doi:10.22100/ijhs.v5i2.595
Original Article

IJHS 2018;5(3):31-34
ijhs.shmu.ac.ir
IJHS
International Journal of Health Studies

Comparison of Shoulder Posture and Scapular Kinematic among Swimmers with and Without Shoulder Pain

Aynollah Naderi[1*], Shahabeddin Bagheri[2], Mohammad H. Rezvani[1]
[1] School of Sport Sciences, Shahrood University of Technology, Shahrood, Iran.
[2] School of Physical Education and Sport Sciences, University of Nahavand, Hamadan, Iran.

Received: 28 May 2019
Accepted: 18 November 2019

Abstract

Background: *Posture impairment can be an integral component of overuse injuries in the sport. The purpose of this study was to compare the shoulder posture and scapular kinematic among swimmers with and without shoulder pain.*
Methods: *Thirty-six swimmers, 18 swimmers without shoulder pain, and 18 swimmers with shoulder pain, with were selected as samples in consultation with an orthopedic specialist. Static and dynamic posture including FH-FSP were measured using a digitized, side-view photograph; pectoralis minor length using a tape measure; scapular anterior tilting index via a ruler; scapular rotation as well as protraction by a DiVeta method.*
Results: *The results showed that FH and FS angle were significantly greater in the swimmers with shoulder pain than those without shoulder pain. On the other hand, scapular protraction and rotation were not significantly different between the groups. However, pectoralis minor length was significantly shorter in the swimmers with shoulder pain than those without shoulder pain. FS angle and pectoralis minor length were significant predictors for shoulder pain.*
Conclusions: *The results of our study regarding the role of posture and scapular kinematics in the shoulder pain are inconclusive due to the large number of confounding variables that may have influenced the results. Future studies should be performed to evaluate the effects of these variables.*

Keywords: Scapula, Position, Protraction, Upper cross syndrome.
[*]Corresponding to: A Naderi, **Email:** ay.naderi@yahoo.com
Please cite this paper as: Naderi A, Bagheri S, Rezvani MH. Comparison of shoulder posture and scapular kinematic among swimmers with and without shoulder pain. Int J Health Stud 2019;5(3):31-34.

Introduction

Good posture refers to the natural and balanced maintenance of various parts of the body.[1,2] In such postures, muscles activity is minimum and the body is at minimum fatigue and pain with maximum efficiency.[1] Poor posture in the long term can result in negative patterns and compatibility in the joints and soft tissues of the body.[3,4] The negative compatibility includes shortness and stiffness of the agonist muscles where prolongation and weakness of the antagonist muscles lead to postural abnormality. These muscle changes as muscle imbalance affect the natural state of the body and is associated with morbidity.[5]

Janda referred to the "upper cross syndrome" as the muscle imbalance associated with the upper quarter of body affecting the posture of neck and thoracic spine and shoulder girdle.[6] Principally, the muscles of upper posterior of the neck and pectoral area that are the tonic muscles are short while the muscles of the deep anterior of neck and shoulder area that are phasic are inhibited and weakened.[6,7] This syndrome leads to the scapular muscles imbalance, impaired scapula movement and position, and in turn spinal malalignments, shoulder pain, as well as biomechanical dysfunction of the Glenohumeral join.[8,9]

Abnormal scapular movements and its position relative to the thoracic are associated with various shoulder injuries, including shoulder impingement, rotator cuff rupture, and Glenohumeral joint instability that is very common in athletes.[9] Ludewig and Reynolds[10] recently reported a significant reduction in the rate of rotation of the shoulder, posterior tilt of the scapula, and external rotation by the arm elevation in patients with impingement syndrome and rotator cuff rote rupture. In 1996, Inman and Abbott[11] firstly proved the relationship between the shoulder ranges of motion and scapular position during arm movement. It was confirmed by other studies revealing an association between scapular kinematics and Glenohumeral joint pathologies.[9] In a study, Su et al.[12] found that swimmers with a tight latismus dorsi show changes in the scapular internal rotation, and posterior tilt of scapula during the arm elevation. Scibek Carpenter[13] and Fayad Roby-Brami[14] observed differences in scapular rhythm in those who had complete rapture or pain in the rotator cuff as well as those with shoulder impingement as compared with normal individuals.

