Journal of Bodywork & Movement Therapies xxx (2016) 1–4

Contents lists available at ScienceDirect

Journal of Bodywork & Movement Therapies

journal homepage: www.elsevier.com/jbmt

Scapular dyskinesis among competitive swimmers

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ARTICLE INFO

Article history:
Received 18 July 2016
Received in revised form
19 November 2016
Accepted 23 November 2016

Keywords:
Shoulder pain
Scapular dyskinesis
Swimmers
Shoulder evaluation

ABSTRACT

Aim: To evaluate the prevalence of scapular dyskinesis (SD) in competitive swimmers during training sessions.
Methods: Repeated measurement observational study.20 young competitive swimmers were filmed before, at midpoint and at the end of a training session, performing shoulder flexion and abduction. SD was examined separately by two assessors. Demographic and Quick Disabilities of the Arm, Shoulder, and Hand questionnaires were collected.
Results: SD was observed in 30% of the swimmers before training, in 70%, an hour later, and in 80%, upon completion of the training session. The difference between the baseline and mid-practice was close to significance (p-value = 0.055), and between mid-practice and end of practice was significant (p = 0.004).
Conclusions: This study confirmed that the prevalence of SD increases throughout a training session in most swimmers. The main reason might be fatigue of the muscles which stabilize the scapula, therefore, when examining a sportsmen's shoulder, it is important to examine the SD post-training or following simulation of the training session in the clinic.

1. Introduction

Individuals who intensively and repetitively work with their upper extremities (swimmers, tennis players, gymnasts, etc. and manual laborers such as hairdressers, painters, etc.) frequently suffer from shoulder pain, impingement syndrome or rotator cuff tears. In swimmers, supraspinatus tendinopathy is the most common cause of shoulder pain (Heinlein and Cosgarea, 2010). Rotator cuff tears can cause pain inhibition followed by a decrease in muscle activation (Falla et al., 2007).

Among patients suffering from rotator cuff pathologies, 68% were observed with scapular dyskinesis (Warner et al., 1992). It is as yet unknown as to whether dyskinesis is a cause, effect or compensation for rotator cuff pathology (Kibler et al., 2013).

Prevalence of shoulder pain in swimmers can range between 40% and 91% depending on age, swimming style, perception of pain, changes in the training volume during the year, etc. (Madsen et al. (2011); McKenna et al., 2012). Heinlein and Cosgarea (2010) and Johnson et al. (2003) describe in detail shoulder biomechanics during glide (catch), pull through and recovery phases of swimming. In the glide phase, when the forward hand enters the water, the upper trapezius elevates the shoulder, then protraction and upward rotation occurs due to the serratus anterior with retraction ensuing due to the rhomboids. These muscles hold and stabilize the scapula in place. The pull through phase occurs due to the latissimus dorsi, subscapulris and pectoralis major muscles that adduct, extend and internally rotate the humerus while the teres minor externally rotates it. In the recovery phase, the deltoid and supraspinatus are the main active muscles. The most prominent pathology is the weakness of the serratus anterior and the increased activity of the rhomboids during the pull through phase, resulting in a winging scapula and impingement of the biceps and supraspinatus tendons (Pink et al., 1991).

The alteration of normal kinematics of the shoulder is called scapular dyskinesis (Kibler et al., 2009), which is associated with shoulder pain and pathology (Kibler and McMullen, 2003). Various causes of scapular dyskinesis include bony posture or injury, joint instability or internal derangement, neurological and soft tissue alterations associated with inflexibility (Kibler et al., 2013). Scapular dyskinesis results in a winging or dysrhythmia of the scapula.

A winging scapula is defined as a prominence of the medial border or anterior tilt of the scapula (Kibler et al., 2013) which can be seen when there is a weakness or delayed activation of the

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http://dx.doi.org/10.1016/j.jbmt.2016.11.011
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serratus anterior or the lower trapezius muscles (Kibler, 1998; Kibler et al., 2013). An anterior tilt with protraction can be caused by a short pectoralis minor and a short head of the biceps brachii (Borstad and Ludewig, 2005).

