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Original Research

The Effect of a Water-Based Training Program on Pain, Range of Motion and Joint Position Sense in Elite Female Swimmers with Impingement Syndrome

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ABSTRACT

One of the most common causes of shoulder problems in competitive swimmers is thought to be damage to the sub-acromial structures known as shoulder impingement syndrome. The present study aimed was to investigate the effect of a water-based training program on pain, range of motion, and joint position sense of the shoulder joint in elite female swimmers with shoulder impingement syndrome. Thirty elite female swimmers with an age range of aged 20-30 were randomly assigned to experimental or control groups. The experimental group performed a water-based training protocol, and the control group performed conventional swimming stretching exercises for eight-week. Pain, range of motion, and shoulder joint position sense were assessed before and after the intervention. The results showed a significant difference between the mean of variables in the two experimental and control groups before and after the exercise protocol ($p < 0.001$). The mean pain intensity in the experimental group decreased compared to pre-exercise, which was statistically significant ($p < 0.001$), and no significant statistical difference was observed in the control group. Besides, the range of motion, internal and external rotation, flexion, and abduction in the experimental group had increased compared to condition before the training, which was statistically significant ($p < 0.001$). In this section, no significant statistical difference was observed in the control group. The results also show a significant improvement in the joint position sense of in the experimental group compared to the control group ($p < 0.001$). According to the results, the eight-week program of water-based training was effective in improving pain, range of motion, and the joint position sense of women swimmers with shoulder impingement. This can be explained by the improvement of muscle imbalance between the dynamic stabilizers of the shoulder complex and maintain of the subacromial space in a way that prevents soft tissue impinge, reduces pain, and consequently increases range of motion and improve joint position sense in people with this complication.

Keywords: Training, Swimming, Shoulder Impingement syndrome, Pain

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Introduction

Due to the frequent use of the shoulder joint in overhead activities and movements, the structures of this joint are under stress and many micro traumas. This factor can gradually affect the stabilizing mechanisms of this joint, which are mainly muscles, and lead to instability and injury (1). Pain and inflammation in sports activities that require repeated use of the hand in movements above the head and actually above the horizontal plane, especially in swimming, often occur in athletes. Swimming is a unique activity because it primarily requires the upper body to provide the driving force, and 90% of this driving force is provided mainly by the torque produced by the shoulder joint (1). A large amount of repetitive force is applied by the shoulder joint, which is why the swimmer's shoulder is the most important injury, affecting 40% to 91% of competitive swimmers (1). Swimmers have a high potential for shoulder injury due to the exceptional nature of the various stroke in swimming and the large volume of repetitions required during training (2). Therefore, the nature of this sport in various aspects plays a kay role in increasing the risk of pain and shoulder disorders (3). Among shoulder injuries, Shoulder Impingement Syndrome (SIS) is more common and is the most common cause of pain, limited mobility, and proprioceptive dysfunction (4). SIS is believed to be the most common cause of shoulder pain, and accounts for up to 65% of all shoulder complaints (5). This condition, also known as swimmer's shoulder, is caused by pressure on the subacromial tissues, which narrows the subacromial space (6). The pain is caused by movements that cause the subacromial bursa and the supraspinatus muscle to impinge between the acromion process and the head of the humerus.

Most authors believe that weakness in one or more scapular muscles may lead to an imbalance in a couple of forces around the scapula and often with kinematics and abnormal scapulohumeral rhythm, limited range of motion and pain (7–9) severe disability, reduced quality of life, and limited function in these patients (10,11). Clinical experience and scientific evidence show that athletes who use the hand frequently in overhead movements, especially swimmers, have abnormal shoulder girdle muscle activity and abnormal scapular kinematics of the scapula and scapulohumeral rhythm (12). The most important goals in rehabilitating people with SIS are to reduce the common problems and disorders associated with pain and improve upper limb function (13). The general treatment protocol for shoulder injuries in swimmers begins with a combination of ice, traction, and anti-inflammatory drugs (6). Recent studies suggest that exercise therapy is one of the most important treatments for patients with this complication due to its availability, non-invasiveness, and low risk (6,14). Many research have been carried out on shoulder girdle muscle strengthening has been done using free weight training to increase strength, power, and is often based on a dry environment. At the same time greater stability and motor control are often forgotten in water sports (15). Athletes in water sports such as diving and water polo have adapted to this condition due to the long time they have been training in the water and have adapted to this condition according to the principle of training adaptation, and this will cause damage at the beginning of training, in the meantime. The use of water-based training has been an essential aspect of rehabilitation. The most important properties of water that make it easier to training include immersion, viscosity, and hydrostatic pressure. Water reduces weight by up to 90%, reduces the pressure on the joints, and allows you to do exercises with a greater range of motion and intensity, as well as less pain and pressure (16,17). the buoyancy of the water allows the limbs to move more efficiently with less force, increasing coordination (18). Aquatic intervention by strengthening the muscles around the joint and reducing the pressure on it, increasing sensory feedback and proprioceptive, can be an ideal environment to improve balance, muscle strength, and endurance. Various studies have concluded that performing an exercise program can lead to Significant advances in muscle strength and power in each of the lower and upper extremities (16,19,20). Water-based training offers an alternative to land-based training, both in terms of post-injury recovery and for athletes with muscle or joint damage (21). Therefore, given that the water environment creates better conditions for recovery than land, and considering that very little research on the rehabilitation of shoulder injuries in water, this study was set up to investigate the effect of a water-based training program on pain, range of motion (ROM) and proprioception in elite female swimmers with impingement syndrome.

