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Original Article

The relationship between scapular and core muscle endurance in professional athletes

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Abstract

Aim: Scapular and core muscle endurance is known to reduce risk of injury and improve performance. But, there was no study investigating relationship between scapular and core muscle endurance in athletes. To identify relationship between scapular and core muscle endurance in professional athletes.

Material and Methods: Fifty-two professional athletes (basketball, football and handball players) (age:19.88±5.98, BMI:21.65±2.82) were included in study. Scapular muscle endurance was assessed with scapular endurance test. Core muscle endurance was evaluated using McGill core endurance tests (trunk flexion, Sorensan test, and the side bridge) and prone bridge test.

Results: Spearman correlation analysis results showed that a positive moderate correlation was found between scapular endurance and prone bridge test (r: 0.524, p: 0.000). Scapular endurance test was shown to have positive correlations with Sorensen test (r: 0.292, p: 0.039).

Conclusion: Scapular and core muscle endurance is very important in performance and identifying risk of injury. As a result of this study, it can be seen that in athletes, scapular muscle endurance increases as core muscle endurance increases. This suggests that development of scapular and core muscle endurance in athletes is necessary for performance and for prevention of injuries. There is need for additional studies to investigate effect of scapular and core muscle endurance on performance and injury risk in athletes.

Keywords: Scapular endurance; core muscle endurance; athletes.

INTRODUCTION

The kinetic chain theory defines core stability as the ability to control the position and movement of the trunk over the pelvis to allow optimum production, transfer and control of force and motion to the terminal segments in integrated athletic activities (1). The core involves many different muscles which stabilize the shoulders, the pelvis and the spine and provides a base for movement in the extremities (2). Major core muscles are transversus abdominus in the anterior, multifidus in the posterior, pelvic floor in the inferior and diaphragm at the superior. Minor core muscles are the latissimus dorsi, gluteus maximus and the trapezius (2,3). All of these muscles attach directly or indirectly to the extensive thoracolumbar fascia and spinal column, which connect the upper and lower limbs (4). The core is seen as the center of the functional kinetic chain. The core muscles are activated through a feed-forward mechanism shortly before movements of the upper and lower extremities to act as a base which skilled movements can be performed (5,6). This feed-forward mechanism is necessary for obtaining mobility and stability of the extremities. These findings support the theory that movement control and stability are developed in a core-to-extremity (proximal-distal) and cephalo-caudal manner (head-to-toe) (7). Core stability has been shown to promote efficient body mechanics, allowing the athlete to maximize force output while minimizing loads placed on proximal joints (6). The relationship between optimal scores on trunk muscle endurance tests, good athletic performance and prevention of injuries has been supported in sports like football, handball and volleyball (8,9).

Just like the core, the scapula is a pivot used in transferring large forces and high energy from the legs and trunk which

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are the major sources of force and energy, to the arms and hands which are the actual delivery mechanism of the energy and force (10,11). The overall normal function of the scapula depends greatly on the normal function of the scapular muscles (12). For optimal stability and functional movement of the scapulothoracic joint, one of the major necessities is having strong scapular muscles (1,13). Sufficient endurance of these muscles is essential in order to maintain a consistent, proper scapulohumeral rhythm throughout prolonged overhead activity (14). When the scapula is unsuccessful in performing its role in stabilization, shoulder function is inefficient and a decrease in neuromuscular performance may occur (15). Moreover, in conditions such as injury where there is a loss in endurance, subacromial impingement may occur due to improper scapular rotation (14).

Previous studies have shown that when scapular stabilization is impaired and when the endurance of core muscles is decreased, an increase in risk of injury and a decrease in the performance of athletes arises (16-20). Although increased scapular and core muscle endurance is known to reduce the risk of injury and improve performance, there was no study investigating the relationship between scapular and core muscle endurance in athletes. Therefore, the present study aims to investigate whether there are any relationships between scapular and core muscle endurance in athletes.