Dysrhythmia is defined as the presence of one or more of the three following conditions: 1) a not smooth and continuous movement; 2) an excessive or premature elevation or protraction during elevation or lowering of the arms; 3) an excessively early downward rotation when lowering the arms (Kibler et al., 2013; McClure et al. (2009)).

Kibler et al. (2002) described three types of dyskinesis based on the three axes of scapular motion on the thorax (McClure et al., 2001; McQuade et al., 1998). The first type of dyskinesis is a prominence of the inferior medial border of the scapula occurring when the scapula abnormally rotates around the transverse axis. The second type is a prominence of the entire medial border occurring when the scapula abnormally rotates around the vertical axis. The third type is a prominence of the superior medial border.

Because sportsmen and manual laborers are usually physically fit, a regular examination in the clinic often does not detect scapular dyskinesis. However, as shown by Madsen et al.'s research (Madsen et al., 2011), dyskinesis in swimmers on occasion does not appear at the beginning of their workout, but at midpoint or even later. Madsen et al., 2011 in the only study on swimmers found dyskinesis in 82% of competitive pain-free swimmers at the end of their training session.

In competitive swimmers, muscle fatigue can occur due to repetitive overhead activity. On average, a competitive swimmer completes 8–10 strokes per 25 m, swims 60,000–80,000 m per week with each shoulder rotating 30,000 times a week (Heinlein and Cosgarea, 2010). Muscle fatigue can cause a decrease in muscle strength and balance resulting in uncontrolled scapular movements (McQuade et al., 1998). Dyskinesis can result in different injuries and dysfunctions, particularly shoulder impingement, which can occur if there is excessive protraction (Ludewig and Cook, 2000; Lukasiewicz et al., 1999). Detection of such late dyskinesis may be important in prevention and treatment of shoulder pain and injuries in athletes and manual laborers.

Our aim was to evaluate the prevalence of scapular dyskinesis in competitive swimmers found during their training sessions. We hypothesized that as the training session progresses, scapular dyskinesis will occur.

2. Methods

2.1. Design

Repeated measurement observational study.

2.2. Sample

Convenience sample of 20 competitive swimmers (of all strokes and distances) was recruited.

Inclusion criteria: at least six training sessions a week, minimum of 1½ hours per training session.

Exclusion criteria: None.

The study was observational, with no intervention and was approved by the swimmers' coach. All participants received an explanation of the aims and procedures of the study and signed an informed consent form. The study was approved by the Institutional Review Board (IRB) of the Recanati School for Community Health Professions, Faculty of Health Sciences, Ben-Gurion University of the Negev.

2.3. Setting

The study was conducted at “Ganey Omer” and “Cafri Omer” swimming pools, Omer, Israel.

2.4. Instrumentation and procedures

A digital video camera was used to record the tests. The distance between participant and camera varied to allow clear depiction of shoulder blades as well as waist, head and elbows (McClure et al., 2009). The observation method has good validity and interrater reliability as shown in previous studies (McClure et al., 2009; Tate et al., 2009).

This study was based on Madsen et al.'s study (Madsen et al., 2011). All participants were asked to fill out a demographic questionnaire. Data on upper limb symptoms (health-related quality of life) were evaluated using the Quick Disabilities of the Arm, Shoulder and Hand questionnaire (Quick DASH) including the optional sports module, which has been found to be valid for detecting upper limb disability. The Quick DASH, reliable in English, (Mintken et al., 2009), was adapted to Hebrew (Ziv, 2006). Shoulder pain experienced during the previous week's training sessions were also collected via the visual analogic scale (VAS).

Swimmers were evaluated while wearing their swimsuits, but the scapular region was clearly seen at the time of examination and on the tape. The test was conducted three times: the first evaluation was performed before the beginning of the training session; the second, after 60 min; and the last one at the end of the session (at a consistent time of one and a half hours). The testers performed full range arm flexion and abduction (in the forearm mid-position). The athletes were asked to perform three repetitions of each movement while videotaped from the back.

