion during inspiration.	Reliability ICC 0.99 (Bockenhauer et. al. 2007)
Evaluation of manual muscle strength	To evaluate the muscle's ability to perform the agonistic function effectively.	Validity ($p < 0.001$) and reliability of 0.90 (Spearman's rank correlation) were confirmed by Rider et. al. (2010).
Evaluation of the resting scapula through skin surface palpation	To evaluate the resting position of the scapula on the thoracic wall.	Validity ($p < 0.005$) was confirmed by Lewis, et al., (2002) with a reliability of ICC 0.88 by T'jonck & Lysens, (1996).
Visual evaluation of dynamic scapular position	To evaluate the position of the scapula during gleno-humeral flexion	Validity ($p < 0.001$) was confirmed by McClure et al. (2009a) with a reliability of a kappa of 0.85 (McClure et al. 2009b).

Measurements

The swimmer was positioned prone with the gleno-humeral joint in 90° of abduction, elbows flexed and thumbs pointing forward. If the scapula was not in the ideal plane (15°–30°) from the frontal plane into the sagittal plane, a towel was placed under the shoulder girdle to ensure ideal alignment for the scapula (Nijs et al., 2007; Struyf et al., 2012). The passive range of scapula adduction was evaluated by placing one hand under the shoulder joint and the other hand on the scapula and passively moving the scapula into adduction (ideal range for scapular retraction is less than five centimetres between the medial border of the scapula and the spine). The swimmer was instructed to do scapular retraction actively. Ideally the active range should be equal to the passive range. The swimmer was guided through the test movement to familiarise him or her with the test. After the assisted movement, the swimmer was allowed to practice the test movement once before the test commenced.

For the test, the swimmer performed this action twice, doing scapular retraction through the full range of motion and holding the inner range of contraction for fifteen seconds. The researchers observed for the following possible substitutions: scapular elevation or retraction (movement of the inferior angle or superior-medial corner superiorly), scapular downward rotation (movement of the acromion inferiorly), gleno-humeral horizontal abduction (gleno-humeral instead of scapular movement), gleno-humeral adduction and thoracic extension.

Intervention

The aim of the exercises was to retrain and strengthen the middle fibres of the trapezius specifically (Cools, Dewitte & Lanszweert, 2007; Oyama, Myers, Wassinger & Lephart 2010; Lynch, Thigpen, Mihalik, Prentice & Padua, 2010; De Mey, Danneels, Cagnie & Cools, 2012). The exercises aimed at the retraining of motor control, strengthening of the concentric inner range hold of the muscle and eccentric control. Strengthening and endurance of the serratus anterior and the trapezius middle and lower fibres. The stretch of the pectoralis minor aimed to increase flexibility of the muscle.

Exercises and stretches were performed twice a week, scheduled around the swimmers' regular training and strengthening sessions, for six weeks. The intervention and control groups followed the same programme for the retraining of the scapular muscles (Cools et al., 2007; Struyf et al., 2012b) and the stretching of the pectoralis minor muscle (Lynch et al., 2010).

Statistical analysis

Data summary included descriptive statistics i:e. mean, standard deviation, median, range and 95% confidence intervals by treatment group over time. Treatment groups were also assessed with respect to the observed longitudinal data making use of ANCOVA and mixed model analysis. Testing was done at the 0.05 level of significance.

Results

At baseline, 67 swimmers were evaluated. At six weeks, 58 swimmers were tested and at five months, 48 swimmers were evaluated. The reasons for the drop-outs were: six swimmers withdrew, four swimmers changed to another swim school, three were injured at the specific evaluation times and one participated at the time of evaluation in a race and five swimmers moved. The distances between female and male swimmers are displayed in Table 2.

Table 2: Distance between T4 and the root of the scapula

	Female					**Male**				
	N	**Left mean**	**SD**	**Right mean**	**SD**	**N**	**Left mean**	**SD**	**Right mean**	**SD**
Baseline	33	8.4	1.33	8.5	1.57	34	8.6	1.83	9.1	1.73
6 weeks	28	9.2	1.90	8.9	1.64	28	8.7	1.59	8.7	1.27
5 months	22	8.6	1.51	8.4	1.30	26	8.6	1.72	8.9	1.56

*Measurement done in centimetres

The results of the trapezius middle fibres muscle test (baseline to 6 weeks and baseline to 5 months) can be viewed in Table 3.

Table 3: The results of the middle fibres of the trapezius functional muscle test (baseline to 6 weeks and baseline to 5 months).

The trapezius middle fibres (McNemar test)					
Group	**Side**	**Status quo**	**Deteriorate**	**Improve**	**P value**
Eccentric control					
Baseline to 6	Left	23/57	3/57	31/57	0.0000
weeks	Right	23/57	3/57	31/57	0.0000
Baseline to 5	Left	29/48	3/48	16/48	0.0114
months	Right	29/48	3/48	16/48	0.0114
Muscle function test can be performed without proximal fixation of the shoulder girdle / trunk					
Baseline to 6	Left	36/57	1/57	20/57	0.0001
weeks	Right	35/57	2/57	20/57	0.0005
Baseline to 5	Left	19/48	1/48	28/48	0.0000
months	Right	17/48	1/48	28/48	0.0000
Muscle can contract actively to meet the same range as passively tested (medial border of scapula 5cm from thoracic spine)					
Baseline to 6	Left	36/57	1/57	20/57	0.0002
weeks	Right	32/57	3/57	22/57	0.0007
Baseline to 5	Left	11/48	0/48	37/48	0.0000
months	Right	8/48	0/48	39/48	0.0000
Swimmer can hold inner range position for 15 seconds (2 repetitions)					
Baseline to 6	Left	35/57	1/57	21/57	0.0001
weeks	Right	34/57	2/57	21/57	0.0004
Baseline to 5	Left	22/48	1/48	24/48	0.0001
months	Right	22/48	1/48	24/48	0.0000
Swimmer can perform test without fatigue					
Baseline to 6	Left	35/57	1/57	21/57	0.0001
weeks	Right	34/57	2/57	21/57	0.0002
Baseline to 5	Left	29/48	2/48	17/48	0.0024
months	Right	30/48	2/48	16/48	0.0040
Swimmer can perform test with relaxed breathing					
Baseline to 6	Left	30/57	1/57	25/57	0.0000
weeks	Right	29/57	2/57	26/57	0.0000
Baseline to 5	Left	31/48	2/48	15/48	0.0063
months	Right	32/48	2/48	14/48	0.0103