Material and Methods

Participants

The present study was an interventional and quasi-experimental research with pre-test and post-test design. SIS subjects were recruited from the participants aged 20 to 30 years' elite female swimmers from Qazvin, Alborz, and Tehran provinces. A power analysis was performed with G*power software ver. 3.1.9. The sample size calculation was carried out with a power of 0.95, alpha level of .05, and effect size of 0.80. 30 subjects with SIS were recruited, and were randomly allocated into two groups including water-based (n=15) and control (n=15). Prior to conducting the study, all samples signed written consent for this study. The data collection form, which identified age, weight, height, athletic background, medical history or medications, injuries, trauma, or surgery in the shoulder joint, was approved by sports and orthopedic specialists and interviewed by an examiner. The samples were then examined by a sports medicine specialist and tested for the Hawkins-Kennedy, Neer, and painful arc clinical trials. If two of the three tests were positive, the SIS would be confirmed. Subjects were included with the history of active membership in one of the teams in the province at least in the last three years, lack of participation in other sports, history of symptoms for at least two months, painful arches after raising the hand, pain in During resistance testing and positive testing of Hawkins-Kennedy tests, Neer (22,23). Exclusion Criteria; symptoms of trauma following traumatic lesions, dislocation of the glenohumeral joints, acromioclavicular, surgical history, fracture, malignancy, and shoulder instability and neck pain syndrome, neurological and rheumatic diseases, diabetes, and depression, unwillingness to continue the program (23). It should be noted that the samples of the two groups were homogeneous in terms of age, height, weight, and sports history, and due to the limited number of swimmers in the four types of swimming, swimmers who practiced breast crawling were selected. The consent of the individuals for voluntary attendance was obtained from the individuals. Ethics approval was obtained from the University of Nahavand Ethical Committee (Code number: IR.NAHGU.REC.1399.002).

Outcome measurement

Pain assessment

Visual analog pain scales were used to assess pain. Participants were asked to indicate the amount of pain on the VAS. The linear scale is horizontally continuous from 100 mm moving from "painless" at the left end to "worst imaginable pain" at the right end (24). Twenty mm reduction in visual scale is clinically acceptable (24).

ROM Assessment

Painless active ROM (flexion, abduction, internal rotation, and external rotation) was measured in the shoulder joint using the Biometrics SG110 electro goniometer. This device has been used in previous studies in people with SIS (25). Intraclass correlation coefficients (ICC) is found to be between 0.95 and 0.98 (26). It should be noted that the ROM joint was measured in two stages and the mean of the two stages was recorded.

Flexion: The subject was first asked to lie on his back with his arm in a supine position and his forearm in a neutral position. The electromagnetic arm was then fixed to the subject's arm axis, and its fixed arm was placed parallel to the armpit line. At this stage, the subject was asked to perform the shoulder flexion movement. Meanwhile, the test tube was fixed by the researcher's colleague, and after the subject's arm reached the end of the range of motion, the chassis pressed the device to record the amount of range of motion on the device monitor (27,28).

Abduction: The subject was asked to stand with his back to the wall and his arm in a supine position with his torso and forearm in a neutral position. The electromagnetic arm was then fixed on the subject's arm axis, and its fixed arm was placed parallel to the body line. At this stage, the subject was asked to perform shoulder ablation. Meanwhile, the test tube was fixed by the researcher's colleague, and after the subject's arm reached the end of the range of motion, the chassis of the device was pressed to record the amount of range of motion in the device monitor (27,28).

