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ORIGINAL RESEARCH

IS THERE A RELATION BETWEEN SHOULDER DYSFUNCTION AND CORE INSTABILITY?

Ahmed Radwan, PT, DPT, PhD[1]
Jennifer Francis, BS, DPT[1]
Andrew Green, BS, DPT[1]
Eric Kahl, BS, DPT[1]
Diane Maciurzynski, BS, DPT[1]
Ashley Quartulli, BS, DPT[1]
Julianne Schultheiss, BS, DPT[1]
Ryan Strang, BS, DPT[1]
Brett Weiss, BBA, DPT[1]

ABSTRACT

Background: Overhead athletes often suffer injury to the glenohumeral joint secondary to inherent instability. However, little is known about the relationship between core stability and shoulder dysfunction among athletes.

Purpose: The purpose of this study was to analyze the difference between healthy athletes and those with shoulder dysfunction in regard to core stability measures. Secondary purpose was to explore the relationship between measures of core stability and measures of shoulder dysfunction.

Methods: Participants consisted of NCAA Division III overhead athletes (28 males, 33 females) with a mean age of 19.3 $\pm$ (1.1) years, mean weight of 173.6 $\pm$ (36.9) pounds, mean height of 67.8 $\pm$ (3.5) inches. Functional questionnaires (the Kerlan-Jobe Orthopaedic Clinical Scale [KJOC] and the QuickDASH sports module) as well as Single-Leg Stance Balance Test (SLBT), Double Straight Leg Lowering Test (DLL), Sorensen Test, and Modified Side Plank Test were completed in a randomized order with consistent raters.

Results: MANOVA was significant at ($p = .038$) for the comparison between the experimental group and the control group for the values of Right SLBT. The experimental group had significantly less balance than the control group with means of 10.14 $\pm$ (5.76) seconds and 18.98 $\pm$ (15.22) seconds respectively. Additionally, a positive correlation was found between the DLL and the KJOC at ($r = .394$, $p > .05$) and a negative correlation was found between the Right SLBT and the Quick DASH sports module (QD) at ($r = -.271$, $p > .05$).

Discussion and Conclusion: Balance deficiency was found in athletes with shoulder dysfunction. According to this study, greater shoulder dysfunction is correlated with greater balance and stability deficiency. Therapists and trainers should consider incorporating balance training as an integral component of core stability into rehabilitation of athletes with shoulder dysfunction.

Level of Evidence: 3b

Keywords: Core stability, KJOC, overhead athletes, shoulder dysfunction.

[1] Physical therapy program, Utica College, NY, USA

This research was approved by Utica College Institutional Review Board (IRB) prior to conducting the study.

CORRESPONDING AUTHOR
Ahmed Radwan PT, DPT, PhD
Assistant professor, Physical therapy program, Utica College.
Address: 1600 Burrstone road, Utica College, Utica, NY, 13502, USA
Email: aradwan@utica.edu
Office: 315-792-3853

INTRODUCTION

Athletes performing overhead motions require highly skilled movements performed at high velocities. This requires flexibility, muscular strength, coordination, synchronicity and neuromuscular control at the shoulder complex.[1] Considering the extraordinarily high demands placed on the shoulder during overhead motion, it is subsequently one of the most commonly injured sites in the human body.[1] Injuries to the shoulder complex range from shoulder impingement syndrome, rotator cuff pathology, biceps tendonitis, instability, and labral tears.[2]

In order to maintain functional stability during limb movement, muscular strength and endurance is required around the lumbar spine. This area is referred to as the core and includes the abdominal muscles anteriorly, the paraspinals and gluteals posteriorly, the diaphragm superiorly, and the pelvic floor and hip girdle musculature inferiorly.[3] The core musculature becomes active in a feed-forward fashion during upper extremity movement.[4] This mechanism occurs as the body prepares for potential perturbation of spinal stability when movement begins.[4] In sports that require a great degree of overhead skill, the core provides a foundation upon which muscles of the upper and lower extremities rely.[5]

Connections have also been made between core stability and athletic performance.[3] Core stability has been proven to be an essential component of biomechanical efficiency, allowing the athlete to maximize force production while minimizing loads placed on peripheral joints. This is especially important during complex movements such as: running, jumping, swimming, throwing, and spiking.[6] Due to the three-dimensional nature of complex movements, athletes must have adequate core strength in order to provide effective stability during a wide variety of movements.[7,8]

