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Efficacy of Six Weeks Stability Exercises on the Glenohumeral Joint of Female Tennis Players with Scapular Dyskinesia

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ABSTRACT

International Journal of Exercise Science 15(3): 962-973, 2022. Background: Stabilizing exercises reduce pain intensity, improves shoulder position and scapular function, and provides an appropriate strategy for the improvement of scapular dyskinesia. The purpose of this study was to investigate the effect of six weeks of stability exercises (stretching-strengthening) on joint proprioception, strength, and range of motion of the glenohumeral joint in female tennis players with scapular dyskinesia. Methods: Thirty-six female elite tennis players with scapular dyskinesia in both experimental and control groups participated in this study. Goniometer, Isokinetic and Biodex devices were used to evaluate the range of motion, internal and external rotation strength in 60° and 180°, and joint proprioception at 45° and 60°, respectively. Also, the lateral scapular slide test (LSST) was used to evaluate the scapulohumeral rhythm. For analyzing dependent variables and determining statistical significance the ANCOVA and an alpha of 5% was used. Results: The results of this study indicated the effect of the stability exercise program on the range of motion of internal (p = 0.016) and external (p = 0.023) rotation of the shoulder. Also, significant differences were observed between the control and training groups for internal rotation strength 60° (p = 0.013), 180° (p = 0.017) and external rotation strength 60° (p = 0.005), 180° (p = 0.045) and strength ratio 60° (p = 0.001) and 180° (p = 0.023). However, there were no significant differences for proprioception. Conclusion: In general, the findings of this study support the effectiveness of exercise therapy as a safe intervention for improving scapular function in tennis players with scapular dyskinesia.

KEY WORDS: Scapular dyskinesia, performance, joint stability, exercise.

INTRODUCTION

Hitting the ball, especially the kick serve is the most effective shot in tennis that can influence the outcome of the match (23). Therefore, a proper understanding of important associated factors with these shots is essential for coaches to assist players in developing their skills and improving their performance (34). The scapular muscles in cooperation with the rotator cuff muscles provide adequate control and power transmission for the glenohumeral and scapulothoracic joint movement (14).

The scapula stabilizers play the most important role in coordinating and maintaining the movement of the shoulder complex (34). Cuff and scapular rotators allow three-dimensional shoulder movements by restricting excessive movement that can be a risk for joint integrity (14). Scapular dyskinesia (SD) occurs whenever there is an abnormal position in the movement or function of the scapula (13, 21). The prevalence of SD affects the overall function of the upper extremities and is generally higher in overhead athletes than in other athletes (8, 24). Multiple factors that may affect dyskinesia involve bone deformities, joint problems, neurological disorders, and soft tissue imbalances. Soft tissue mechanisms for scapular dyskinesis involve inflexibility (tightness) or intrinsic muscle problems. Inflexibility and stiffness of the pectoralis minor and biceps short head can create anterior tilt and protraction due to their pull on the coracoid (5). Posterior shoulder inflexibility can lead to glenohumeral (GH) internal rotation deficit (GIRD), which creates a 'wind-up' of the scapula on the thorax with reduced humeral internal rotation and horizontal abduction. Alterations in peri-scapular muscle activation are related to scapular dyskinesis. Serratus anterior activation and strength are decreased in patients with impingement and shoulder pain, contributing to the loss of posterior tilt and upward rotation causing dyskinesis (9). In addition, the upper trapezius/lower trapezius force couple may be altered, with delayed onset of activation in the lower trapezius, which alters scapular upward rotation and posterior tilt. SD also reduces the range of motion in shoulder flexion movement in overhead athletes (29). As a factor in causing SD, impingement syndrome reduces shoulder external rotation and increases upper trapezius muscle activity. The SD is also caused by rotator cuff muscle fatigue and subluxation or dislocation of the GH joint, which can alter sensory feedback, and when sensory feedback changes, the central nervous system errs in the motor instructions needed to produce normal motor pathways (22).

