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Impact of Scapular Stabilization Exercises on Pain, Shoulder Position, and Performance in Volleyball Players with Scapular Dyskinesia

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ABSTRACT

Background: This study aimed to examine the impact of a regimen of scapular stabilization exercises on pain, shoulder position, and performance in volleyball players diagnosed with scapular dyskinesia.
Methods: This semi-experimental, applied study involved 30 female volleyball players with scapular dyskinesia, who were purposefully selected and randomly assigned to control and training groups. The position of the shoulder, shoulder pain, and specific performance of the volleyball players were assessed using photographic methods, a numeric pain rating scale, and the AAHPERD service test. The training group performed scapular stabilization exercises for eight weeks. Post-tests were conducted after the exercise regimen. Parametric data were analyzed using paired t-tests and analysis of covariance, while non-parametric data were evaluated using the Wilcoxon and Yeoman-Whitney tests.
Results: The findings indicated that an eight-week program of scapular stabilization exercises significantly improved shoulder position and specific performance and reduced shoulder pain in volleyball players with scapular dyskinesia.
Conclusion: Scapular stabilization exercises can effectively enhance shoulder position, improve specific performance, and alleviate shoulder pain in volleyball players suffering from scapular dyskinesia.

Introduction

An optimal posture necessitates the coordination of various body parts, one of which, the scapula, plays a pivotal role in maintaining good posture. The crucial role of the scapula bone has gained significant attention in recent years. Indeed, the scapula plays a substantial role in facilitating smooth and coordinated movements of the shoulder girdle [1]. The position of the scapula is critical to the body's posture, the strength and endurance of the shoulder girdle muscles, and the prevention of injuries in the targeted area. Maintaining this bone in abnormal positions disrupts the performance of the shoulder muscles and leads to various abnormalities in the shoulder girdle. Furthermore, the proper positioning of the scapula is a vital component in the performance of the shoulder joint. It enables precise access to the target in the upper limb and optimal performance of daily tasks, such that most of the shoulder's range of motion is attributable to the movement of the scapula-thoracic joint.

Alterations in the normal position of the scapula and the movement pattern, caused by changes in the activity of the serratus anterior and trapezius muscles, are referred to as scapular dyskinesia [2, 3]. This term denotes the abnormal movement pattern of the scapula [3] and is categorized as a shoulder functional disorder [4]. Symptoms include the protrusion of the inner edge and lower angle of the scapula relative to the chest in both static positions and dynamic movements.

The movement pattern in scapular dyskinesia is

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associated with chronic shoulder pain in overhead-throwing athletes, instability, rotator cuff tears, and shoulder impingement syndrome. These disorders can lead to insufficient upward rotation of the shoulder, instability of the glenohumeral joint, thoracic outlet syndrome during hand elevation, and long-term compressive force on the cervical spine [3].

This syndrome can result in shoulder pain, which causes compensatory movements in the muscles surrounding the shoulder girdle. The kinematics of the scapula and the activity pattern of the associated scapular muscles influence the shoulder. Disruptions in these areas can cause pain, limit the range of motion, and lead to functional disorders in the shoulder girdle [5].

Scapular dyskinesia can be attributed to many factors. These include bone factors such as having an increased arch in the back area, poor fusion or non-fusion of a clavicle fracture, and joint factors including severe instability or arthrosis of the acromioclavicular joint, as well as instability or a stuck glenohumeral joint [6].

The researchers suggest that abnormal scapula movement may be associated with weakness in the surrounding muscles. Overactivity in the upper part of the trapezius, coupled with inhibition of the serratus anterior and lower part of the trapezius muscles, can lead to changes in the normal kinematics of the scapula [5, 7, 8]. Effective posture, movement, stability, muscle performance, and motor control of the shoulder are significantly influenced by scapular function. Consequently, dysfunction in any of these muscles may result in an abnormal shoulder condition or a movement disorder leading to shoulder dysfunction [9]. The position and orientation of the scapula in athletes engaged in overhead activities, such as volleyball, differ significantly from those in athletes from other sports. This suggests that these athletes adapt according to their specific fields of activity [10]. The inability of the scapula to perform these roles results in a loss of physiological and biomechanical efficiency, thereby reducing the efficiency of shoulder function. This can lead to poor performance and an increase in shoulder injuries [11]. Therefore, the scapula bone and shoulder girdle are crucial in various sports, including volleyball.

