The Effect of Suspension Training on Some Factors Related to the Shoulder Injuries in Athletes with Scapular Dyskinesis

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ABSTRACT

This study aimed to examine the effect of suspension training on some factors related to the shoulder injuries in athletes with scapular dyskinesis. The present study employed a semi-experimental pre-test and post-test design. Thirty male athletes with scapular dyskinesis were randomly allocated into either the training or control group, with 15 individuals in each. Identification of scapular dyskinesis was conducted through the utilization of a lateral scapular slide test. During the pre-test stage, the shoulder joint muscles strength, proprioception and functional stability, were assessed via manual dynamometer, upper body functional balance test, and imaging methods, respectively. Subsequently, the training group participated in an 8-week suspension training, with three sessions per week. Following the 8-week intervention period, all participants underwent the same measurements administered during the pre-test stage. Statistical analysis was conducted using a two-way analysis of variance at a significance level of $P \leq 0.05$ to analyze the research findings. The findings from the two-way analysis of variance indicated that, during the post-test stage, the experimental group showed significant enhancements in muscle strength, functional stability, and accuracy of shoulder joint proprioception in comparison to the control group. The study's results suggest that suspension training used in this study can be employed to enhance shoulder muscle strength, functional stability, and accuracy of shoulder joint proprioception, which may assist in ameliorating disorders resulting from scapular dyskinesis. Furthermore, the findings imply that incorporating these exercises into training regimens could help prevent shoulder joint injuries.

Keywords: Scapular dyskinesis; suspension training; Shoulder; Injury; Prevention

INTRODUCTION

Scapular dyskinesis is a condition that involves dysfunction in the positioning of the scapula bone (Saini, Shah, & Curtis, 2020). This condition can affect the alignment and movement of the shoulder joint, potentially leading to reduced performance, particularly in overhead sports (Asker et al., 2018). Early identification and management of scapular dyskinesis can help prevent further damage to the shoulder girdle and reduce the risk of injury (Saini, et al., 2020).

Previous studies have demonstrated that scapular dyskinesis can lead to impairments in strength (Bullock et al., 2021; Moghadam, Rahnama, Dehkordi, & Abdollahi, 2020), range of motion (Moghadam, et al., 2020; Naderifar & Ghanbari, 2022), activation and timing of the shoulder muscles (Gonçalves et al., 2022; Petviset, Sakulsriprasert, Vongsirinavarat, & Wattananon, 2021), shoulder girdle function (Huang, Weng, Chang, Tsai, & Lin, 2023) and proprioception (Sayaca et al., 2021; Zarei, Eshghi, & Hosseinzadeh, 2021). These variables are critical for optimal shoulder function and performance. Impairments in muscle strength and joint stability are two critical risk factors that can significantly increase the likelihood of injury in athletes who participate in overhead sports (Bullock, et al., 2021). Athletes with scapular dyskinesis exhibit a decrease in the strength of the infraspinatus and supraspinatus muscles (Merolla, De Santis, Campi, Paladini, & Porcellini, 2010). This is while the results have shown the rotator cuff muscles generate compressive force that helps to stabilize the humerus against the glenoid cavity, resulting in improved stability of the shoulder joint (Seitz, McClelland, Jones, Jean, & Kardouni, 2015). Seitz et al. found that athletes with scapular dyskinesis exhibit weakness in the lower and middle trapezius muscles, as compared to those without any signs of dyskinesis (Seitz, et al., 2015). There is a direct relationship between strength and stability in the shoulder joint. Therefore, impairment in strength can lead to a reduction in functional stability of the shoulder and finally an increase in likelihood of shoulder injuries (Bullock, et al., 2021).