External rotation: The subject was asked to lie on his back and the shoulder should be placed at an angle of 90 degrees to the trunk with the arm abduction. The electromagnetic arm was then fixed to the subject's forearm axis, and its fixed arm was placed perpendicular to the ground. The assistant was then asked to hold the subject's arm steady. In this position, the forearm was rotated outward and the elbow was positioned 90 degrees. And after reaching the end of the range of motion, press the chassis of the device to record the amount of range of motion in the monitor of the device (27,28).

Internal rotation: The subject was asked to lie on his back and the shoulder should be placed at an angle of 90 degrees to the trunk with the arm abduction. The electromagnetic arm was then fixed to the subject's forearm axis, and its fixed arm was placed perpendicular to the ground. The assistant was then asked to hold the subject's arm steady. In this position, the forearm was rotated inward and the elbow was positioned 90 degrees. And after reaching the end of the range of motion, press the chassis of the device to record the amount of range of motion in the monitor of the device (27,28).

Joint position sense assessment

Shoulder joint position sense (JPS) was assessed using a goniometer with the standard method mentioned in previous research. The subject was asked to lie on his back on the bed, his arm and elbow were placed in a 90-degree flexion position. The position and angle of the shoulder joint as well as the reconstruction of the angle were performed by a digital camera. The camera position was set at a distance of 5 meters from the examiner and in line with the shoulder. Then the ulnar and olecranon processes were marked. The measured angle is defined by the intersection of the two lines in such a way that the first line is obtained horizontally parallel to the bed on which the person is lying and the second line is obtained from the connection of the ulnar process with the olecranon. Then, when the subject’s eyes were closed, the subject's arm was inactivated to a 45-degree external rotation, and the subject was asked to recall this angle and reconstruct it after 5 seconds. The same was done for the 80-degree angle. Evaluations were then performed using AutoCAD software (29,30).

Training protocol

To implement the exercise protocol, the experimental group performed 3 sessions per week for eight weeks, with one hour each (10 minutes of warm-up, 40 minutes of specific exercise in the water, and 10 minutes of cooling) according to Table 1. Stretching exercises were performed in 3 sets and lasted a maximum of 30 seconds. Resistance and neuromuscular coordination exercises were performed in 3 sets with 10 repetitions in the first four weeks and 3 sets with 12 repetitions in the second four weeks. The progress of the exercises was adjusted according to the depth of the water and the type of exercise. In the first week, in-depth stretching exercises, in the second week, deep-stretching and resistance exercises, in the third week, low-depth stretching and resistance exercises, and in the fourth week, and the following weeks, all exercises in the previous sections plus neuromuscular exercise was performed. The control group also used conventional stretching exercises among swimmers.

Table1. Description of training protocol

Exercise	**Description**
Stretching exercises (Shallow)	Running back and forth along with a hand-held swimming pattern, in the shallow
	Step sideways with arm extension from 0 to 45 degrees
	Stretch in the overhead position using a ladder or pool wall
	Stretching in the internal position of rotation and extension (arm to back) using floating tools
	Stretch in the external rotation position using the pool wall
Resistance exercises (Deep)	Shoulder abduction with resistance board
	Shoulder flexion with resistance board
	Shoulder scaption with resistance board
	Internal and external shoulder rotation with resistance board
	Horizontal abduction/adduction of the shoulder

	with resistance board
PNF exercises (Shallow)	Stretch in the overhead position using a ladder or pool wall
	Stretching in the internal position of rotation and extension (arm to back) using floating tools
	Stretch in the external rotation position using the pool wall
Neuromuscular exercises (Deep)	Horizontal Abduction and Adduction
	Shoulder abduction with high speed, short arch and painless range
	Shoulder adduction with high speed, short arc and in painless range
	Shoulder flexion with high speed, short arc and in painless range
	Shoulder extension with high speed, short arc and in painless range

Statistical analysis

Normal data distribution was determined using the Shapiro-Wilk test. Confirming that the distribution of data is normal, to investigate the statistical difference of each variable between groups from the statistical analysis of one-way Repeated Measure ANOVA with Greenhouse-Geisser correction and to examine the differences within the subjects in each variable before and after the test. Data are reported as mean and standard deviations. Statistical analysis was performed using SPSS Statistics (IBM SPSS Statistics Version 22. For all analysis, the level of significance was set at 0.05.

Results

The anthropometric parameters of subjects of the research subjects in each group are presented in Table 2. There was no significant difference in the anthropometric parameters of individuals between groups ($p<0.05$). The Shapiro–Wilk test indicates that the groups are normal in the mentioned characteristics.