2.5. Outcome measures

The main outcome measure of this study was the prevalence of scapular dyskinesis at three time intervals during the training session. If scapular winging or dysrhythmia was seen unilaterally or bilaterally, the test was defined as “positive”, meaning that the swimmer had exhibited signs of scapular dyskinesis. If not, it was defined as “negative” normal scapular kinematics. Two assessors, both senior year physical therapy students from Ben Gurion University were trained to evaluate scapular dyskinesis by observing videotaped examples of normal and abnormal scapular movement (McClure et al., 2009). Assessors separately observed the video records and categorized the scapular dyskinesis as present or absent. If the two assessors agreed, then dyskinesis of the scapula was diagnosed. When a disagreement arose, the outcome was resolved after repeated evaluation and discussion. Agreement between raters after first independent evaluation of tapes was 65% (39 cases), 21 (35%) cases were reevaluated separately and an agreement was reached on another 9 (15%) cases, the rest 12 (20%) cases required additional reevaluation and discussion.

2.6. Statistical analysis

All statistical analyses were performed using the SPSS 17.0 for Windows (SPSS, Chicago, IL, USA). Statistical analyses were conducted at a 95% confidence level. A p-value < 0.05 was considered significant.

Descriptive statistics were used to characterize the sample. Shoulder dyskinesis was presented as prevalence. The chi-square test was used to compare the prevalence of shoulder dyskinesis between baseline and mid-practice evaluations.

Shapiro-Wilk tests were used to test VAS, Quick-DASH and

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Table 1
Descriptive statistics of swimmers (N = 20).

Variables	Mean ± SD	Minimum-Maximum
Age (years)	15.35 ± 2.23	12–20
Weight (kg)	63.35 ± 9.94	43–81
Height (m)	1.70 ± 0.11	1.51–1.87
BMI (kg/m^2)	21.83 ± 2.06	17.11–24.65
	N (%)	
Sex (females)	6 (30.00%)	
Previous shoulder trauma	3 (15.00%)	
Right hand dominance	16 (85.00%)	
Subjects with shoulder pain during training	11 (55%)	

SD = Standard deviation, BMI = Body mass index.

Table 2
Dyskinesis of scapula during training.

Time of evaluation	Dyskinesis (N %)
Baseline	6 (30%)
Mid-practice (after 1 h)	14 (70%)
End of practice (after 1.5 h)	17 (85%)
Comparison baseline vs mid-practice	$\chi^2 = 3.67$, p = 0.055
Comparison baseline vs end of practice	$\chi^2 = 1.51$, p = 0.219
Comparison mid-practice vs end of practice	$\chi^2 = 8.24$, p = 0.004

Quick-DASH sport for normality. Because the tests showed that data in not normally distributed we used the one-way Kruskal-Wallis test to compare the pain (VAS shoulder pain during training) and health-related quality of life measures (Quick-DASH and Quick-DASH sport) in subjects with and without dyskinesis at different stages of training.

3. Results

The descriptive statistics of the swimmers are shown in Table 1. The average age of the swimmers was 15.35 ± 2.23. Six females and 14 males participated in the study; 15% reported a previous injury and 55% reported pain during the training.

The prevalence of dyskinesis in swimmers is shown in Table 2. Scapular dyskinesis was observed in 30% of the swimmers before beginning training (baseline); in 70% of the swimmers an hour after beginning the practice (mid-point) and in 80% an hour and a half after beginning the practice (end of practice). The difference between the baseline and mid-point was not significant (p = 0.055), but may imply a tendency, thus necessitating deliberation in future studies. The difference between the baseline and end of practice was non-significant (p = 0.219), and the difference between the mid-point and end of practice was statistically significant (p = 0.004).

Out of three subjects that had a history of shoulder pain (no one had fracture or dislocation), two had no dyskinesis at baseline examination. All six subject that had scapular dyskinesis at baseline evaluation, showed it at following evaluations, and all 14 subjects that showed dyskinesis at mid-point evaluation, had it at end of practice.