On the other hand, changes in scapular position have been found to have a significant impact on the proprioceptive function of the shoulder joint, potentially leading to disruptions in the neuromuscular reflexes responsible for joint protection (Seitz, et al., 2015). This can lead to increased pressure on the joint, instability, and a heightened risk of injury (Sayaca, et al., 2021). This highlights the importance of maintaining proper scapular position to ensure optimal shoulder joint function. These findings align with previous research on the role of proprioception in joint stability and injury prevention (Zarei, et al., 2021). As such, paying close attention to proprioceptive accuracy in athletes with scapular dyskinesis is of utmost importance.

Academic literatures highlights the importance of selecting appropriate strategies for athletes with scapular dyskinesis to address the various variables affected by this condition (Giuseppe et al., 2020; Moghadam, et al., 2020). It is crucial to use non-invasive and cost-effective interventions that not only target these variables but also enhance performance and prevent injury. Suspension training has gained popularity in the sports community in recent years. The prominent feature of this training method is the use of body muscles in a suspended environment, which not only targets the intended muscles but also promotes muscular strength development and coordination between the kinetic chains by creating cohesive contractions along the closed kinetic chain

(Khorjahani, Mirmoezzi, Bagheri, & Kalantariyan, 2021). In addition, the functional nature of this training method and its emphasis on utilizing the core stabilizer muscles of the body in most of the movements have been noted (Karabay, Emük, & Kaya, 2019; Khorjahani, et al., 2021). It has been demonstrated that there is a direct correlation between core stability and upper limb injury occurrence (Zarei, et al., 2021).

Hence, it is hypothesized that suspension training, with the aforementioned characteristics, could be a viable option for improving factors related to the shoulder injuries in athletes with scapular dyskinesis. Therefore, the objective of this study is to examine the effectiveness of suspension training on functional stability, muscle strength, and proprioceptive accuracy of the shoulder joint in athletes with scapular dyskinesis.

METHODS

Study design

The current study employs a quasi-experimental research methodology utilizing a pretest-posttest design with two distinct groups.

Study population and selection of samples

The study population of the present research includes all male university athletes in overhead sports such as volleyball, handball, and basketball in the city of Rasht. The sample of this study consists of 30 individuals from the study population aged between 20 and 30 years who met the criteria for participation in the study. Before the study began, all subjects were notified of the potential risks and benefits of participating in the research. All subjects signed a consent letter to participate in the project. The sample size for the study was determined using an appropriate statistical formula based on previous studies with similar characteristics (Khorjahani, et al., 2021). A confidence interval of 0.95 and a test power of 80% were established, with an effect size of 0.7. Consequently, the sample size for each group was calculated as 13 individuals. However, to account for potential sample dropout during the study, the sample size was increased to 15 individuals for each group. To ensure homogeneity between the groups, each group was comprised of 5 volleyball players, 5 basketball players, and 5 handball players. The inclusion criteria for the study were being male, participating in university-level volleyball, basketball, or handball, and having scapular dyskinesis. The exclusion criteria were a history of injuries such as dislocation or fracture in any of the shoulder girdle bones, complete tear of the shoulder girdle muscles, adhesive capsulitis in the shoulder joint (diagnosed by a physician), any atrophy in the shoulder girdle muscles, skeletal muscle disorders in the upper limb, including forward head posture, protracted scapula, kyphosis, scoliosis (any physical abnormality affecting the study process, diagnosed by a physician), dissatisfaction to continue participation in the study, absence from two consecutive sessions or more than 3 sessions of training. The study followed the Helsinki Declaration recommendations of Human Ethics in Research.