MATERIAL and METHODS

Design

Cross sectional study

Participants

Fifty-two professional athletes (30 females and 22 males) (basketball, football and handball players) (age:19.88±5.98, BMI:21.65±2.82) were included in the study. Athletes who had; shoulder pain in the last three months, undergone upper extremity surgery, a deformity in their upper extremity, lower extremity injury, any neurological problem or systemic illnesses were excluded from the study. The consent for the athletes younger than 18 years was obtained from their coaches/trainers.

G * power (version 3.1.9.2, Düsseldorf, Germany) program was used to determine the number of individuals that should be included in the study. According to the results of the power analysis, $\alpha = 0.05$, $(1- \beta) = 0.95$, the effect size = 0.25 by taking the minimum size of the sample size is determined as 50 people.

Before the start of the study, the athletes' age, gender, weight, height, dominant side, sport modalities, whether they have had a injury, medical history were examined (Table 1). Ethics committee approval was obtained from Gazi University Ethics Committee with the number 77082166-604.01.02-.

Procedures

The scapular endurance test (SET), developed by Sahrmann, is based on an exercise used to improve the performance of the serratus anterior and trapezius muscles (21,22). For this test, athletes were positioned with 90° shoulder and 90° elbow flexion in standing position (Figure 1). The athletes held a digital dynamometer in their hands and an adjustable stick was placed between their elbows in order to maintain the test position. Participants were instructed to stabilize their scapulas in neutral position. Subsequently, the athletes were asked to perform shoulder external rotation to reach 1 kg of load and maintain this load shown in the dynamometer. When the athletes were no longer able to bear the load, dropped the stick or could not maintain the 90° shoulder flexion, the test was finished (23,24). The measurement was repeated twice and the results were recorded as seconds. The highest value was recorded.

The core muscle endurance was evaluated with the prone bridge test and three core muscle endurance test created by McGill. The McGill endurance tests are; the trunk flexor endurance test, Sorensen test and side bridge test (25). The reliability of trunk muscle endurance tests in athletes was demonstrated by Evans et al (26).

The trunk flexor test began in the sit-up position with their trunk supported at 60° of trunk flexion. Knees and hips were flexed at 90°, arms crossed over chest. Then the support of the trunk was removed and the athletes were asked to maintain this position as long as possible (25).

The Sorensen test (for trunk extensor muscle endurance) was performed in prone position on the examination table. The pelvis, hip and knees of the athletes were fixed to the treatment table up to the anterior superior level of the spina iliaca with non-elastic belts. The body and the upper extremities were supported using a chair the same height with the surface of the table. Next, the chair was removed and the athletes tried to maintain the horizontal body position as long as possible with their arms crossed position on the chest (25).

The side bridge test was performed on a mat lying on their sides. The athletes' knees and feet were positioned in extension and placed on top of each other. While the athletes lifted their hips off the mat, the body weight was supported only by their elbows and feet which remained on the floor. The test was ended when the athletes were no longer able to maintain this position (25).

The prone bridge test was performed in the prone position on the mats and receiving support from their elbows. The athletes' elbows were placed under their shoulders and a narrow space was left between their feet. Then, they were asked to only keep their forearms and toes on the floor, raise their hips and maintain this straight position. The test was ended when this position could no longer be maintained (27). All of the core muscle endurance results were recorded as seconds.

Statistical Analysis

Statistical analysis was performed using 'Statistical Package for Social Sciences' (SPSS) Version 22.0 (SPSS inc., Chicago, IL, ABD). The suitability of the parameters with normal distribution was analyzed with visual (histogram and possibility graphics) and analytical methods (Kolmogorov-Smirnov/Shapiro-Wilk tests). The descriptive statistics were shown as mean and standard deviations. The correlation coefficients and statistical significances for at least one relationship that did not display normal distribution were calculated with the Spearman test. For statistical significance, the type-1 error performance was used as %5.

RESULTS

The demographic characteristics of the athletes are shown in Table 1.