Although there is a great deal of evidence about the association between some injuries, such as shoulder impingement, rotator cuff rupture, as well as latismus dorsi stiffness and scapular kinematics,[8,12,15] there is still lack of evidence on the relationship between the upper crossed syndrome and scapular kinematic as well as position.

Understanding the effects of upper cross syndrome on the scapular kinematics and muscle activity is important since upper crossover syndrome is correctable and can provide a pathway to improve shoulder mechanics thereby reducing the risk of shoulder pain. In addition, clinicians need to know what factors affect the scapular kinematic during arm movement in order to prescribe a more effective rehabilitation program. Accordingly, the purpose of this study was to investigate the effect of upper crossover posture on the scapula kinematics (protraction and upper rotation) in swimmers with and without pain.

Materials and Methods

This research is descriptive. The statistical population consisted of swimmers with an age range of 18 to 50 years from Islamabad Gharb city. Among them, 12 subjects with upper cross syndrome with pain, 12 subjects with upper interstitial syndrome without pain, and 12 healthy subjects with orthopedic diagnosis were selected as a statistical sample. The statistical sample of this study was based on Forte, de Castro[16] study. This study was conducted in the summer of 1394 at Zainibee club in Islamabad Gharb city.

Inclusion criteria were as follows: presenting at least two of the symptoms such as forward head posture, kyphosis, rounded shoulder, and internal rotation of the arm, weakness of deep flexor muscle of neck, shortness or stiffness of sternocleidomastoid, stiffness or shortness of the chest muscles.[10] The stiffness of the upper trapezius muscles and levator scapula as well as weakness of the lower and middle trapezius muscles were the other inclusion criteria.[17] In addition, one positive test for upper cross syndrome was another inclusion criterion. Neck flexion test was used to assess the weakness of the deep flexor muscles of neck and shortness or stiffness of the sternocleidomastoid muscle. To perform this test, the participants laid on the back, then gently elevated their head and looks at their foot. If the deep neck flexors are weak, the sternocleidomastoid muscle is activated too much and the jaw moves forward while the chin is protracted. This causes excessive neck extension.[18] Jull's test was also conducted in these participants. The subject would lay on the back on the table, lifting their head up to 1 cm from the table; in this case, the chin is tucked and the participant should not lift their head up or down. This test is positive if the patient's chin pokes, the head shakes, or the head rises up or falls.[18] Exclusion criteria were as follows; dislocation of Glenohumeral and Acromeo-Clavicular joints, surgery, and fractures, shoulder instability, cervical pain syndromes, neurological diseases, rheumatoid arthritis, diabetes, and depression.[19,20]

After selection, the subjects completed the questionnaires containing the demographical information completed through the interview. They also signed the written consent form after gaining full knowledge of the study process.

Pain intensity at rest, during activity, and at night were measured on a VAS ranging from 0 (no pain) to 100 (worst possible pain).[21]

Forward-head, forward-shoulder posture (FH-FSP) was assessed using a digitized, side-view photograph taken in a relaxed-standing posture. Initially, tragus and acromion anterior tip were marked with an adhesive dot, and a pointer was taped to the skin overlying the C7 vertebra.[22] A side-view photograph was obtained with Adobe AutoCAD 2010 being to calculate the forward head angle (FHA) and forward shoulder angle (FSA).

Scapular protraction and rotation were assessed using DiVeta method (1990).[1] The lower angle, the root of the scapula, the tip of the acromion, and thoracic vertebrae spine corresponding to the root of the scapular spine were marked by a marker through the surface anatomy. A anthropometric meter was used to measure the distance from the thoracic vertebrae spine corresponding to the root of the scapular spine to the acromion process (BAE), the distance from the root of the scapular spine to the tip of the acromion (AE), the distance between the inferior angle of the scapula and the corresponding mark on the thoracic spine (CD), and the distance between the marks on the thoracic spine corresponding to the root of the scapular spine and the inferior angle of the scapula (BC). All measurements were recorded to the millimeter. The following formula was used to determine scapular protraction and scapular rotation: scapular protraction = BAE/AE and scapular rotation = $\tan\theta$ = CD/BC.[23]