Several studies have emphasized that exercise therapy can be effective in restoring normal scapular kinematics (10, 16, 28). Thus, scapula-focused exercise therapy is known as one of the most important physiotherapy interventions in people with shoulder impingement syndrome and scapular dyskinesia (25, 28, 33). Scapular correction and stabilization exercises are a type of program that is used to gain stability and strength of the muscle groups around the scapula to maintain the proper position of the scapula, reduce related pain, and symptoms of the disease (25). Stabilizing exercises increase muscle mass, strength, and capillaries around muscle fibers, which can increase blood flow (33). Therefore, it reduces pain intensity, improves shoulder position and scapular function, and provides an appropriate strategy for the improvement of SD (33). The scapula stabilization protocol emphasizes muscle retraining in dynamic scapular stabilization by doing exercises with shorter lever lengths, then kinetic chain cooperation exercises, and progress towards exercises with long levers (33). Also, there is an emphasis on the use of closed and open chain exercises to improve SD, and the training protocols involve these chains (14). However, limited data are available on the effect of scapular stabilization exercises on scapular position, proprioception, strength, and range of motion of the glenohumeral joint.

Therefore, the present study was performed to investigate the effect of 6 weeks of strength and stretching exercises on proprioception, strength, and range of motion of the glenohumeral joint in female tennis players with scapular dyskinesia. The main hypothesis was that 6 weeks of stabilization exercise can improve internal and external strength, strength ratio, internal and external ROM, and proprioception in the experimental group.

METHODS

Participants
A sample size of thirty-six participants for achieving an alpha level of 0.05 and a power (1 - β) of 0.80 and based on a statistical power analysis from a pilot study was deemed necessary. Thirty-six elite female tennis players were selected to participate in the present study. They had to train in a professional club and we got the training time information from their club. They had at least 3 years of experience in playing tennis (3-5 times "6-10 hours" a week) and should have scored more than 1.5 in the Lateral Scapular Slide Test (LSST) and no history of upper limb injury or neurological diseases. The division of participants into experimental group (n = 16, age 22.50 ± 3.16 years, body mass 61.12 ± 4.03 kg, height 167.81 ± 4.18 cm, BMI = 21.70 ± 1.22) and control group (n = 17, age 23.76 ± 2.72 years, body mass 63.82 ± 4.08 kg, height 169.29 ± 2.66 cm, BMI = 22.26 ± 1.28) was simple random sampling. Due to injuries of two people and withdrawal of one, 33 subjects were eventually included for the post-test (16 people from the training group and 17 people from the control group) (Figure 1: Flowchart). This study was approved by the University Research Ethics Committee (#DBSI22112019). The participants were aware of the pros and cons of the study prior to any data collection and then read and signed an institutionally approved informed consent document, following the declaration of Helsinki. This research was carried out fully in accordance with the ethical standards of the International Journal of Exercise Science (26).

Protocol
Intragroup with pretest-posttest and control group design. Subjects were prohibited from performing upper body exercises for at least 6 hours prior to attending the laboratory. All participants received specific instructions about warming-up and stretch-strengthening procedures. Afterward, the demographical characteristics of participants were assessed. Participants performed a general warm-up with 5-min of jogging and a specific warm-up with 5-min playing tennis without a ball in each session. All participants attended the pre-test session before performing any experimental protocol. The Cybex CSMI isokinetic dynamometer machine, the Biodex Multi-Joint System (Biodex Corp., NY, USA), and universal goniometer were used to evaluate the concentric strength of the external/internal rotator muscles at 60° and 180° angular velocity, proprioception, and the upper extremities ROM, respectively. Then, all participants of the training group performed strength and stretching training for 6 weeks (twice a week, 12 sessions, and 1 hour per session) in addition to specific tennis activities; and the

control group maintained only specific tennis activities. After six weeks, the same tests were performed (post-test) and in all sessions, participants were verbally encouraged, and all measurements were performed by a researcher at a specific time, between 2 pm and 5 pm.