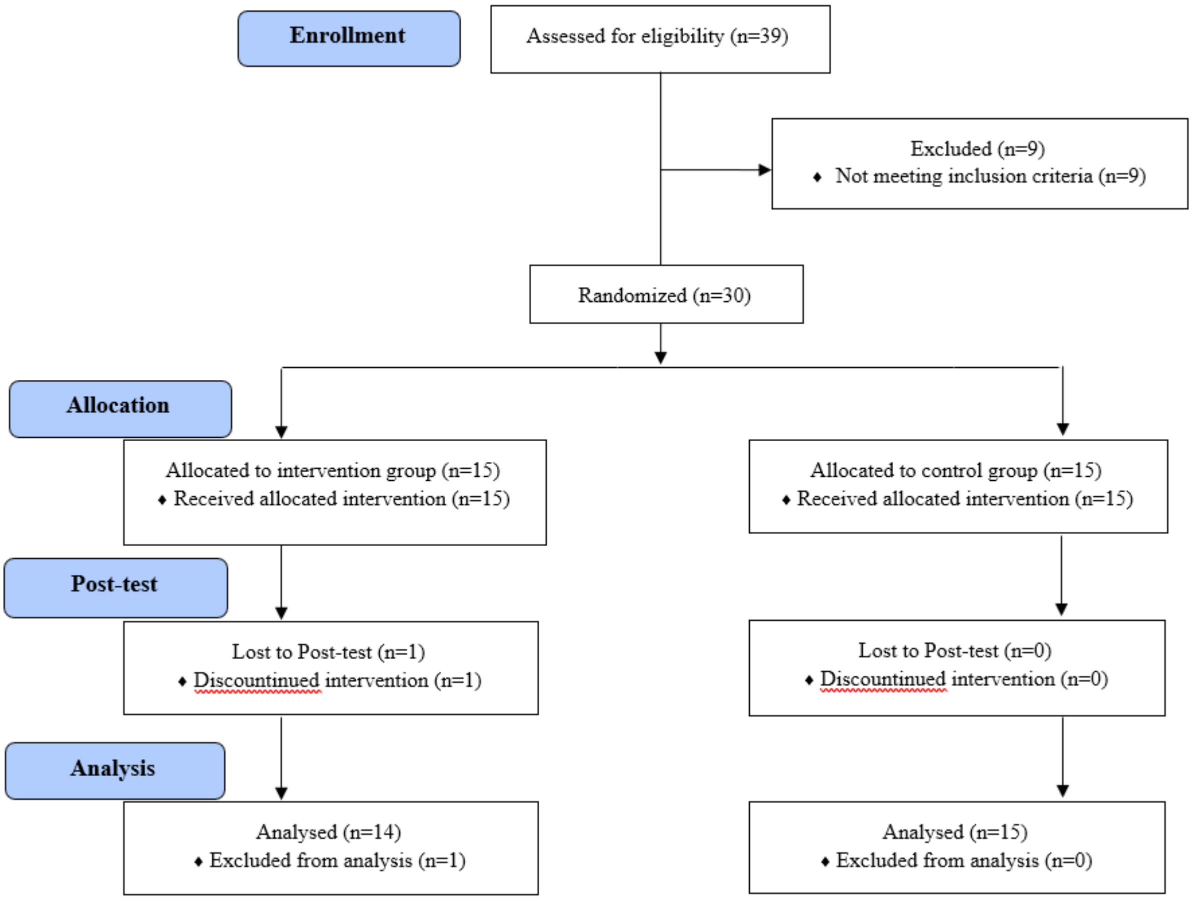

Figure 1. CONSORT flow chart of samples enrollment, allocation, post-test and analysis.

Preparation

The process of conducting the research was as follows: after issuing a call for participation in the research project on virtual platforms, individuals who expressed their interest in participating in the study were invited to attend a predetermined location in the laboratory for initial examinations and to assess their eligibility for inclusion or exclusion from the study based on the inclusion and exclusion criteria. Upon arrival at the laboratory, a detailed explanation of the study objectives and participation requirements was provided to the individual. Then, the informed consent form and personal information form were completed by the individual. Afterward, initial measurements were taken, including anthropometric measurements and assessment of shoulder movement disorders to determine the presence or absence of scapular dyskinesis.