Therapeutic exercise is a recognized treatment method for shoulder disorders. Among the effective exercises are strength, stretching, and shoulder stabilizing exercises [12, 13]. Scapular corrective and stabilizing exercises, a training program, enhance the stability and strength of the muscles surrounding the scapula. The aim is to maintain the proper position of the scapula, reduce associated pain, and alleviate disease symptoms. These exercises are frequently prescribed in rehabilitation programs for various types of shoulder pain syndromes. They can correct abnormal functional movement and placement associated with abnormal dynamic adjustment and stability of the entire shoulder girdle. Additionally, scapular corrective exercises can improve pain, disability, and scapular alignment [12, 13].

Given the existing research gap, the high prevalence of shoulder overuse injuries in volleyball players, and the lack of similar research on volleyball players with scapular dyskinesia, it is necessary to conduct an intervention. This would investigate the effect of scapular stabilizing exercises, emphasizing the prevalence of one-sided activity in this group of athletes and the occurrence of scapular dyskinesia among them. The impact of this type of training on shoulder pain and its effect on shoulder position and performance needs to be studied. Therefore, our research aims to study the impact of scapular stabilization training on the shoulder position, pain, and function of athletes with scapular dyskinesia.

Methods

This research was applied and semi-experimental, operating under the code of ethics IR.IAU.URMIA.REC.1400.051. The study's statistical population was comprised of female volleyball athletes aged 18-25 years with scapular dyskinesia and shoulder pain from the city of Urmia. The samples for this research (N: 30) were selected through a convenient sampling method from the community, with consent obtained and based on the formula for sample size. They were then randomly assigned into control (N: 15) and experimental (N: 15). One of the main inclusion criteria for this study was having scapular dyskinesia and dominant shoulder pain. Exclusion criteria included any history of previous surgery and fractures in the joints of the upper limbs, any physical deformity affecting the research process, participation in any rehabilitative exercise and therapeutic exercises within the last six months, a burst of the rotator cuff muscle, and a history of surgery for shoulder stability, an inability to flex and abduct the shoulder by 150 degrees, and unwillingness to continue exercises and evaluations during the research. A written informed consent form was obtained from the research samples.

The Observational Scapula Dyskinesia Test (SDT) was utilized to evaluate scapular dyskinesia. In this process, the subjects stood with their hands at their sides, elbows straight, and shoulders in a neutral rotational position. The examiner was situated one and a half meters behind the subject. The subjects were instructed to raise both hands in the frontal and sagittal planes, counting to three with their thumbs up, and then lower them in three seconds. This sequence was repeated five times for both arm flexion and abduction, performed bilaterally. The prominence of the inferior angle and the medial side of the affected scapula was identified as a scapular dyskinesia disorder (Figure 1). The reliability of this method ranges between 0.75 and 0.95 [14].

In the pre-test stage, the forward shoulder position was evaluated using photography from the body's profile view. This method has been used in many studies and has desirable reproducibility. Using this method to measure the forward shoulder angle, two anatomical indicators were first identified: the acromion protrusion on the right side and the spinous process of the 7th cervical vertebra. These were marked with a landmark, with an embossed landmark used for the 7th cervical vertebra's spinous process. Next, subjects were asked to stand at a designated spot beside a wall, with their left arm towards it. The camera was then positioned 265 cm away from the wall, aligned with the person's shoulder level. After bending the upper extremity

Figure 1: scapula Dyskinesia Test (SDT)

forward for three counts and standing comfortably while looking at an imaginary point, a photo of the body profile was taken [15]. Finally, AutoCAD software recorded the forward shoulder angle [15].