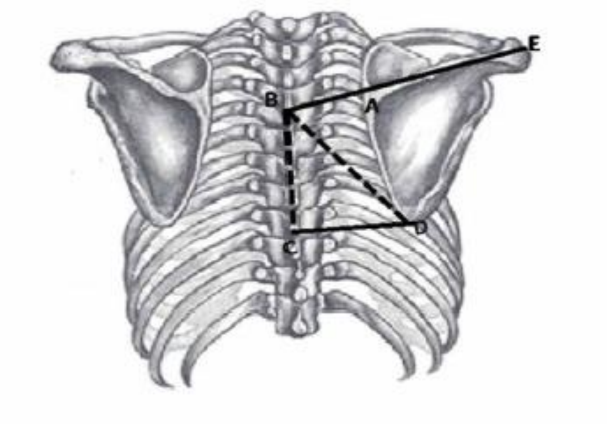

Figure 1. Scapular protraction measurement

Scapular anterior tilting index was 100 times the distance between the posterior border of the acromion and the table in a relaxed supine position[24] divided by the body height.[15] Resting pectoralis minor length was measured with 1 mm resolution in a relaxed-standing posture.[15] The distances between caudal edge of the fourth rib at the sternum and the medial-inferior aspect of the coracoid process, the insertion and origin of the muscle, were estimated upon complete exhalation. PML index was calculated from the average of three trials. PML is a measure of the relative length of pectoralis minor: PMI = 100 × PM length (cm)/subject height (cm), where PM is the pectoralis minor.

SPSS statistical software (version 18.0, SPSS Inc., Chicago, IL, USA) was used for statistical analyses. The Shapiro-Wilk test indicated that all data were normally distributed. We used independent t-test to compare the variables of shoulder posture and scapular kinematics between the groups. Logistic regression models were used to determine the odds of sport injury with psychological variables as predictors. Significance level was set at 0.05.

Results

Participant characteristics were similar between groups and there were no significant differences between the groups in terms of age, weight, height, sports history, and practice session (Pvalue > 0.05) (table 1).

Table 1. Demographical variables of participants

Variables	Swimmer without pain	Swimmer with pain	t	Pvalue
Age (y)	26.5 ± 7.2	24.3 ± 6.3	0.97	0.30
Weight (Kg)	72.53 ± 4.9	70.2 ± 5.4	1.50	0.20
Height (cm)	171.6 ± 5.76	170.3 ± 6.3	0.70	0.50
Sports history (y)	7.5 ± 2.6	9.15 ± 2.3	2.01	0.07
Practice session (n/w)	3.4 ± 1.2	4.2 ± 1.4	1.80	0.08

The data for the postural variables and scapular kinematic variables in each group are reported in table 2. Regarding FHP and FSP variables, our results show significant differences between groups (Pvalue < 0.05). FH angle was significantly greater in the swimmers with shoulder pain than pain-free swimmers (Pvalue < 0.05). In addition, FS angle was also significantly greater in the swimmers with shoulder pain than those without it (Pvalue < 0.05).

Regarding scapular kinematic, only the degree of scapular anterior tilting was significantly larger in the swimmers with shoulder pain than those without pain (Pvalue < 0.05). However, independent t-test analysis revealed that there were no significant differences in terms of scapular protraction and scapular upward rotation between the groups (Pvalue > 0.05). Resting pectoralis minor length was also significantly shorter in the participants with shoulder pain than pain-free subjects (Pvalue < 0.05).

Table 2. Independent t-test results for comparison of variables between the groups

Variables	Swimmers without pain	Swimmers with pain	t	Pvalue
FHP (degree)	51.8 ± 3.5	58.2 ± 3.9	5.2	0.001
FSP (degree)	55.2 ± 4.1	59.7 ± 4.3	3.2	0.010
Scapular protraction (mm)	17.3 ± 2.7	18.6 ± 3.1	1.5	0.200
Scapular rotation (degree)	34.2 ± 4.8	36.1 ± 3.6	1.3	0.200
Scapular anterior tilting (% height)	2.9 ± 0.30	4.3 ± 0.7	7.8	0.001
Pectoralis minor length (%height)	10.1 ± 0.6	7.9 ± 0.4	12.9	0.001