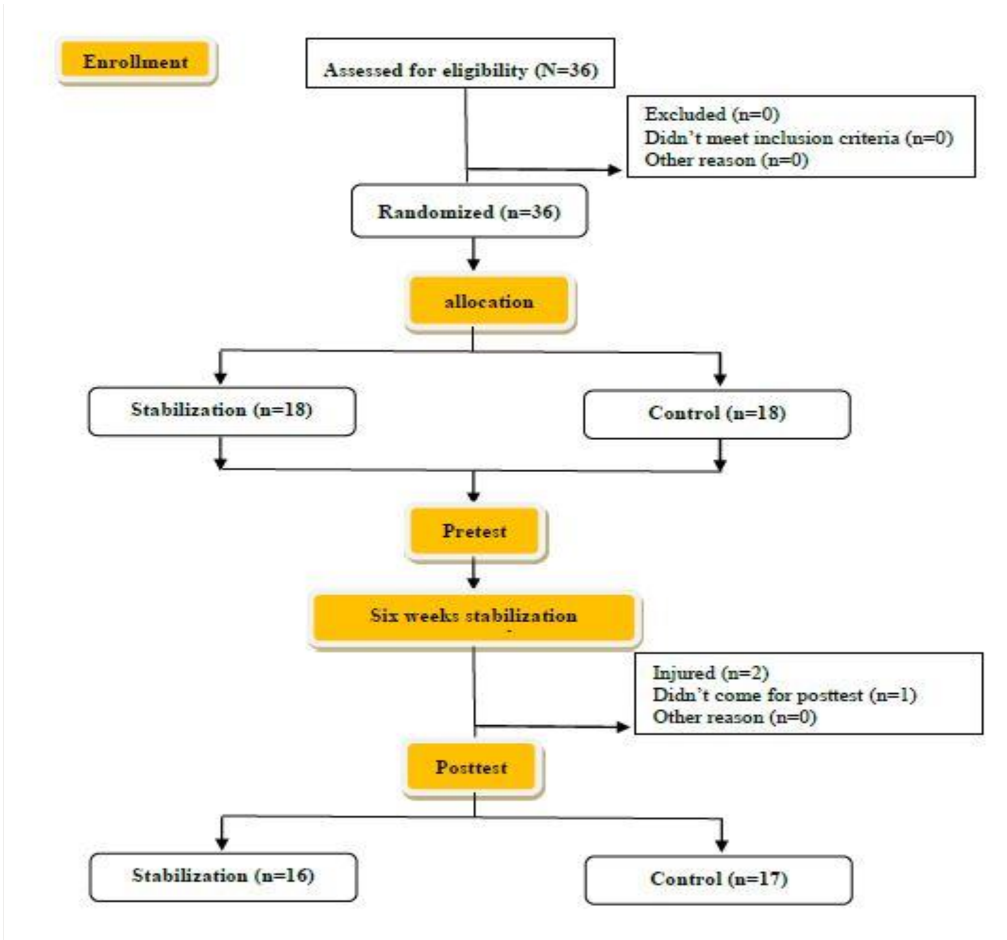

Figure 1. Flowchart

Intervention: The training group performed a stretching-strengthening training protocol. The training protocol was divided into two parts, as follows: 1. Static Stretching: all participants performed 3 active static stretches of 45-sec between sets at 70-90% of the point of discomfort (POD), where 0 = "no stretch discomfort at all" and 100% = "the maximum imaginable stretch discomfort". The participants performed the following exercises: cross-body adduction, sleeper stretches, and corner stretches 2. Strength training: all participants performed 8 different strengthening exercises including ceiling punch, pron-T, and prone-Y, bilateral external rotation from zero degrees with Thera-Band, standing dynamic hug with Thera-Band, lawnmower, Blackburn, and Swedish swim (push up). The progression in intensity of exercises changed once every two sessions – changing the type of movement for both types of exercises, increasing the number of movements, sets for strength exercises, and increasing the time of stretch for stretching exercises – while observing the overload principle (Table 1)(3, 14, 20, 30).

Table 1. Stretching and Strength Protocols.

	First	T/Rep	Set	Second	T/Rep	Set
Week 1	Sleeper stretches	10s	3	Cross body adduction	10s	3
	Pron T	8	3	Ceiling punch	8	3
	Prone Y	8	3	Pron T	10	3
Week 2	Sleeper stretches	15s	3	Cross body adduction	15s	3
	Bilateral external rotation	8	3	Blackburn exercises	8	3
	Prone Y	10	3	Bilateral external rotation	10	3
Week 3	Sleeper stretches	15s	4	Corner stretches	15s	3
	Bilateral external rotation	10	4	Blackburn exercises	12	3
	Standing dynamic hug	8	4	Prone Y	12	3
Week 4	Sleeper stretches	20s	4	Corner stretches	20s	3
	Bilateral external rotation	12	4	Blackburn exercises	12	3
	Pron T	12	4	Standing dynamic hug	12	3
Week 5	Sleeper stretches	25s	4	Corner stretches	25s	3
	Lawnmower exercises	12	4	Push up	12	3
	Blackburn exercises	12	4	Bilateral external rotation	12	3
Week 6	Cross body adduction	30s	4	Corner stretches	30s	3
	Lawnmower exercises	15	4	Standing dynamic hug	15	3
	Blackburn exercises	15	4	Lawnmower exercises	15	3

Legend: T = Time, Rep = Repetition, s = Second

Instrumentation:
The Lateral Scapular Slide Test (LSST): The LSST is used to determine the scapular position with the arm abducted in three positions. It can be reliable in screening scapular position (ICC: 0.83-0.96)(12). For the LSST evaluation, participants were asked to stand backside to the examiner. Then, the inferior angles of the participants' shoulders were marked as a reference point, and the distance between the two inferior angles was measured and recorded using a tape measure (mean of three measurements). To evaluate the lateral motion and symmetry of the scapulae, the LSST was used at 0°, 45°, and 90° of shoulder abduction (18). These measurements were done for both left and right shoulders.