Evaluation of scapular dyskinesis

To assess scapular dyskinesis, the lateral scapular slide test (LSST) developed by Kibler was used. The validity of this test is high in the neutral position and low in two other positions (45 and 90 degrees), and its intergroup reliability is high (0.87-0.94) as well as its intragroup reliability (0.63–0.79) (Kibler, Sciascia, & Wilkes, 2012). In this test, the inferior angle of the scapula was marked on the skin with a marker, and the distance between it and the adjacent vertebra was measured in three standing positions: 1- hands by the sides of the body, 2- hands on the lower back with the palm facing backward and the four fingers facing forward, and 3- arms in 90 degrees of abduction with the palm facing downward. The measurement was repeated three times on each side, and if there was a difference of 1.5 cm or more between the two sides, the test was considered positive, and the individual was identified as having scapular dyskinesis (r = 0.90) (Kibler, et al., 2012).

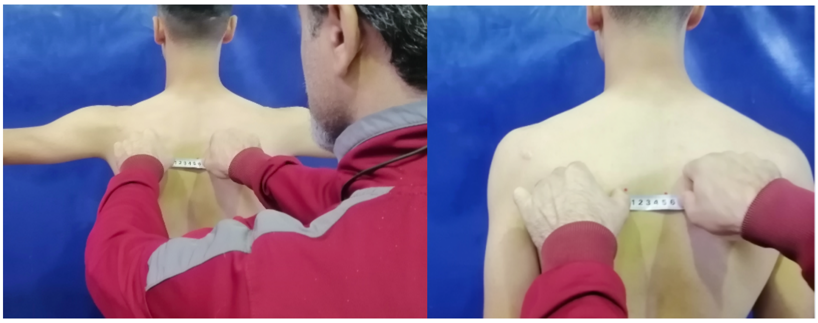

Figure 2. Evaluation of scapular dyskinesis

Evaluation of muscle strength

To measure the maximum isometric strength of internal and external rotator muscles of the shoulder joint, a handheld dynamometer model CASE-01163 manufactured by Lafayette Instrument Company, USA was utilized. To do this, the individual was placed in a supine position on a flat surface, and the shoulder was abducted to 90 degrees, with the elbow flexed to 90 degrees and hanging from the surface (angles were measured with a standard goniometer). The handheld dynamometer was placed on the anterior surface of the forearm just above the wrist for internal rotation and on the posterior surface for external rotation. A folded towel was placed under the arm to maintain humeral adduction. Then, the individual was instructed to exert maximum force for 2 seconds, without moving the arm, in the direction of internal and external rotation, respectively, against the handheld dynamometer. The maximum isometric force exerted by the individual was recorded on the digital display of the device (ICC = 0.88-0.96) (Hannah, Scibek, & Carcia, 2017).

Evaluation of functional stability

To assess the functional stability of the shoulder joint, the Y balance test was used. To perform this test, the individual stood on their hands and toes, keeping their spine and lower limbs in a straight line. The dominant hand was chosen as the support. The position of the hand was marked by a designated line, and the feet were separated by the width of the shoulders. In this position, the individual was asked to reach as far as possible in the medial, inferior-lateral, and superior-lateral directions with their free hand while maintaining the position of the supporting hand, torso, and lower limbs. To enable comparisons between individuals, the reach distances along the upper limb (the distance from the seventh cervical vertebra to the end of the longest finger in 90 degrees of shoulder abduction and elbow extension, wrist and finger extension) were normalized. The reaching task was performed continuously in all three directions without rest, and the individual was allowed to rest their free hand on the ground after each trial. This process was repeated three times, and the average of the three correct trials in all three directions was recorded as the composite score of the individual in the functional stability test. The intra-tester reliability of this test was reported as good to excellent (0.80-0.90) (Gorman, Butler, Plisky, & Kiesel, 2012; Zarei, et al., 2021).