The Numeric Pain Rating Continuum assessed pain in the dominant shoulder. This scale is represented by a 10 cm long horizontal bar, with 0 at one end indicating no pain and ten at the other end indicating severe pain (Figure 2). Subjects were asked to quantify the pain they experienced in their dominant shoulder joint by referring to this spectrum [16]. This continuum further categorizes the intensity of pain into four levels: none (0 to 4 mm), mild (5 to 44 mm), moderate (45 to 74 mm), and severe (75 to 100 mm) [17]. The validity of this scale has been reported as 0.70, and its reliability as 0.97 [18].

The AAHPERD volleyball service test assessed volleyball players' sports performance. For this test, subjects stood in front of a marked field and performed ten correct and legal services. These services required the ball to pass over the net and land in the marked area. Balls that hit the net or landed outside the field were not awarded any points. The subject's score was calculated based on the number of times the ball hit the opposite field. As depicted in Figure 3, the scoring was as follows: 4 points were awarded for the end of the field, 3 points for the two side areas, and 1 and 2 points for the middle of the field. The final score for the subjects was determined by the sum of the points obtained from serving ten times [19].

The exercise program was conducted over eight weeks, with three sessions per week. Each session lasted 40 minutes and was supervised by the researcher. Each training session included warm-up and cool-down periods, each lasting between 5 to 10 minutes. The exercises in the current protocol included scapular retraction, push-up plus, scapular retraction and depression exercises, suspension, and leaning forward (Table 1). The program aimed to activate more movement units in the muscles

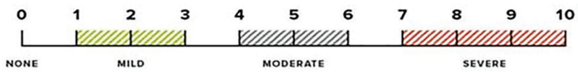


Figure 2: Numeric scale of pain continuum

of this area, thereby generating more force to achieve scapular retraction. This helps restore the position of the scapula, thereby increasing the mobility of the scapula during shoulder movements. The training load was adjusted based on the principle of individual differences and the difficulty in performing the training program. This was achieved by increasing the weight force and modifying the band tension. During the first six weeks of training, the focus was on improving postural awareness and using an exercise ball to strengthen the scapular stabilizers in the performance position [20].

The Shapiro-Wilk test was utilized to verify the normality of the data distribution. The paired t-test and the analysis of covariance test were employed for the analysis of parametric data. In contrast, the Mann-Whitney U and Wilcoxon tests were used for non-parametric data. All statistical operations were conducted using SPSS software, version 24.

Results

Table 2 presents the individual characteristics of the subjects, including weight, height, age, body mass index, and sports history.

The independent t-test results, which were used to investigate the variables' homogeneity, confirmed the descriptive variables' homogeneity in both groups.

The independent t-test results, which were used to investigate the variables' homogeneity, confirmed the descriptive variables' homogeneity in both groups. As per Table 3, it was found that all research variables, except for the pain variable, were normal.

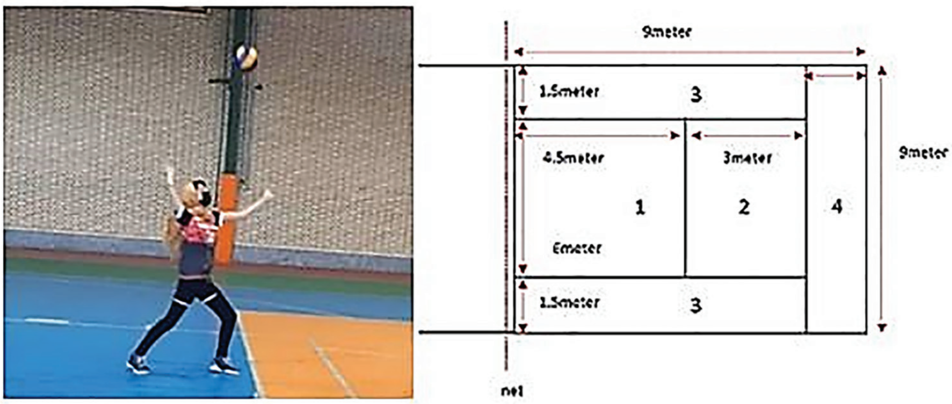
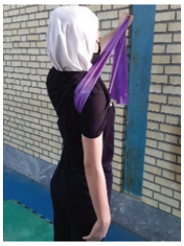