Table 2: Subject Characteristics in two groups (mean ± SD)

value	Control group (15 = n)	experimental group (15 = n)	p
Age	24.7±1.38	24.00±1.15	0.31
Height	169.20 ± 5/73	168.5±5.94	0.47
Weight	62.80±8.11	64.40±3.42	0.19

The values for the measured variables, including joint pain, shoulder ROM and JPS, pre-test and post-test subjects as mean (standard deviation), are reported in Table 3.

As shown in Table 3, the decrease in the mean pain intensity in experimental group showed a significant difference compared to before the exercise ($p<0.001$) and no significant statistical differences were observed in the control group. In addition, an increase in ROM of external and internal rotation flexion and abduction in the experimental group during post-test compared to pre-test were observed ($p<0.001$).

Table 3: Mean and standard deviation of the variables measured in in two the in pre-test and post-test

Variable		Group	Pre-test	Post-test	P Within group	P Between group
Pain (mm)		Cot	63.4± 15.5	11.4±.00 64	0.612	<0.001*
		Exp	62.8 ±21.4	23.3 ±17.98	<0.001*	
ROM (degree)	Int.Rot	Cot	27.2 ±6.34	26.6 ±6.65	0.501	<0.001*
		Exp	26.3 ±6.11	41.5 ±3.50	<0.001*	
	Ext.Rot	Cot	34.4 ±6.23	33.7 ±9.10	0.418	<0.001*
		Exp	34.3 ±5.39	45.00 ±5.86	<0.001*	
	Flx.	Cot	120.1 ±19.44	118.0 ±18.82	0.363	<0.001*
		Exp	119.4 ±13.12	126.2 ±9.42	<0.001*	
	Abd	Cot	123.5 ±12.20	120.4 ±13.85	0.121	<0.001*
		Exp	123.4 ±15.55	136.5 ±9.35	<0.001*	
JPS 45 degrees		Cot	6.5 ±4.21	6.1 ±4.14	0.451	<0.001*
		Exp	5.93 ±2.11	3.1 ±2.12	<0.001*	
JPS 80 degrees		Cot	4.9 ±2.45	5.3 ±2.90	0.213	<0.001*
		Exp	5.21 ±2.28	2.3 ±1.88	<0.001*	

Discussion and Conclusion

The present study aimed to investigate the effect of a water-based training program on pain, range of motion, and joint position sense in elite female swimmers with SIS. The main findings of study were the training program in water 1) reduced pain 2) increased range of motion, and 3) improved JPS of elite female swimmers with SIS. According to the results of the present study, a water-based training protocol reduces pain in athletes with SIS. The results of this study is in line with the existing literature, which collectively indicates that engaging in each type of water-based training decreases pain. In this regard, studies by Kaya et al. (31), Selik et al. (32), Roy et al. (33), Yeganeh et al. (11), can be mentioned. Because SIS occurs when dynamic and static shoulder stabilizers fail to retain subacromial space for some reason, soft tissue structures are under pressure, and, as a result, irritation and inflammation occur (32). Also, this syndrome is usually caused by sports or other activities that require repeated use of the upper arm (34), and since the present research samples are athletes who have used the physical activity many times during the week. Frequent arms were above the head, therefore, according to the findings of the present study and previous research, it seems that training improves muscle imbalance between shoulder dynamic stabilizers, and helps to maintain the subacromial space and consequently prevent soft tissue entrapment. And this reduces the pain and inflammation in people with this syndrome.