External and internal muscle strength: The Cybex CSMI isokinetic dynamometer (CSMI Cybex Humac Norm, USA) was used to assess the strength of rotator cuff muscles. It can be reliable in assessing isometric contractions (ICC: 0.88), concentric and eccentric contractions (ICC: 0/92), and strength ratio of agonist and antagonist muscles (ICC: 0.62, ICC: 0.73)(1). The evaluation conditions were the same for all participants. The maximum external/internal torque of the shoulder was recorded at an angular velocity of 60°/s and 180°/s. Participants performed three sub-maximum attempts, resting for 5 minutes between positions (60° and 180°) at different angular velocities. Then, the maximum torque recorded by the isokinetic device was normalized using the participant's weight. External/internal rotator cuff strength and external/internal rotation ratio were reported in the upper limb in terms of N/m (17).

Joint Proprioception: The Biodex Multi-Joint System (Biodex Corp., NY, USA) was used to assess the shoulder proprioception. This device has an electro-goniometer with a sensitivity of 1°. It can be reliable in assessing shoulder proprioception (ICC: 0.92). Active angle repositioning was measured while the participants were in a seated position, their back was vertical, their shoulder was positioned at 90° of abduction and the elbow was flexed to 90°. Participants were blindfolded to exclude visual signals related to the joint position (31). After the subjects warming up and at the beginning of the test, the subjects' shoulders were passively moved to 45- or 60-degrees external rotations of the shoulders by the researcher. Then, the participants were asked to focus on the desired angle for three seconds. Then the subjects' shoulders were passively returned to the starting point by the examiner. The shoulder was held in the starting position for three seconds. Then the participant was asked to actively return to the simulated angle (target). When participants felt their shoulders at the target point, they pressed a switch to prevent extra movement of the dynamometer. The test was generally repeated three times at 45° and 60° angles, with a two-minute break between each test. The absolute error score (AES) is the difference between the desired angle (45° or 60°) and the target point (with eyes closed). This technique has good accuracy and validity to assess shoulder joint position sense (4).

External and internal rotation range of motion: The universal goniometer was used to assess shoulder external and internal range of motion. It is reliable to assess shoulder external and internal range of motion (ICC: ≥ 0.94) (19). In this measurement, the participant was lying on their back. The hand whose internal rotation's range was to be measured was placed at 90° shoulder abduction and 90° elbow flexion. To neutralize the arm and prevent extra movement in the shoulder joint, folded towels were placed under the participant's arm and the lower part of the arm was held in place. While the axis of the goniometer was on the olecranon process the stationary arm of the goniometer was in the vertical direction and its movable arm was along the midline of the forearm. The opposite arm was also placed freely next to the body. In this position, the participant's forearm actively moved down (internal rotation) and up (external rotation) as far as possible and, at the end of the range of motion, the obtained angle was measured and recorded (11).

Statistical Analysis

Shapiro-Wilk and Levene tests were used to evaluate the normality of data distribution and homogeneity of variances in the data, respectively. After evaluating the assumptions related to the analysis of covariance including equality of variances, homogeneity of regression, and linearity of the relationship between the covariate variable, and the independent variable was used ANCOVA for analyzing all dependent variables. SPSS 22 software was used to perform statistical analysis. An alpha of 5% was used to determine statistical significance.

RESULTS

Table 2 shows the absolute mean values (± standard deviation) for dependent variables and two presuppositions of the analysis of covariance, namely the homogeneity of the regression slope, which is examined based on the interaction between the covariance or control variable and the independent variable, and the linearity of the correlation between the covariate and the independent variable judged by the *F*-statistic of covariate variable. It also shows the effect of the independent variable on the dependent variable after removing the effect of the covariate variable.

Table 2. Mean and standard deviation, interaction, covariate, and group effects for both groups.