The comparison of pain and quality of life measures in subjects with and without dyskinesis at different stages of training is shown in Table 3. There was no significant difference in the pain and the quick DASH score between athletes with or without scapular dyskinesis at any training stage. Subjects with scapular dyskinesis at mid-pint had significantly higher values (p = 0.017) on the quick DASH sport module than subjects without dyskinesis.

4. Discussion

This study examined 20 competitive swimmers before, during and at the end of a training session in order to evaluate the increase in prevalence of scapular dyskinesis throughout the progression of a single practice session. We found that scapular dyskinesis has a tendency to appear after one hour of training. In addition, significant association was found between the quick-DASH sports questionnaire and scapular dyskinesis at mid-practice, which may imply a relationship between scapular dyskinesis and shoulder disability during overhead sport activities.

Park et al. (2014) also observed 84% of scapular dyskinesis among swimmers. The differences in the results can be explained by Park et al.'s use of weights adjusted by body weight. In our study weights were not used. Weights increase the load and challenge the stabilizing muscles of the shoulder girdle and thus may cause more visible dyskinesis. In addition, in Park et al.'s study, the assessors observed 10 repetitions, while we observed only three. More repetitions increase the chances of noting scapular dyskinesis. McClure et al., 2009 referred to subtle dyskinesis as another possible outcome which can decrease the amount of absolute positive scapular dyskinesis relative to our study.

Our study was based on Madsen et al.'s research (Madsen et al., 2011) who demonstrated the development of scapular dyskinesis during a training session among pain-free competitive swimmers. In contrast, our study included three swimmers who had previously suffered from shoulder pain or other injuries, in order to explore its influence on scapular dyskinesis. Surprisingly, we did not find any significant difference in pain levels between swimmers with or without scapular dyskinesis. Muscle fatigue due to repetitive overhead activity might be the main reason for the dyskinesis.

Scapular dyskinesis can cause overload on the different structures of the shoulder (Bak and Fauno, 1997; Sein et al., 2010). The lack of correlation between pain and presence of scapular dyskinesis may be explained by the fact that the dyskinesis is not permanent and can disappear after training sessions thus affecting the shoulder structure only during training. Another explanation is that pain may develop four to eight years later, as shown in previous studies (Bak and Fauno, 1997; McMaster and Troup, 1993; Rupp et al., 1995).

Study limitations: The dyskinesis was classified only as positive or negative. Subtle dyskinesis was defined as positive, which may demonstrate more positive outcomes compared to McClure's study

Table 3
Comparison of pain and quality of life measures in subjects with and without dyskinesis at different stages of training.

Dyskinesis		VAS shoulder pain during training			Quick-DASH			Quick-DASH Sport		
		N	Mean ± SD	Comparison[a]	N	Mean ± SD	Comparison[a]	N	Mean ± SD	Comparison[a]
Baseline	No	14	1.43 ± 1.83	$\chi^2 = 2.956$, p = 0.086	14	7.84 ± 6.65	$\chi^2 = 0.045$, p = 0.832	13	6.25 ± 8.07	$\chi^2 = 1.440$, p = 0.230
	Yes	6	2.00 ± 1.90		6	7.58 ± 4.69		5	16.25 ± 20.06	
Mid-practice	No	6	1.83 ± 1.94	$\chi^2 = 1.722$, p = 0.189	6	4.93 ± 3.35	$\chi^2 = 1.722$, p = 0.189	6	1.04 ± 2.55	**$\chi^2 = 5.660$, p = 0.017**
	Yes	14	1.50 ± 1.83		14	8.98 ± 6.56		12	13.02 ± 13.97	
End of practice	No	3	2.00 ± 1.00	$\chi^2 = 0.273$, p = 0.601	3	3.79 ± 4.73	$\chi^2 = 1.562$, p = 0.211	3	2.08 ± 3.61	$\chi^2 = 1.274$, p = 0.219
	Yes	17	1.53 ± 1.94		17	8.46 ± 6.04		15	10.42 ± 13.50	

[a] Results of one-way Kruskal-Wallis test. Statistically significant (p < 0.05) differences marked in bold.