Table 1. Demographic characteristics of athletes

Age (years) (x±ss)		19.88±5.98
Body weight (kg) (x±ss)		68.31±13.93
Height (cm) (x±ss)		176 ±11
BMI (kg/m²) (x±ss)		21.65 ±2.82
Dominance	Right (n)	47
	Left (n)	5
Sport modalities	Basketball (n)	20
	Football (n)	16
	Handball player (n)	16
Trunk flexor endurance test (x±ss)		149.11±100.20
Sorenson test (x±ss)		150.69±62.87
Side bridge test (x±ss)		64.92±26.71
Prone bridge test (x±ss)		106.49±47.00

BMI: Body Weight Index

A moderate positive correlation was found between the scapular endurance test and the prone bridge test (r=0.524, p=0.000, Table 2). Similarly, a low positive correlation was found between the scapular endurance test and the Sorensen test (r=0.292, p=0.039, Table 2). There was no correlation between the trunk flexor test and side bridge test of the scapular endurance test (p>0.05, Table 2).

Table 2. The relationship between scapular and core muscle endurance in athletes

		SET	FLEX	EXT	SIDE	PRONE
SET	r	1	0.070	0.292	0.093	0.524
	p		0.628	0.039*	0.521	0.000*
FLEX	r		1	0.389	0.235	0.198
	p			0.005	0.101	0.169
EXT	r			1	0.413	0.414
	p				0.003*	0.003*
SİDE	r				1	0.373
	p					0.008
PRONE	r					1
	p					

*Statistically significant association (p<0.05), SET: Scapular endurance test, FLEX: Flexion endurance test, EXT: Extansion endurance test, SİDE: Side bridge test, PRONE: Prone bridge test

DISCUSSION

In this study, which investigated the relationship between the scapular and core muscle endurance in athletes, it was found that the scapular endurance test was associated with the prone bridge and the trunk extensor tests.

Core stability is defined as the ability to control the position and movement of the trunk over the pelvis and lower extremities (1). This allows the core to generate, transfer, and control force and motion to the distal segments (25). The dynamic stability of the spine refers to the ability of using muscular strength and endurance functionally, to control the spine whilst performing functional and athletic activities (28). Better core stability has been proven to promote efficient body mechanics, allowing the athlete to maximize force production while minimizing loads placed on proximal joints (1). Identifying athletes who may be at risk for injuries, assessing rehabilitation outcomes and in-sports performance enhancement programs of injured athletes is important (29). This is especially important during complex movements, such as: running, jumping, swimming, throwing, and hitting a volleyball (1,6). When literature is examined, it can be seen that many studies investigating the relationship between core muscle endurance and performance tests can be found (7,16,19, 20). Most of these studies have concluded that; spinal stabilizer muscles which consist of the core musculature, have an influence on spinal stability and impact athletic performance (30). When division 1 football players (19) and female soccer players (20) were assessed, it was concluded that the relationships between core muscle endurance and performance were not strong. In the study conducted by Clayton et al., the relationship between isokinetic core strength and various performance tests was investigated in college baseball players. The results showed a correlation between isokinetic core strength and the backwards overhead medicine ball throw (16).

According to previous studies, scapular muscle endurance was found to be associated with injury risk and performance (17,18,31). Scapulothoracic muscles were found to be susceptible to muscle fatigue and it is known that muscle fatigue alters the scapular kinematics (17,31). It has been shown that there is a correlation between altered scapular kinematics and shoulder impingement (18). Therefore, the assessment of scapular muscle endurance is clinically significant (13). Due to the importance of the kinetic chain principles during daily movements and particularly during complex sport movements, local adaptations at the scapulothoracic joint may affect the quality of movement via the kinetic chain and alter the quality of the final outcome. Stronger protractors may lead to an increase in the energy transfer from the trunk to the upper extremities or vice versa, and thus improve athletic performance (10).