Variable			Group	Mean ± SD		Interaction		Covariate		Group	
				Pre-test	Post-test	*F*	Sig	*F*	Sig	*F*	Sig
Proprioception		45º	Control	3.58 ± 1.00	3.47 ± 0.79	0.96	0.333	6.07	0.019*	0.41	0.525
			Training	3.75 ± 0.77	1.93 ± 0.57						
		60º	Control	5.17 ± 1.01	5.00 ± 1.00	1.61	0.214	7.78	0.009*	0.01	0.967
			Training	4.95 ± 0.85	2.87 ± 0.71						
Strength	IN	60º	Control	52.11 ± 4.32	51.81 ± 4.89	1.31	0.260	108.9	0.001*	2.39	0.013⁋
			Training	53.15 ± 3.95	57.75 ± 4.94						
		180º	Control	45.91 ± 3.31	46.51 ± 3.50	1.63	0.210	28.39	0.001*	2.32	0.017⁋
			Training	46.26 ± 3.61	50.88 ± 4.53						
	EX	60º	Control	41.08 ± 4.59	41.87 ± 4.72	5.26	0.291	163.51	0.001*	9.04	0.005⁋
			Training	40.32 ± 3.53	47.68 ± 4.21						
		180º	Control	38.26 ± 4.11	39.40 ± 4.94	0.28	0.599	50.53	0.001*	0.57	0.045⁋
			Training	39.76 ± 4.45	44.91 ± 4.59						
Strength Ratio		60º	Control	0.79 ± 0.11	0.81 ± 0.15	11.76	0.183	199.03	0.001*	13.36	0.001⁋
			Training	0.74 ± 0.08	0.79 ± 0.07						
		180º	Control	0.84 ± 0.13	0.86 ± 0.18	2.01	0.166	57.97	0.001*	1.48	0.023⁋
			Training	0.88 ± 0.13	0.86 ± 0.12						
ROM	IN		Control	55.00 ± 5.29	55.88 ± 4.79	0.91	0.346	151.73	0.002*	0.13	0.016⁋
			Training	54.75 ± 6.12	60.50 ± 6.73						
	EX		Control	76.94 ± 10.95	77.47 ± 10.91	0.20	0.657	381.27	0.001*	1.50	0.023⁋
			Training	78.62 ± 7.51	85.18 ± 7.73						

Legend: IN = Internal, EX = External, PRE = Pretest, POST = Posttest. * = Significant of Covariate Variable. ⁋ = Significant Effect of Independent Variable on Dependent Variable

Table 2 shows that the interaction of the covariate variable and the dependent variable is not significant for joint proprioception of 45° and 60°, internal and external strength at 60° and 180°, strength ratio of 60 and 180 degrees, and in internal and external ROM, so the presupposition of homogeneity of the regression slope is respected for all dependent variables. Also, the results of the table indicated that the correlation presupposition of the covariate variable and the dependent variable is respected for all dependent variables.

According to the results of table 2, after removing the effect of the covariate variable, significant differences were observed between the control and training groups for internal strength at 60 degrees ($p = 0.013$) and 180 degrees ($p = 0.017$). Also, significant differences were observed between the control and training groups for external strength at 60 degrees ($p = 0.005$) and 180 degrees ($p = 0.045$). There were significant differences at 60 degrees ($p = 0.001$) and 180 degrees ($p = 0.023$) for the strength ratio.

For internal (p = 0.016) and external (p = 0.023) ROM, we have found significant differences between the control and training groups. While there were no significant differences between the control and training groups for proprioception at 45 degrees (p = 0.525) and 60 degrees (p = 0.967). In the other words, 6 weeks of stabilization exercise had a significant effect on internal and external strength at 60 and 180 degrees, strength ratio at 60 and 180 degrees, and internal and external ROM.

DISCUSSION

The study aimed to investigate the effect of 6 weeks of stability exercises (stretching-strengthening) on joint proprioception, strength, and range of motion of the glenohumeral joint of female tennis players with scapular dyskinesia. The main hypothesis was that stabilizing exercises affect the glenohumeral joint proprioception, strength, and range of motion. While our findings support the hypothesis of improvement in strength and range of motion after using stability exercises (stretching-strengthening). These data did not support the hypothesis of improvement in proprioception after using stability exercises. Our results support the findings of Moghadam et al. (2019). They demonstrated that different types of exercise therapy, such as stretching, scapular focused strengthening, and stabilization exercises, could reduce pain and disability. Therefore, they concluded that scapula-oriented exercises reduce pain and disability in individuals with shoulder impingement syndrome (SIS) and may improve scapular position and motion both in asymptomatic individuals.