Figure 3. Evaluation of functional stability

Evaluation of proprioception

To evaluate the accuracy of the proprioceptive sense of the shoulder joint during 90 degrees of abduction, digital camera imaging was used. First, the individual's shoulder girdle was marked, and a single shoulder abduction movement was reconstructed at a 90-degree angle. To perform the test, the individual was seated on a chair and asked to raise their shoulder to 90 degrees of abduction in a trial manner, during which the tester commanded them to remember this angle. Then, the main test was performed, and the tester was asked to reconstruct the 90-degree abduction movement. When they reached the target angle, they said "reached," and the tester immediately took a picture from the back view. Then, the photos were analyzed using Kinovea software to determine the accuracy of shoulder joint proprioception during abduction movement. It should be noted that to emphasize the accurate evaluation of proprioceptive sense, the movement was performed with eyes closed. The average of three correct trials was considered as the reconstruction angle of the proprioceptive sense of the shoulder joint. The reliability of this method was reported as 0.87–0.96 (Elrahim, Embaby, Ali, & Kamel, 2016; Herrington, Horsley, Whitaker, & Rolf, 2008).

Figure 4. Evaluation of proprioception

Training protocol

After conducting the pre-test assessments, the participants in the training group performed 8 weeks of suspension training. During this period, all participants were asked to perform their normal daily activities and refrain from exercises that emphasized the upper limb muscles and could affect the study results. The control group was asked not to perform any sports activity during the study period. The first researcher fully monitored and supervised all the training sessions. The suspension trainings were performed using for 8 weeks in 24 training sessions that lasted 25–30 minutes for each session by the subjects of suspension training group. The suspension progressive exercises were designed to increase the intensity of the exercises each week relative to the previous week by adjusting the exercise duration, level and/or type so that they most closely resemble the common functional movements in volleyball, basketball and handball in the final week. All exercises performed were based on the books and papers published in the field of suspension trainings (Dawes, 2017; Melrose & Dawes, 2015; Mohamed, 2016). The first Researcher possessed the suspension coaching degree (grade I) with a 3 years experience. Following the training period, all factors were reassessed using the same procedure as the pretest.

Table 1. suspension training protocol

Week	Exercises	Set- Reps- Rest
1–2	Standing push-up plus, Chest press, standing overhead triceps extension, Scapular retraction, Inverted row, Supine iron cross, Elbow plank, Supine plank, Dual-arm external rotation	3-10-20
3–4	Standing push-up plus, Inverted row, Rear deltoid row, Biceps curl, Dual-arm external rotation, Dual-arm internal rotation, Standing overhead triceps extension, Reverse biceps curl, side plank, rotation plank	3-12-15
5–6	Scapular retraction, Field goal, Sprinter chest press, Push-up plus, Rear deltoid row to Y, Dual-arm external rotation, Dual-arm internal rotation, Reverse Crunch, rotation plank	3-10-10
7–8	Low row, I- Y- T exercise, T fly, Single-arm inverted row, Off-center chest press, kneeling overhead triceps extension, Dual-arm external rotation Inverted	3-12-10

Statistical analysis

To assess normality, the Shapiro-Wilk statistical test was conducted on the data. A Two-Way analysis of variance with repeated measures was then used to examine intergroup differences in the post-test stage of the study. All statistical analyses were performed using SPSS software (23.0; IBM SPSS Inc., Chicago, IL, USA), and the significance level was set at 0.05.

RESULTS

Table 2 presents demographic information for the subjects, categorized by group. Based on the results of the independent t-test, no significant differences were found in the demographic variables of the research subjects between the two groups.