A logistic regression was conducted to determine the contribution of postural variables to the prediction of shoulder pain. According to the results, FS angle, scapular anterior tilting, and resting pectoralis minor length were significant predictors of shoulder pain (Pvalue < 0.05). The final model was statistically significant, ($\chi 2$ = 53.4, Pvalue < 0.001), explaining 56% of the variance in sport injury and correctly classifying 68% of cases. Increasing pectoralis minor length was associated with a reduction in the likelihood of shoulder pain. For every point increase in pectoralis minor length, the odds of suffering shoulder pain would decrease by 17%. Each degree rise in the FS angle increases the odds of experiencing shoulder pain by 24%, and each point increase in the scapular anterior tilting would increase the odds of suffering shoulder pain by 18% (table 3).

Table 3. Logistic regression analysis for variables predicting shoulder pain

Variables	β	S.E.	Wald	OR	Pvalue
FSP (degree)	2.43	0.38	18.2	1.24	0.001
Scapular anterior tilting (% height)	2.21	0.31	23.2	1.18	0.010
Pectoralis minor length (% height)	-2.83	0.23	32.2	0.83	0.020

Discussion

The purpose of this study was to compare the postural variables and scapular kinematic between subjects with shoulder pain and healthy subjects. According to the results, FH and FS angle were significantly larger in the swimmers with shoulder pain than without shoulder pain. In addition, pectoralis minor length was significantly shorter in the swimmers with shoulder pain than pain-free subjects. However, scapular protraction and rotation were not significantly different between the groups. FS angle and pectoralis minor length were significant predictors for shoulder pain.

Muscle shortness has specifically been theorized to play an important role in scapular dyskinesia, as can affect both the scapular position and movement. Borstad and Ludewig[15] suggested that individuals with short pectoralis minor have altered scapular kinematics similar to those with Subacromial impingement, confirming the results of our study. Another study has shown a negative relationship between pectoralis minor length and scapular kinematic, based on biomechanical measures.[25] Pectoralis minor shortness can limit normal scapular movement, causing a more anteriorly tilted, protracted, and rotated scapula during arm elevation.[26] This can lead to subacromial space narrowing, which in turn leads to shoulder pain.[15]

As mentioned previously, there was no significant difference in scapula protraction and rotation between swimmers with shoulder pain and those pain; these results are inconsistent with the findings of a previous study. Additionally, no significant difference was found between the groups in terms the amount of thoracic spine curvature. Our study results are inconsistent with Kibler,[27] who found that scapula protraction is 1 cm greater in the shoulder with pain than shoulder without pain in athletes with shoulder injuries. Note that Kibler assessed the distance from T7, to the inferior border of the scapula and did not control the scapular size. Kibler evaluated the scapula protraction in three different angles of arm abduction. It is therefore possible that the Parascapular muscle weakness, such as rhomboid and middle trapezius, leads to aggravated scapular protraction. On the other hand, considering that the measurement of the scapular position in the present study was performed with the upper extremities on the sides, muscle weakness may have no effect on scapular protraction or downward rotation. Confirming our explanation, Diveta Walker[28] reported that weakness of the pectoralis minor and middle trapezius muscles has no effect on scapula protraction, when scapula protraction was performed with the upper extremities on sides.

A previous study revealed that head and shoulder postural impairments are associated with muscular imbalances surrounding the scapula. Some of this muscle imbalance includes shortening of the upper trapezius, the splenius and semispinalis capitis and cervicis, the cervical erector spinae and the levator scapulae musculature.[1] Thus, it was assumed that these postural impairments may change the position of the scapula and impair the scapular kinematics in swimmers with shoulder pain, which was confirmed in our study. In line with our study, a research has shown FSP to be significantly greater in individuals with shoulder pain as compared to healthy individuals.[29] FSP is defined as forward deviation of the shoulders associated with scapular protraction which is caused by a muscular imbalance between a shortened pectoralis minor and a lengthened middle trapezius.[29] FSP also places the lower trapezius and serratus anterior in the positions that lead to weakness of these muscles thought to negatively influence scapular tilting.[30,31] Overall, this muscle imbalance would increase anterior scapular tilt and scapular internal rotation as important factors that can be associated with shoulder pain.[32] Thus, this altered scapular kinematics, anterior scapular tilt, is correlated to short pectoralis minor and week serratus anterior as well as lower trapezius muscles. These changes are thought to produce a compressive impingement under the acromion, creating a mechanical block to elevation of the humerus and irritation of the subacromial tissues leading to shoulder pain.