Studies indicate that inappropriate alterations of scapula kinematic cause a reduction in normal physiological, mechanical, and shoulder girdle movement control (6). Scapular dyskinesia (SD), involves an abnormal protrusion at the inner edge and inferior angle to the thorax in a static position or during dynamic movements (15). The scapulothoracic joint is a unique joint that its movement is not dependent on the bony structure. On the contrary, it is the coordinated activity of the muscle groups around the scapula that determines the dynamic position of the scapula. Therefore, functional and neuromuscular dysfunction in each of these muscle groups may cause abnormal scapular position and dysfunction in the shoulder girdle (36).

Studies in the treatment of scapular dyskinesia have routinely used a variety of exercises and therapeutic exercise programs. In general, these treatment programs include anterior and posterior stretching of the shoulder girdle, muscle relaxation techniques, motor learning techniques to normalize impaired movement patterns, and strengthening programs to improve rotator cuff and scapular muscle function. However, there is no agreement on the optimal exercise regimen and the frequency and intensity of the exercise program. There is also limited evidence regarding the effect of scapular stabilization exercises on scapular dyskinesia (2, 7).

Camargo et al. (2009) examined the effect of strengthening and stretching exercises during working hours, which were performed twice a week in case of pain and physical impairments (7). They showed that using strengthening and stretching exercises help to reduce physical impairments and severity of pain in male workers (7). The goal of conservative treatment is the recovery in scapular retraction movement, posterior tilt, and external rotation.

Special exercises to reduce scapular traction and improve scapular kinematics are stretching and stabilization exercises. Başkurt et al. (2011) showed that scapular stabilization exercises could be effective on muscle strength, improve joint proprioception, and reduce scapular dyskinesia if they include stretching and strengthening exercises (2). The purpose of scapula stabilization exercises is to improve joint strength and proprioception and are based on strengthening and stretching exercises (32, 35). Some studies have shown that increasing the strength of the scapula stabilizing is more in the scapula stabilizer muscle group and concluded that this increase in muscle strength seems to improve the ability to control the scapula and reduce scapular dyskinesia. The results support the hypothesis that scapular dyskinesia rehabilitation programs can include stabilizing exercises (2).

Turgut et al. (2017) conducted a study on 30 people with shoulder injury syndrome and SD to evaluate the effect of stabilizing exercises. They found that stabilizing, stretching, and strengthening exercises of the rotator cuff muscles affect the three-dimensional kinematics of the scapula (35). Also, stabilizing, stretching, and strengthening exercises of the rotator cuff muscles increased the external rotation, upper rotation, and posterior tilt at 90° of shoulder elevation (27). Our stability exercises protocol was based on open and closed chain exercises, which included Swedish swimming movements on stable and unstable surfaces, retraction with elastic resistance (Blackburen and Lawnmower exercises)(32, 35).

One of the potential factors in changing the kinetic chain of the body is the change in the direction of movement and kinematics of the scapula in the shoulder girdle area. Stabilization exercises are a series of regular exercises in the rehabilitation of the scapular joint that increase the strength and activity of the scapular muscles. But conscious control exercises have recently entered the field of exercise therapy and rehabilitation, which increase a person's awareness of the position of the joint. Neuromuscular control exercises increase joint proprioception and improve nerve afferents to the central nervous system. Stability/stabilization exercises can both improve the strength of the muscles around the joint and the kinematics of the scapula. Increasing scapular motion control improves the kinematics of the shoulder girdle and upper limbs, and in turn facilitates the lower extremity kinetic chain, which means the desired direction in the body kinetic chain.

This study has some limitations that should be considered when interpreting the current results. Intensity control in the special stabilization exercises was not precise, as it was controlled by the examiner. Tennis players trained with DS were evaluated and, therefore, our results are not generalizable to other conditions, populations (healthy table tennis players) or men. Further studies could look at a different order of exercises, different intensities, or different combinations of physical abilities.

Practical Application: Our results indicated that stabilizing (stretch-strengthening) exercises could improve shoulder girdle strength and range of motion which could result in a normal circumstance in scapula kinematic and shoulder girdle function. Consequently, stabilizing exercises could prevent shoulder girdle injuries. Thus, future research should investigate the effects of different stretch-strengthening protocols with varied durations and repetitions. The result of this study demonstrated the additive effect of stabilizing exercises on internal and external strength and ROM of the shoulder joint. It can provide useful data to elite female tennis players which could help them improving their performance and preventing shoulder girdle injuries.

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