Core stability is becoming an increasingly popular topic in rehabilitation research with regard to the prevention of various spine and lower extremity injuries. Deficiency in core strength leads to a breakdown in form, therefore predisposing athletes to injury.[7]

Balance is an integral component of core stability. Many clinical neuromuscular imbalances occur between synergistic and antagonistic muscles. This is characterized by early dominant activation of trunk muscles and delay in activation of synergistic muscles.[9] This imbalance can cause instability and excessive joint motion in the direction of the overhead activity.[10] This faulty movement can lead to excessive abnormal accessory gliding, thereby increasing trauma to the joint and causing increased risk for dysfunction and pain.[10] The movement system is very adaptable to change and strives to maintain normal function. Therefore if imbalances develop, compensatory movements will occur to restore mobility, often resulting in tissue damage.[10]

Despite the current interest surrounding core stability, there is limited research on the relationship between the core and shoulder pathologies. Considering the high prevalence of shoulder injuries that occur in overhead athletes, there is a need to further examine the correlation between these injuries and core stability in terms of both strength and balance. Therefore, the purpose of this study was to analyze the difference between healthy athletes and those with shoulder dysfunction in regards to core stability measures. The secondary purpose was to explore the relationship between measures of core stability and measures of shoulder dysfunction.

METHODS

Sixty-one Division III overhead athletes (28 males, 33 females) were recruited to participate in this study. Their mean age was 19.3 $\pm$ (1.1) years, mean weight was 78.7 $\pm$ (16.7) kg., and mean height was 172.2 $\pm$ (8.9) cm. Several overhead sports were represented in the sample (six football players, seven swimmers, three water polo players, thirty one lacrosse players, one baseball player, six softball players, six field throwing athletes, and six basketball players). There were 48 healthy participants and 14 participants with shoulder dysfunction. Subjects were classified as having shoulder dysfunction if they had history of noncontact shoulder injury and scored less than 80 on the KJOC.[11] Subjects were excluded if they were either in the acute stage of the injury or if they were not actively participating in their respective sports as a part of their team when the study was conducted.

Upon entering the data collection station subjects completed the KJOC and QD scales and had demographic measures taken. Subjects were then randomly assigned to start at one of the core measures stations as follows; Single-Leg Stance Balance Test (SLBT), Double Straight Leg Lowering Test (DLL), Sorensen Test, and Modified Side Plank Test. Each test was conducted by consistent raters.

At the SLBT station, the participant's ability to maintain single leg balance with eyes closed was tested as an integral component of core stability. Preceded by a practice trial, three trials were performed on each lower extremity with eyes closed, arms crossed at the chest, contra lateral leg slightly flexed, and foot at height of opposite ankle. The timer began once the foot was raised off the ground and stopped once the participant either opened eyes, uncrossed arms, shifted weight, contacted floor or stance leg with the elevated foot, or if the participant's stance leg was no longer in the starting position. In addition, the test was stopped if the participant held the position for a maximum of 45 seconds. The test was then repeated on the opposite foot utilizing the same format. The best score on each foot was recorded.[12]

At the DLL station, the stability of the abdominal muscles was tested. Participants were supine with a standard sphygmomanometer underneath the lumbar curve inflated to a baseline of 40 mmHg with the knees straight and hips bent to 90 degrees. The degree to which the participant could lower their legs (movement toward hip extension), while maintaining the same cuff pressure was recorded using an Absolute Plus Axis Digital Goniometer. If pressure dropped below 40 mmHg on the dial, the participant was instructed to pause and attempt to return the pressure on the dial to baseline. If the participant was unable to return the pressure to baseline after maximal encouragement and visual cueing utilizing the sphygmomanometer dial, the test was discontinued. If able to achieve 40 mmHg, the test would continue until pressure dropped below baseline again, which indicated the end of the test. At this point, the amount of terminal hip extension angle was measured in degrees using the aforementioned digital goniometer. Three consistent raters were needed for appropriate administration of this test.[13]