Figure 3: Marked field for volleyball service test

Table 1: Training Program

Training protocol		**Week**			
Exercise		**First&2nd**	**3rd & 4th**	**5th & 6th**	**7th & 8th**
Scapular retraction (By keeping 20 seconds for each exercise)	Set	3	3	3	3
	Repetition	10	15	20	25
Push-up plus (by keeping 5 seconds)	Set	3	3	3	3
	Repetition	10	15	20	25
Scapular retraction and depression (by keeping 10 seconds)	Set	3		3	3
	Repetition	10	15	20	25
Suspension (by keeping 10 seconds)	Set	3	3	3	3
	Repetition	10	15	20	25
Leaning forward (by keeping 5 seconds)	Set	3	3	3	3
	Repetition	10	15	20	25

Consequently, paired t-tests and covariance analysis were employed to examine shoulder position and performance variables. The Mann-Whitney U and Wilcoxon statistical tests were utilized to examine the pain variable. Table 4 reports the results of the paired t-test for intra-group comparison.

The results of the paired t-test indicate a significant effect of the training program on improving shoulder position (reducing forward shoulder angle) (P=0.001) and enhancing shoulder performance (P=0.001) in the group undergoing shoulder stabilizer exercises. However, a significant difference in performance was observed in the control group after eight weeks. Table 5 presents the results of the analysis of the covariance test for inter-group comparison.

After controlling for the effect of the pre-test, the analysis of the covariance test revealed a significant difference in the post-test results for the variables of shoulder position (P=0.001) and performance (P=0.02) between the exercise and control groups. Specifically, these variables showed significant improvement in the training group compared to the control group. Tables 6 and 7 display the Wilcoxon and Mann-Whitney U test results.

The Wilcoxon test results validate the training program's impact on the reduction of dominant shoulder pain in the scapular stabilization exercises group. Furthermore, the Mann-Whitney U test results indicate a difference between the post-tests of the control and training groups.

Table 2: Descriptive statistics of the research variables

Index	Group	No.	mean±SD	P
Age (year)	Control	15	22.20±2.65	0.32
	Training	15	23.13±2.47	
Height (m)	Control	15	1.69±0.03	0.09
	Training	15	1.71±0.02	
Weight (Kg)	Control	15	60.73±4.23	0.12
	Training	15	63.20±4.21	
Body Mass Index (Kg/M^2)	Control	15	21.06±1.29	0.50
	Training	15	21.41±1.51	
Sport History (year)	Control	15	5.73±2.08	0.64
	Training	15	6.06±1.86	

BMI: Body Mass Index

Table 3: Results of the Shapiro-Wilk test to check the normality of the data distribution

Research Variables	Control Group		Training Group	
	Pre-test	Post-test	Pre-test	Post-test
Dominant Shoulder Pain	0.001	0.001	0.10	0.001
Forward Shoulder	0.11	0.10	0.22	0.08
Performance	0.47	0.12	0.72	0.07

Above 0.05 is normal, and below 0.05 is not normal

Table 4: paired t-test results for intra-group comparison of shoulder position and performance

Variable	Control Group				Training Group			
	Pre-test	Post-test	T	P	Pre-test	Post-test	T	P
Shoulder Position	56.93±1.86	56.60±1.91	1.58	0.13	56.53±1.50	54.80±1.42	6.98	0.001**
Performance	26.80±4.75	28.13±5.02	-2.42	0.02	28.53±3.70	31.40±3.26	-5.56	0.001**

Table 5: Results of analysis of covariance test for inter-group comparison of shoulder position and performance

Variable		Mean squares	F relation	Sig. level	Volume of effect
Shoulder Position	Pre-test	59.36	77.66	0.001	0.43
	Groups	15.68	20.52	0.001**	
Performance	Pre-test	391.81	94.86	0.001	0.16
	Groups	21.85	5.29	0.02*	

Table 6: Results of the Wilcoxon test to examine the pain variable

Group	Control				Training			
	Pre-test	Post-test	Z	P	Pre-test	Post-test	Z	P
Dominant Shoulder Pain	4.00±0.92	3.86±1.12	-0.63	0.52	4.33±0.61	2.46±0.51	-3.50	0.001**

Table 7: Results of Mann-Whitney U test to examine the pain variable

Variable	Group	Pre-test			Post-test		
		U	Z	P	U	Z	P
Dominant Shoulder Pain	Control Training	90.00	-0.99	0.36	32.00	-3.54	0.001**

Consequently, it can be inferred that the effect of training on reducing shoulder pain led to a difference in the post-test results between the groups.