The present study compared the postural variables and scapular kinematic between subjects with shoulder pain and healthy subjects. The swimmers without shoulder pain group exhibited a significantly greater FHP, FSP, and scapular anterior tilting than those with shoulder pain. On the other hand, pectoralis minor length was greater in the swimmers with shoulder pain than those without it. The results showed that FS angle, scapular anterior tilting, and resting pectoralis minor length are significant predictors of shoulder pain explaining

56% of the variance in shoulder pain and correctly classifying 68.0% of cases. Hence, shortening of pectoralis minor and FS angle, scapular anterior caused by it increases the likelihood of occurrence of shoulder pain in the swimmers. Inclusion of the assessment of pectoralis minor muscle length, FS angle, and scapular anterior as a routine part of the shoulder pain examination may aid treatment decision-making to acquire better outcomes. Future studies should attempt to assess the influence of these variables. The important question to answer is the relationship between mobility and posture as well as shoulder pain or the impact of mobility on these two variables.

Acknowledgement

The authors highly appreciate the athelets for their enthusiastic participation. Conflict of Interest The authors declared no conflicts of interest. Formatting of Funding Sources This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflict of Interest

The authors declare that they have no conflict of interest.

References

1. Kendall FP, McCreary EK, Kendall HO. Muscles, testing and function: testing and function: Lippincott Williams and Wilkins; 1983.

2. Yalfani A Anbarian M, Nikoo R, Naderi A. Relationship between postural control with sway- back malalignment in the non-athlete males. Journal Of Ilam University Of Medical Sciences 2014;22:189-201.

3. Bradford C. Acute and adaptive responses to endurance swimming in warm water: University of Otago; 2018.

4. Naderi A Shaabani F, Malki F, Khosravi F. Kinematic changes of body alignment resulting from backpack weight, location and carrying duration in 10 to 12 years old boy schoolchildren. Journal of Applied Exercise Physiology 2017;13:25-36.

5. Barrett E, O'Keeffe M, O'Sullivan K, Lewis J, McCreesh K. Is thoracic spine posture associated with shoulder pain, range of motion and function? A systematic review. Man Ther 2016;26:38-46. doi:10.1016/j.math.2016.07.008

6. Frank C, Page P, Lardner R. Assessment and treatment of muscle imbalance: the Janda approach: Human Kinetics; 2009. p.297.

7. Moore MK. Upper crossed syndrome and its relationship to cervicogenic headache. J Manipulative Physiol Ther 2004;27:414-20. doi:10.1016/j.jmpt.2004.05.007

8. Page P. Shoulder muscle imbalance and subacromial impingement syndrome in overhead athletes. Int J Sports Phys Ther 2011;6:51-8.

9. Greenfield B, Catlin PA, Coats PW, Green E, McDonald JJ, North C. Posture in patients with shoulder overuse injuries and healthy individuals. J Orthop Sports Phys Ther 1995;21:287-95. doi:10.2519/jospt.1995.21.5.287

10. Ludewig PM, Reynolds JF. The association of scapular kinematics and glenohumeral joint pathologies. J Orthop Sports Phys Ther 2009;39:90-104. doi:10.2519/jospt.2009.2808

11. Inman VT, Saunders JB, Abbott LC. Observations of the function of the shoulder joint. 1944. Clin Orthop Relat Res 1996;330:3-12. doi:10.1097/00003086-199609000-00002

12. Su KP, Johnson MP, Gracely EJ, Karduna AR. Scapular rotation in swimmers with and without impingement syndrome: practice effects. Med Sci Sports Exerc 2004;36:1117-23. doi:10.1249/01.mss.0000131955.55786.1a

13. Scibek JS, Carpenter JE, Hughes RE. Rotator cuff tear pain and tear size and scapulohumeral rhythm. J Athl Train 2009;44:148-59. doi:10.4085/1062-6050-44.2.148

14. Fayad F, Roby-Brami A, Yazbeck C, Hanneton S, Lefevre-Colau MM, Gautheron V, et al. Three-dimensional scapular kinematics and scapulohumeral rhythm in patients with glenohumeral osteoarthritis or frozen shoulder. J Biomech 2008;41:326-32. doi:10.1016/j.jbiomech.2007.09.004