At the Sorenson Test station, the stability of the back muscles was tested. Participants were in prone lying (supported by standard gait belts) with the upper body off the end of the examining table supported by a chair. A right angled apparatus was positioned in level with the highest point of the sacrum and on top of both scapulae. During instruction, emphasis was placed on maintaining contact of the back with this apparatus to provide participants with tactile feedback. Upon commencement of the test, participant was instructed to keep their arms crossed over the chest while maintaining a neutral position of the head and neck. At this time, participants were instructed to perform an isometric contraction of trunk extensors and to hold it for as long as possible. The test was stopped if contact with the apparatus was lost or once two minutes had elapsed. Positive verbal reinforcements were given each thirty-second interval.[14]

Finally, at the Modified Side plank Station, the stability of the lateral trunk walls were tested. (Figure 1) The participant was instructed to lay with one shoulder on the ground, arms crossed over chest, head resting on a wedge, and feet supported on a peanut ball. The examiner then asked participant to lift hips off the ground as high as possible. A dangling pulley system rope was aligned at their iliac crest to provide tactile feedback to the position of maximum hip elevation. A practice trial was allowed, followed by the test trial, which was recorded in seconds. Time started when maximum hip elevation was reached and was stopped when the participant's hip lost contact with the pulley system. Encouragement and

Figure 1. *Participant in the Modified Side Plank test starting position on the left side. Arms crossed over chest, head resting on a wedge, and feet stacked on a peanut ball. The examiner then asked participant to lift hips off the ground as high as possible, in order to perform a modified side plank, with a pulley system aligned at their iliac crest to provide tactile feedback.*

feedback was given at 20-second intervals. The test side was chosen in random order, and then repeated on the opposite side by consistent raters.[15]

STATISTICAL ANALYSIS

All statistical analyses were performed using the Statistical Package for Social Sciences (SPSS™) version 20 for Windows. Prior to final analysis, data were screened for transcription errors, bivariate correlation, normality assumptions, homogeneity of variance, as prerequisites for parametric calculations of the analysis of difference and analysis of relationship measures. Alpha level was set at 0.05 to control for type I error.

Multivariate Analysis of Variance test (Hotelling Trace test) was used to analyze the difference between healthy participants and participants with shoulder dysfunction. This was followed by an analysis of relationship between the scores of the KJOC and core stability measures using the Pearson Product Moment Correlation Coefficient followed by the respective significance testing and regression analysis.

RESULTS

Criteria for parametric testing were met and a multivariate analysis of differences was performed to compare the six dependent variables (Sorensen test, DLL test, right and left Side Plank tests, and right and left SLBT) between healthy participants (control group n = 47) and participants with shoulder dysfunction (experimental group n = 14). MANOVA was significant at p = .038 for the comparison between the experimental group and the control group for the right SLBT. The experimental group had significantly lower balance than the control group with means ± (SD) of 10.14 ± (5.76) and 18.98 ± (15.22) respectively. No other significant statistical differences were found between the remainder of the dependent variables. Outcomes are presented in Table 1.

Additionally, the correlation between the QuickDASH sports module and the KJOC with each core stability test was calculated using Pearson Correlation Coefficient. A moderate positive correlation was found between the Double Leg Lowering test and the KJOC questionnaire with r = .394, p > .05. Similarly, a weak negative correlation was found between the right Single Leg Balance test and the QuickDASH sports module with r = –.271, p > .05. Both correlations support the fact that greater shoulder dysfunction is associated with greater balance and stability deficiencies.

DISCUSSION

According to the results of this study, balance was found to be statistically lower in participants with shoulder dysfunction compared to healthy participants. Since balance is one of the components of core stability,[16] one can imply that overhead athletes with shoulder dysfunction that participated in this study had non-optimal core stability compared to their healthy peers.