The endurance of the scapular and core muscles are both associated with injury risk and performance. Scapular and core muscle endurance may also affect each other. As a result of our study, it was found that; core muscle endurance was positively correlated with scapular muscle endurance. This relationship can be explained via several mechanisms. The first mechanism could be; the thoracolumbar fascia which covers the trunk like a band (32). The thoracolumbar fascia connects the lower and upper extremities in order to combine the superior/ inferior and right/left parts of the kinetic chain (33). It consists of anterior, middle, and posterior layers. The superficial lamina of the posterior layer arises from the latissimus dorsi muscle. The transversus abdominis has extensive attachments to the middle and posterior layers of the thoracolumbar fascia (34). The superficial lamina forms a fascial cover connecting posteriorly. This cover contains several muscle groups. These muscles are pectoralis major and minor, rhomboideus major and minor, trapezius, and serratus anterior. The superficial lamina continues towards the caudal end, and reaches the latissimus dorsi and gluteus maximus (24,35). These layers have important biomechanical functions as a mediator in the transfer of load and energy between the upper and lower extremities and abdominal wall and the lumbopelvic region (36). With its connection to the internal obliques and transversus abdominis muscles, the thoracolumbar fascia functions to provide further cylindrical stabilization to the spine (33,37). By contracting prior to limb movement and independent of respiration, another muscle shown to assist with spinal stability is the diaphragm (33). The another mechanism could be the "serape effect" mechanism which supports the connection between the body and the extremities (38). According to this mechanism, the muscles which form the body have a crisscross design. This creates the mechanism which provides the force production between the shoulders and contralateral hips. The diagonal tension of the body occurring with the rotation of the shoulders and the hips in opposite directions is called the "serape effect." It takes place with the interaction of the rhomboideus major, rhomboideus minor, serratus anterior and oblique abdominal muscles (38). According to Gracovetsky's spinal machine theorem, the oblique abdominal muscles work together with the other core muscles and create a rotator torque by bringing out kinetic and potential energy. As a result of this torque, many functional movements that are based on the core muscles, such as walking, throwing and similar movements are formed. The power which comes from the body and lower extremities joins the power produced in the upper extremities through the thoracolumbar fascia and maximum power production is achieved (39,40). These mechanisms explain the biomechanical integration of the body and extremity segments in the kinetic chain approach (38). Another reason is could be due to the fact that the shoulder positions in the scapular endurance test and the prone bridge test are similar.

The importance of core stability has been clarified by studies that specifically address patterns of muscle activation during sportive activities. It has been shown that, in response to rapid arm movements, muscle activation patterns in the lower extremity commence and proceed upwards through the trunk and to the arm (41). This force development pattern initiating from the ground through the core to the extremity has been demonstrated in tennis (11) and baseball (42). Findings that suggest the trunk and peri-scapular muscles are responsible for nearly 85% of the muscle activation required to decelerate the forward moving arm during throwing is evidence showing the importance of core stability (43). These findings provide a basis for further research to evaluate the specific role of core stability in performance, injury, and rehabilitation (33).

The study conducted by Edmondston et. al showed that the scapular endurance test had moderate reliability in athletes with postural neck pain (21). The findings of Eraslan et. al indicate that scapular muscle endurance which was evaluated using the scapular endurance test was found to be significantly lower in textile workers who had chronic shoulder pain (23). Hazar et. al found a fair positive correlation between scapular muscle endurance and the side bridge test in healthy subjects. In their study, only McGill endurance tests were used for evaluation. As a conclusion they recommend that the prone bridge test should be included in the evaluation (24). In our study, a moderate positive correlation was found between the prone bridge test and scapular muscle endurance.

Increased muscle endurance of the core will lead to an increase in scapular muscle endurance and reduce the risk of shoulder injury. Therefore the upper extremity will also provide normal functioning and improve the performance of the athlete. To reduce the risk of injury and to improve performance, exercises that increase the core muscle endurance of the athletes should be included in the training programs of the athletes.

CONCLUSION

As a result, a relationship was found between scapular and core muscle endurance in athletes. Scapular muscle endurance may affect core endurance via the kinetic chain. Therefore, in order to increase sportive performance and decrease risk of injury, it is important to include athletes in exercise programs that improve scapular and core muscle endurance. These exercise programs should be designed in order to bring out the optimal performance of athletes. Future studies should investigate the effects of both scapula and core muscle endurance on upper extremity injury risk and athletic performance.

The results could have been more illustrative of the injury-related outcome if athletes with and without injuries were evaluated. This may be the limitation of the study.

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