Discussion

Our research aims to study the impact of scapular stabilization training on the shoulder position, pain, and function of athletes with scapular dyskinesia. The research results demonstrate that a course of scapular stabilization exercises in the experimental group, compared to the control group, significantly reduces shoulder pain, improves shoulder position, and enhances the specific function of athletes with scapular dyskinesia.

The results of the present research suggest that a course of scapular stabilization exercises significantly impacted the shoulder pain of volleyball players with scapular dyskinesia, leading to a reduction in shoulder pain. Scapular stabilization exercises can lead to a reduction in pain in the dominant shoulder, which aligns with the findings of Başkurt et al.'s research [21]. According to Kadi et al., pain alleviation is likely due to muscle hypertrophy in strength training, which leads to increased blood flow and a reduction in pain intensity [22]. Scapular stabilization exercises are utilized to achieve stability and strength of the muscles involving the scapula, to maintain the proper position of the scapula, to relieve pain, and to alleviate disease symptoms. These exercises are continuously prescribed as a fundamental component in rehabilitation programs for various types of shoulder pain [13]. Therefore, this exercise protocol can be implemented in accordance with the exercise regimen of this research to reduce pain in athletes with dyskinesia.

The results of the current study reported that scapular stabilization exercises significantly influenced the shoulder position of athletes with scapular dyskinesia, leading to an improvement in their shoulder position. Scapular stabilization exercises can lead to an improvement in the shoulder position of athletes with scapular dyskinesia, which aligns with the studies of Sepehari Far et al., Park et al., and Haji Hosseini et al. [23-25]. In their frequent and regular exercises, volleyball players use their hands extensively in front of the body, and most athletes use the dominant hand. Therefore, the possibility of disturbing the symmetry and position of the scapula (creating scapular dyskinesia) and the occurrence of forward shoulder deformity is common in this group of athletes. To prevent and correct these disorders, it is suggested that coaches and volleyball players of different ages use these exercises to modify abnormal situations and prevent pain and damage to other soft tissues.

Furthermore, the results of the present study reported that scapular stabilization exercises significantly impacted the specific function of athletes with scapular dyskinesia. Scapular stabilization exercises can improve the function of athletes with scapular dyskinesia, which aligns with the study by Donatelli et al. [26]. Generally, frequent use of the dominant arm can lead to functional impairment and ligament laxity due to joint and muscle contraction [27]. In over 68% of cases, shoulder dysfunction occurs concerning the position and movement of the scapula [28]. The trapezius and serratus anterior muscles are the primary muscles that help to position the scapula and maintain the rhythm of the scapula, leading to pain reduction and performance enhancement [29, 30]. In addition, if the function of the shoulder is impaired or the muscles stabilizing the scapula are weakened, the position of the scapula will change [1]. Geronimo et al. [31] reported that improving muscle function is an effective intervention for improving recovery and preventing shoulder dysfunction. Therefore, scapular dyskinesia is associated with changes in scapular position, pain, and reduced scapular function in athletes, and stabilizing exercises can improve these components in scapular dyskinesia. The inability to control the level of sleep, nutrition, and mental states of the subjects was one of the limitations of the present research.

Conclusion

Based on the results obtained, the exercises implemented in this study serve as a suitable, scientific, cost-effective, and side-effect-free solution for reducing shoulder pain, enhancing shoulder positioning, and improving the function of athletes with scapular dyskinesia. Consequently, it is recommended that trainers and health and corrective movement specialists utilize these exercises to enhance shoulder positioning, boost the specific performance of volleyball players, and alleviate their dominant shoulder pain.

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Conflict of Interest: None declared.

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