In concordance with Gribble and Hertel,[16] the SLBT was utilized as the tool for measuring static postural control. Postural control is essential to athletes, as it is an indicator of appropriate neuromuscular function and stability therefore, important for both injury prevention and rehabilitation. Ease of administration, high reliability, and low cost of this test

Table 1. *Comparison Between Normal Athletes and Athletes With Shoulder Dysfunction Regarding Dependent Measures of Core Stability.*

Core stability measure	Athletes with shoulder dysfunction	Normal athletes
Sorenson Test	81.8±(30.7) seconds	70.2 ±(31.4) seconds
Double Leg Lowering Test	9.4 ±(4.9) degrees	8.4 ±(7.5) degrees
Modified Side plank (right)	43 ±(28.6) seconds	35.1±(25.7) seconds
Modified Side plank (left)	52.1±(36.8) seconds	47.4±(41.9) seconds
Single Leg Balance (right)	10.1 ±(5.8) seconds *	18.9±(15.2) seconds
Single Leg Balance (left)	10.1±(6.7) seconds	16.9 ±(13.7) seconds

*significant at p = 0.05

are all reasons why the SLBT can be used to assess one of the components of core stability. In addition, Cosio-Lima, Reynolds, Winter, Paolone, and Jones[17] advocate the use of the SLBT in assessing core stability in patients with Low Back Pain.

In the current study there was no significant difference between the control and the shoulder dysfunction group in scores on the Side Bridge Test. The current study used a Modified Side Bridge Test (as described earlier in the methodology section) in order to account for shoulder pathology and possible pain in subjects. This differed from the test position used by McGill et al.[15] The difference in the test positions may account for the variation of the study results.

The use of the Sorensen Test to measure core stability by examining the isometric endurance of the trunk extensors is commonly mentioned throughout the literature. The Sorensen Test is the best test used to evaluate endurance of back extensors. In the current study there was no significant difference of Sorensen Test score between the shoulder dysfunction and the control group. The difference in results between this study and ours may be attributed to the difference in subjects' demographics, pathologies, and overall number of participants.[14]

The core flexors were assessed by the use of the DLL test. Arab et al concluded that the DLL test is reliable, sensitive, and specific for the core flexors. In their study, there was a lower score in the group of subjects that had low back pain compared to subjects without pain. The difference in the way the DLL test was performed in the two studies may explain the varying results. Arab et al.[18] had the patient hold his or her legs 20 degrees from the floor and for as long as possible. The current study involved the subject's legs being taken to 90 degrees and then the subject was asked to slowly lower legs to table while maintaining 40mmHg on a sphygmomanometer that was placed beneath the lumbar spine. The first method may allow for more substitution by the subject, such as arching his or her back and hence allowing for longer period of hold.

The results of the current study confirm that the KJOC scores were moderately correlated with the DLL scores. The importance of the DLL Test as a measure of core stability has been recommended for the assessment of core stability among the athletic population by Sharrock, Cropper, Mostad, Johnson, and Malone.[13] This test requires a high level of muscle activation and stabilization throughout the trunk because of the long lever arms of the lower extremities and narrow base of support for the trunk and upper extremities. It was reported in literature that this test is both valid and reliable in assessing core strength.[13]

Although there is a lack of evidence to support the correlation between shoulder dysfunction and core stability, there is information to show how the core musculature is activated during upper extremity movements.[4] The results of the current study are in agreement with Brumitt and Dale, who recommended that core stability exercises should be included when an athlete is completing a rehabilitation program for their shoulder injury.[4]

The previously found clinically sensitive but statistically insignificant correlations between measures of core stability and extent of shoulder dysfunction might have occurred due to various reasons. Many of the tests that were utilized in this study required modifications to minimize the stresses and strains on the shoulder joint complex. Second, the battery of tests administered may be sensitive to the general population and not a specific set of individuals with shoulder dysfunction. Lastly, the subjects with shoulder dysfunction who participated in this study were not in the acute phase of injury and demonstrated overall high scores on the functional questionnaires.

LIMITATIONS OF THE STUDY

The study is limited by the small sample size of participants with shoulder dysfunction, the randomized sample of convenience, the strict inclusion criteria, and the absence of dynamic multi-planar testing procedures. Finally, modifying the Side Plank test to evade participants' discomfort may have threatened the validity of its use.

CONCLUSION

The results of this study demonstrated that collegiate overhead athletes with shoulder dysfunction had less balance compared to healthy athletes. Additionally, poor performance of these athletes in some of the core stability measures was correlated to the extent of their shoulder dysfunction. Such results may support the use of balance and core stability training in the design of successful rehabilitation protocols for overhead athletes with shoulder dysfunction.

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