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(McClure et al., 2009). In addition, we did not differentiate between the dominant and non-dominant side of the scapular dyskinesis.

We employed only an observational dyskinesis test without an electromyographic or 3D motion analysis which reduced the examination's validity. The type of training session might also have influenced the outcomes because the swimming practice may have only focused on the technique or may have consisted of long or short distance swimming sets. In our study, we asked the swimmers to identify their average level of general pain experienced during swimming training sessions, not that specific training session.

5. Conclusions

This study demonstrated that in most of the swimmers, scapular dyskinesis increases as a swimming session progresses regardless of pain levels. The main cause for this increase may be the fatigue of the stabilizer muscles of the scapula; therefore, a standard examination in the clinic will not detect scapular dyskinesis. The scapula should be examined during and after the training session or while imitating the training conditions in the clinic.

Further studies are needed in order to fully understand the reasons and consequences of scapular dyskinesis during training and its relationship to pain and injury. We also recommend the development of a shoulder pain prevention program for swimmers and an investigation of its effectiveness.

Financial support

None.

Conflict of interest statement

There were no funding or financial benefits to the authors. This paper has not been presented in the past in any form. No conflicts of interest have been reported by the authors or by any individuals in control of the content of this article.

Ethical approval

The study was approved by Institutional Review Board (IRB) of the Recanati School for Community Health Professions, Faculty of Health Sciences, Ben-Gurion University of the Negev.

Author disclosures

No commercial party having a direct financial interest in the results of the research supporting this article has or will confer a benefit upon the authors or upon any organization with which the authors are associated.

Acknowledgments

The authors thank Mrs Phyllis Curchack Kornspan for her editorial services.