15. Borstad JD, Ludewig PM. The effect of long versus short pectoralis minor resting length on scapular kinematics in healthy individuals. J Orthop Sports Phys Ther 2005;35:227-38. doi:10.2519/jospt.2005.35.4.227

16. Forte FC, de Castro MP, de Toledo JM, Ribeiro DC, Loss JF. Scapular kinematics and scapulohumeral rhythm during resisted shoulder abduction–implications for clinical practice. Phys Ther Sport 2009;10:105-11. doi:10.1016/j.ptsp.2009.05.005

17. Torres E. Maintaining body balance, flexibility, and stability: a practical guide to the prevention and treatment of musculoskeletal pain and dysfunction. Physical Therapy 2004;84:1208-9.

18. Valli J. Chiropractic management of a 46-year-old type 1 diabetic patient with upper crossed syndrome and adhesive capsulitis. J Chiropr Med 2004;3:138-44. doi:10.1016/S0899-3467(07)60101-3

19. Naderi A, Rezvani MH, Shaabani F, Bagheri S. Effect of kyphosis exercises on physical function, postural control and cuality of life in elderly men with hyperkyphosis. Iranian Journal of Ageing 2019;13:464-79. doi:10.32598/SIJA.13.4.464

20. Naderi A. The comparison of effects 3 corrective exercise methods on the spinal alignment of the individuals with sway back posture. Journal of Applied Exercise Physiology 2018;14:29-48. [Persian].

21. Clark P, Lavielle P, Martínez H. Learning from pain scales: patient perspective. J Rheumatol 2003;30:1584-8.

22. Thigpen CA, Padua DA, Michener LA, Guskiewicz K, Giuliani C, Keener JD, et al. Head and shoulder posture affect scapular mechanics and muscle activity in overhead tasks. J Electromyogr Kinesiol 2010;20:701-9. doi:10.1016/j.jelekin.2009.12.003

23. Dvir Z, Berme N. The shoulder complex in elevation of the arm: a mechanism approach. J Biomech 1978;11:219-25. doi:10.1016/0021-9290(78)90047-7

24. Host HH. Scapular taping in the treatment of anterior shoulder impingement. Phys Ther 1995;75:803-12. doi:10.1093/ptj/75.9.803

25. Cools AM, Struyf F, De Mey K, Maenhout A, Castelein B, Cagnie B. Rehabilitation of scapular dyskinesis: from the office worker to the elite overhead athlete. Br J Sports Med 2014;48:692-7. doi:10.1136/bjsports-2013-092148

26. Kibler WB, Ludewig PM, McClure PW, Michener LA, Bak K, Sciascia AD. Clinical implications of scapular dyskinesis in shoulder injury: the 2013 consensus statement from the 'Scapular Summit'. Br J Sports Med 2013;47:877-85. doi:10.1136/bjsports-2013-092425

27. Kibler WB. Role of the scapula in the overhead throwing motion. Contemp Orthop 1991;22:525-32.

28. DiVeta J, Walker ML, Skibinski B. Relationship between performance of selected scapular muscles and scapular abduction in standing subjects. Phys Ther 1990;70:470-6. doi:10.1093/ptj/70.8.470

29. Bullock MP, Foster NE, Wright CC. Shoulder impingement: the effect of sitting posture on shoulder pain and range of motion. Man Ther 2005;10:28-37. doi:10.1016/j.math.2004.07.002

30. Kibler WB, Sciascia AD, Uhl TL, Tambay N, Cunningham T. Electromyographic analysis of specific exercises for scapular control in early phases of shoulder rehabilitation. Am J Sports Med 2008;36:1789-98. doi:10.1177/0363546508316281

31. Ludewig PM, Hoff MS, Osowski EE, Meschke SA, Rundquist PJ. Relative balance of serratus anterior and upper trapezius muscle activity during push-up exercises. Am J Sports Med 2004;32:484-93. doi:10.1177/0363546503258911

32. Ludewig PM, Cook TM. Alterations in shoulder kinematics and associated muscle activity in people with symptoms of shoulder impingement. Phys Ther 2000;80:276-91.