These results were derived using McNemar's test for symmetry (Dawson & Trapp, 1994). Symmetric change from baseline is interpreted as a random event. When the change is directional, it is indicative of a non-random movement (Dawson & Trapp, 1994). However, if a symmetrical change occurs the results are void (Dawson & Trapp, 1994). A statistical significance ($p < 0.05$) denotes asymmetry and therefore a directional movement from one period to another (Dawson & Trapp, 1994).

Discussion

The first aim of the study on which this article was based, was to report on the distance between T4 and the root of the scapula in South African competitive swimmers. The mean distance between the swimmers' T4 and the root of the scapula was more than 8 cm on the left and right sides (Table 2). These data correlate with data obtained by Sobush and colleagues (1996) on female students of the same age. The current data however, do not correlate with data those obtained from patients complaining of shoulder pain (Nijs et al., 2005). Several reasons could explain the discrepancy in the data.The first reason could be attributed the measurement markers used in these studies. Some authors measured the distance between the medial border of the scapula and the thoracic spine with no specific landmark on the scapula (Host, 1995; Nijs et al., 2005). Another measured the distance between the root of the scapula and the midline of the thoracic spine (Sobush et al., 1996). In the current study, both markers of the measurement were specific: T4 and the root of the scapula. Surface palpation of the scapula had been proved to be reliable and valid (Lewis et al., 2002). The second reason could relate to the physical status and posture of the subjects. The possibility that female students (Sobush et al., 1996) may differ in body build and posture from patients reported in previous research (aged 42–70) (Nijs et al., 2005). is possible. The third reason could be accounted for by the age and activity levels of the subjects.

Another important aspect to keep in mind is the aim of the tests. Is the test done to determine whether the scapulae are symmetrical or is the test done to determine whether the scapulae are in abduction? If the test is done to determine symmetry, left should be equal to right regardless of a specific distance. If the test is done to determine whether the scapula is in abduction and a specific measurement indicates abduction or adduction, some normalisation index is necessary. In the current study, the height of the swimmers ranged from 1.5 to 2.05 m and the weight ranged from 42 to 87 kg, indicating a variety of body build. A 'standard' distance of 5.08 cm (Host, 1995), 6 cm (Nijs et al., 2005) or 8.82 (Sobush et al., 1996) cannot be clinically applicable, because the distance must be normalised to adjust for age, body build and posture, and this requires further research. The second aim of the current study was to report on the relationship between the resting length of the trapezius middle fibres and the distance between T4 and the root of the scapula. In the current study, all the swimmers were part of a six-week intervention programme where specific muscle retraining and strengthening exercises were done. The emphases of the exercises were to retrain motor control and quality activation of the specific muscle (Cools et al., 2007; Oyama et al., 2010; Lynch et al., 2010; De Mey, Danneels, Cagnie, & Cools,. 2012). Concentric activation, inner range hold (for 15 seconds) and eccentric control were carefully monitored. The present results showed a statistical improvement over six weeks as well as five months in the quality of function of the trapezius middle fibres. A specific aspect of the muscle activation to be highlighted is the ability of the trapezius middle fibres to adduct the scapula to such an extent that the medial border of the scapula is within 5 cm from the thoracic midline (p-value < 0.01) (Table 3). This indicates that the trapezius middle fibres can perform their agonistic function. Effective muscle contraction is dependent on the ideal length–tension relationship (Levangie & Norkin, 2001). A muscle contracts optimally when the length–tension relationship within a sarcomere is ideal. In this ideal relationship, the action and myosin filaments overlap barely, cross-bridges are formed and the filaments can glide along the entire length of the filament generating tension, and these result in a contracted muscle fibre (Marieb, 2004). It can then be argued that if the trapezius middle fibres contract effectively, without any compensatory or trick movements and relaxed breathing the muscle is in an ideal length to generate enough tension to perform its agonistic function. In this study, the distance between the thoracic spine and the root of the scapula was 8.4 cm–9.2 cm. These results are applicable to competitive swimmers aged 13–23 years.

Conclusion

The painful shoulder of a competitive swimmer is costly in terms of training time endurance and taking part in competitions. Assessment techniques must be cost-effective, clinically applicable, reliable and valid to provide optimum patient care. The current study showed that palpation of the scapula as a technique to measure the distance between T4 and the spinal root is reliable and valid. It was also shown that when the measurement is used to determine the scapula position, a normalisation index must be used to adjust for body build and posture. Furthermore, the distance between the thoracic spine and the scapula does not change regardless of the statistical improvement in the function of the trapezius middle fibres. The research results are of importance for clinical practice, evaluation and rehabilitation programmes for physiotherapists. The data obtained from this study can serve as a baseline for further studies.

Acknowledgements

We want to thank the TuksSwim Club for allowing is to use their facilities. The swimmers who participated in this study contributed to our study. Thank you to Ms Marlize Cochrane who helped with the data collection.

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