Table 2. Demographic characteristics of research subjects in two groups (mean ± standard deviation)

Group Variable	Control	Intervention	P
Age (Year)	27.19±4.7	26.48±6.2	0.319
Heigh t(Cm)	185.01±5.1	184.85±8.3	0.227
Weight (Kg)	88.14±6.1	86.43±5.6	0.412
BMI (kg.m²)	23.72±4.7	23.48±3.6	0.288

A Two-Way analysis of variance with repeated measures was conducted to investigate the effect of 8 weeks of suspension training on internal and external rotator muscle strength, functional stability, and shoulder joint proprioception accuracy. The results of the analysis revealed a significant interaction effect between time (pre-test to post-test) and group (control vs. experimental) on internal rotator muscle strength (η=0.263, P=0.001, F=12.04), external rotator muscle strength (η=0.167, P=0.001, F=9.22), functional stability (η=0.319, P=0.001, F=14.01), and shoulder joint proprioception accuracy (η=0.211, P=0.001, F=8.68).

Additionally, the results revealed significant main effects of time and training intervention on internal rotator muscle strength, with significant effects of time (η=0.281, P=0.005, F=8.23) and training intervention (η=0.194, P=0.021, F=6.79). Similarly, there were significant main effects of time and training intervention on external rotator muscle strength, with significant effects of time (η=0.207, P=0.003, F=10.61) and training intervention (η=0.155, P=0.009, F=8.38). Further, there were significant main effects of time and training intervention on functional stability, with significant effects of time (η=0.313, P=0.001, F=12.52) and training intervention (η=0.199, P=0.001, F=9.85). Finally, significant main effects of time and training intervention were observed on shoulder joint proprioception accuracy, with significant effects of time (η=0.242, P=0.001, F=11.36) and training intervention (η=0.213, P=0.001, F=9.79).

According to the results of the Two-Way analysis of variance, the suspension training had a significant positive impact on internal and external rotator muscle strength, functional stability, and shoulder joint proprioception accuracy in the experimental group when compared to the control group ($P \leq 0.05$).

Table 3. Comparison of muscle strength, functional stability, and proprioceptive accuracy between pre-test and post-test stages in the two groups

Variable	Group	Pre-test mean ± std	Post-test mean ± std	Confidence Interval
Internal Rotator Muscle Strength (N.m^2)	Intervention	13.3±3.6	17.3±4.1	-1.37_-2.62
	Control	13.7±2.9	13.4±2.7	-2.71_1.84
External Rotator Muscle Strength (N.m^2)	Intervention	11.6±4.5	16.9±3.4	-2.05_-2.38
	Control	12.2±3.1	12.8±2.6	-4.11_2.64
Functional Stability (Cm)	Intervention	63.2±7.8	77.3±9.4	-3.53_-1.28
	Control	64.8±8.8	66.4±10.7	-1.69_3.83
Proprioception (Degree)	Intervention	-5.8±0.9	-2.1±0.4	-5.84_-1.26
	Control	-6.1±1.1	-7.3±1.8	-3.19_3.54

DISCUSSION

The objective of this study was to investigate the effects of an 8-week suspension training on some factors related to the shoulder joint injuries such as functional stability, muscle strength, and proprioceptive accuracy in athletes with scapular dyskinesis. Two-Way analysis of variance demonstrated a significant improvement in functional stability, as well as an increase in internal and external rotator muscle strength and proprioceptive accuracy of the shoulder joint following the intervention. These findings suggest that the suspension training may serve as an effective intervention for enhancing functional stability, muscle strength, and proprioceptive accuracy among this population.

The findings of this study are consistent with previous research conducted by Mohamed (Mohamed, 2016), Linek et al. (Linek, Saulicz, Myśliwiec, Wójtowicz, & Wolny, 2016), and Goullet et al. (Goulet & Rogowski, 2018), which respectively reported improvements in the strength of the shoulder joint muscles of swimmers, volleyball players, and professional tennis players following suspension training. However, our results differ from those of Hibberd et al. (Hibberd, Oyama, Spang, Prentice, & Myers, 2012) and Swanik et al. (Swanik, Swanik, Lephart, & Huxel, 2002), who did not observe significant changes in shoulder muscle strength following 6 weeks of strengthening exercises. The disparity in results between our study and those of Hibberd et al. (2012) may be attributed to the shorter duration of the training protocol in their study compared to ours. Additionally, the inconsistency may be attributed to differences in the protocol for measuring muscle strength. Hibberd et al. evaluated the strength of flexor and abductor muscles of the shoulder joint, whereas in our study, we assessed the strength of the rotator muscles of the shoulder joint.