References

Bak, K., Fauno, P., 1997. Clinical findings in competitive swimmers with shoulder pain. Am. J. Sports Med. 25 (2), 254–260.
Borstad, J.D., Ludewig, P.M., 2005. The effect of long versus short pectoralis minor resting length on scapular kinematics in healthy individuals. J. Orthop. Sports Phys. Ther. 35 (4), 227–238.
Falla, D., Farina, D., Graven-Nielsen, T., 2007. Experimental muscle pain results in reorganization of coordination among trapezius muscle subdivisions during repetitive shoulder flexion. Exp. Brain Res. 178 (3), 385–393.
Heinlein, S.A., Cosgarea, A.J., 2010. Biomechanical Considerations in the Competitive Swimmer's Shoulder. Sports Health, United States, pp. 519–525.
Johnson, J.N., Gauvin, J., Fredericson, M., 2003. Swimming biomechanics and injury prevention: new stroke techniques and medical considerations. Phys. Sports Med. 31 (1), 41–46.
Kibler, W.B., 1998. The role of the scapula in athletic shoulder function. Am. J. Sports Med. 26 (2), 325–337.
Kibler, W.B., Ludewig, P.M., McClure, P., Uhl, T.L., Sciascia, A., 2009. Scapular summit 2009: introduction. July 16, 2009, Lexington, Kentucky. J. Orthop. Sports Phys. Ther. 39 (11), A1–a13.
Kibler, W.B., Ludewig, P.M., McClure, P.W., Michener, L.A., Bak, K., Sciascia, A.D., 2013. Clinical implications of scapular dyskinesis in shoulder injury: the 2013 consensus statement from the 'Scapular Summit'. Br. J. Sports Med. 47 (14), 877–885.
Kibler, W.B., McMullen, J., 2003. Scapular dyskinesis and its relation to shoulder pain. J. Am. Acad. Orthop. Surg. 11 (2), 142–151.
Kibler, W.B., Uhl, T.L., Maddux, J.W., Brooks, P.V., Zeller, B., McMullen, J., 2002. Qualitative clinical evaluation of scapular dysfunction: a reliability study. J. Shoulder Elb. Surg. Am. Shoulder Elb. Surg. [et al] 11 (6), 550–556.
Ludewig, P.M., Cook, T.M., 2000. Alterations in shoulder kinematics and associated muscle activity in people with symptoms of shoulder impingement. Phys. Ther. 80 (3), 276–291.
Lukasiewicz, A.C., McClure, P., Michener, L., Pratt, N., Sennett, B., 1999. Comparison of 3-dimensional scapular position and orientation between subjects with and without shoulder impingement. J. Orthop. Sports Phys. Ther. 29 (10), 574–583 discussion 584–576.
Madsen, P.H., Bak, K., Jensen, S., Welter, U., 2011. Training induces scapular dyskinesis in pain-free competitive swimmers: a reliability and observational study. Clin. J. Sport Med. Off. J. Can. Acad. Sport Med. 21 (2), 109–113.
McClure, P., Tate, A.R., Kareha, S., Irwin, D., Zlupko, E., 2009. A clinical method for identifying scapular diskinesis, part 1: reliability. J. Athl. Train. 44 (2), 160–164.
McClure, P.W., Michener, L.A., Sennett, B.J., Karduna, A.R., 2001. Direct 3-dimensional measurement of scapular kinematics during dynamic movements in vivo. J. Shoulder Elb. Surg. 10 (3), 269–277.
McKenna, L., Straker, L., Smith, A., 2012. Can scapular and humeral head position predict shoulder pain in adolescent swimmers and non-swimmers? J. Sports Sci. 30 (16), 1767–1776.
McMaster, W.C., Troup, J., 1993. A survey of interfering shoulder pain in United States competitive swimmers. Am. J. Sports Med. 21 (1), 67–70.
McQuade, K.J., Dawson, J., Smidt, G.L., 1998. Scapulothoracic muscle fatigue associated with alterations in scapulohumeral rhythm kinematics during maximum resistive shoulder elevation. J. Orthop. Sports Phys. Ther. 28 (2), 74–80.
Mintken, P.E., Glynn, P., Cleland, J.A., 2009. Psychometric properties of the shortened disabilities of the arm, shoulder, and hand questionnaire (QuickDASH) and numeric pain rating scale in patients with shoulder pain. J. Shoulder Elb. Surg. Am. Shoulder Elb. Surg. [et al]. U. S. 920–926.
Park, J.Y., Hwang, J.T., Oh, K.S., Kim, S.J., Kim, N.R., Cha, M.J., 2014. Revisit to scapular dyskinesis: three-dimensional wing computed tomography in prone position. J. Shoulder Elb. Surg. Am. Shoulder Elb. Surg. [et al] 23 (6), 821–828.
Pink, M., Perry, J., Browne, A., Scovazzo, M.L., Kerrigan, J., 1991. The normal shoulder during freestyle swimming. An electromyographic and cinematographic analysis of twelve muscles. Am. J. Sports Med. 19 (6), 569–576.
Rupp, S., Berninger, K., Hopf, T., 1995. Shoulder problems in high level swimmers—impingement, anterior instability, muscular imbalance? Int. J. Sports Med. 16 (8), 557–562.
Sein, M.L., Walton, J., Linklater, J., Appleyard, R., Kirkbride, B., Kuah, D., Murrell, G.A., 2010. Shoulder pain in elite swimmers: primarily due to swim-volume-induced supraspinatus tendinopathy. Br. J. Sports Med. Eng. 105–113.
Tate, A.R., McClure, P., Kareha, S., Irwin, D., Barbe, M.F., 2009. A clinical method for identifying scapular dyskinesis, part 2: validity. J. Athl. Train. 44 (2), 165–173.
Warner, J.J., Micheli, L.J., Arslanian, L.E., Kennedy, J., Kennedy, R., 1992. Scapulothoracic motion in normal shoulders and shoulders with glenohumeral instability and impingement syndrome. A study using Moire topographic analysis. Clin. Orthop. Relat. Res. 285, 191–199.
Ziv, E., 2006. In: Schwimer Ety, K.-C.Y., Hagar, Patish (Eds.), The Quick Dash Outcome Measure in Hebrew. Barzilai Medical Center, Ashkelon, Israel (Institute For Work & Health).

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