The findings of this study suggest that suspension training may enhance the function of muscle spindle receptors and improve the accuracy of afferent messages from the shoulder joint to the nervous system, potentially leading to more precise feedback mechanisms (Khorjahani, et al., 2021). This improvement in feedback may contribute to enhanced motor control and stability in the shoulder joint (Moghadam, et al., 2020). As a result of improving the accuracy of nerve messages, more coherent and efficient movement commands can be sent to the muscles, which can lead to better performance of the shoulder joint muscles and ultimately improve functional stability (Zarei, et al., 2021). This improvement in functional stability may reduce the likelihood of shoulder injuries, particularly in athletes with scapular dyskinesis.

Merolla et al. (2010) found a reduction in supraspinatus and infraspinatus muscle strength in athletes with scapular dyskinesis. In their study, participants underwent a 6-month rehabilitation program. The results showed a significant improvement in the strength of both supraspinatus and infraspinatus muscles (Merolla, et al., 2010). Based on these findings, researchers concluded that an imbalance in the strength of the shoulder muscle structure leads to acquired scapular dyskinesis. This imbalance disrupts the length-tension relationship of the rotator cuff muscles, resulting in secondary weakness of the supraspinatus and infraspinatus muscles (Merolla, et al., 2010). Previous studies have shown that rehabilitation programs focused on restoring the balance of shoulder stabilizing muscles can improve rotator cuff strength in overhead athletes (Goulet & Rogowski, 2018). The results of the current study are consistent with these findings, indicating that 8 weeks of suspension training have improved the strength of the shoulder rotator muscles and functional stability in athletes with scapular dyskinesis.

Enhanced functional stability observed among the training group in this study, as a protective mechanism, can prevent unintended movements and injuries in the shoulder joint, which is widely recognized as the most mobile and unstable joint in the body (Zarei, et al., 2021). This is particularly important as previous research has demonstrated a direct relationship between functional stability and proprioceptive accuracy of the shoulder joint (Sayaca, et al., 2021; Zarei, et al., 2021). Previous studies have reported that athletes with higher proprioceptive accuracy in their shoulder joint perform better in upper body functional stability tests, which may significantly reduce the risk of shoulder joint injuries (Jin-Ho, Ki-Jae, Mu-Yeop, Bang-Sub, & Jae-Keun, 2020; Zarei, et al., 2021). Based on the findings of this study and the opinion of Jin-Ho et al. (2020) it can be argued that improved awareness of shoulder position leads to improved performance of afferent and efferent neurons and motor control (Jin-Ho, et al., 2020). Complex movement pattern exercises such as suspension exercises, which are performed in multiple planes and levels of movement and involve multiple joints, may have a double effect on afferent inputs and improve proprioception (Khorjahani, et al., 2021).

The results of the current study demonstrate the positive impact of suspension training on the strength, functional stability, and proprioception of the shoulder joint in athletes with scapular dyskinesis. Given these findings, suspension training can be suggested as a preventative approach to shoulder joint injuries in athletes with scapular dyskinesis. Future research should explore other variables such as kinematics and activation of shoulder girdle muscles after implementing the training protocols used in this study. It is worth noting that the present study had a potential limitation in that it only involved male athletes. Additionally, conducting this research during the COVID-19 pandemic presented challenges in terms of subject recruitment and access to facilities.

CONCLUSION

The findings of this study indicate that suspension training have a favorable impact on variables associated with injury occurrence in athletes with scapular dyskinesis. Consequently, coaches and overhead athletes are advised to incorporate these exercises into their training regimen as a preventative measure against shoulder girdle injuries.

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