Evaluation of the effect of exercise in another part of the present study the effect of exercise protocol in the water on the ROM of the shoulder joint in elite female swimmers with SIS was examined. The results of the present study showed a significant improvement in the ROM of the shoulder joint in athletes with SIS so that there was a significant difference in abduction, internal rotation, and external rotation and flexion in the experimental group compared to the control group. This finding is consistent with the results of the existing researches. Senbursa et al. (2007) compared two therapies, home exercises, and physiotherapy in people with SIS. they showed that both methods improved the ROM of the shoulder joint, but the improvement in the physiotherapy group was more significant (15). Also Yeganeh et al. (2011) compared the effect of topical corticosteroid injection and physiotherapy on pain intensity, ROM and muscle strength of patients with SIS (11). The findings showed that by the end of the twelfth week, the group treated with physiotherapy had shown a more significant improvement in ROM (abduction and external rotation) than in the other group. In addition, Alibakhshi et al. (2010) compared four exercise programs such as exercise therapy, massage therapy, mechanotherapy and combination on rotator cuff muscles in patients with SIS. The researchers said that combination therapy has better therapeutic effects on increasing the ROM of rotator cuff muscles. In such a way that this action reduces the pain in these people and consequently increases the ROM. Therefore, it seems that exercise therapy is more effective than drug therapy for the treatment of people with SIS due to the improvement of muscle imbalance (35). The results of the present study showed a significant improvement in the JPS in the shoulder joint of women swimmers with SIS, which is consistent with the results of, Arami (2012) and Herrington (2010) (29,36). Also, Arami et al. in a study that examined head and neck reconstruction errors concluded that ten sessions of the program of tolerance and JPS of the neck can be effective in improving the sensory error and pain of patients with chronic non-specific chronic neck pain. They argued that proprioceptive exercises are likely to increase attention to the proprioception symptoms of the brain first at the conscious level and then at the automatic level, and another explanatory mechanism for improving the proprioception is the effect of training on activating pathways, and the communication of neural pathways in the relevant sensory area seen in plasticity (36). Herrington, meanwhile, conducted a study of rugby players and reported that a shoulder that was injured compared to a healthy shoulder had a significant error in reconstructing the angle of the JPS, stating that the absolute error of the sense of the joint depends on the degree of rotation (29). Moreover, studies have shown that in shoulder abduction, the sense joint position sense at the end of the ROM is more accurate than in the middle ROM, and this can be due to increased muscle tension (37). In fact, the joint receptors inside the joint capsule respond to mechanical deformation, so if the joint is not mechanically deformed, the receptors will not be stimulated and cause minimal feedback in the sense of state (29). Generally, it can be pointed out that due to neural adaptation, improvement of proprioceptive mechanisms occurs in 6 to 8 weeks of training. Thus, as the level of muscle activity continues to increase, the stimulating levels of muscle spindles and pelvic floor muscles also increase, in other words, with the increase in the activity of alpha motor neurons, followed by gamma (30). Also, pain can reduce the JPS, which is followed by increased exercise and pain relief (38). Therefore, improving muscle control of scapula and rotator cuff muscles in patients with SIS is of great importance. In addition, the shoulder is the most movable joint in the body that relies heavily on muscle control to stabilize its mid-range. The muscles with their neural control are responsible for maintaining the head of the humerus in the center of the glenoid cavity during the mid-range of motion. Any disturbance in this mechanism can be activated; Activated by abnormal displacement of the head of the humerus during movement (39). Furthermore, deltoid rotator cuff muscles form a pair of forces that, if the rotator cuff function is optimal, the head of the humerus is approximately at the center of the glenoid cavity (40). Also, an imbalance between the agonist and antagonist muscles of the glenohumeral and scapulothoracic joints causes damage to the shoulder joint and causes trauma syndrome (41). Therefore, with proper resistance training, this muscle imbalance can be improved, and the head of the humerus can be properly placed in the glenoid cavity, and subsequently prevent soft tissue entrapment. A variety of rehabilitation interventions are used in patients with SIS. The results of the study indicate that exercise therapy is used as one of the important methods of treatment of patients with this complication.

Conclusion

The results of the present study show that the eight-week program of water-based exercises was effective in improving joint pain, ROM, and JPS in women swimmers with SIS. This can be explained by the improvement of muscle imbalance between the dynamic stabilizers of the shoulder complex and the impinging of the subacromial space in a way that prevents soft tissue entrapment, reduces pain, and consequently increases ROM and JPS in people with this complication.

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چکیده فارسی

تأثیر یک برنامه تمرین در آب بر درد، دامنه حرکتی و حس عمقی مفصل شانه در شناگران زن نخبه مبتلا به سندرم گیرافتادگی شانه

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تصور می شود یکی از شایع ترین دلایل مشکلات شانه در شناگران رقابتی آسیب به ساختارهای زیر آکرومیال است که به سندرم گیرافتادگی شانه معروف است .هدف از پژوهش حاضر بررسی تأثیر یک برنامه تمرین در آب بر درد، دامنه حرکتی و حس عمقی مفصل شانه در شناگران زن نخبه مبتلا به سندرم گیرافتادگی شانه بود. ۳۰ شناگر زن نخبه سن ۳۰-۲۰ سال دارای سندروم گیر افتادگی شانه به طور تصادفی در گروه تجربی یا کنترل قرار گرفتند. گروه تجربی یک پروتکل تمرین در آب و گروه کنترل تمرینات کششی مرسوم در شناگران را در مدت ۸ هفته اجرا نمود. پیشرونده بودن تمرینات متناسب با عمق آب و نوع تمرین تنظیم شد. درد، دامنه حرکتی (فلکشن، ابداکشن، چرخ داخلی و خارجی) و حس وضعیت مفصل شانه (۴۵ و ۸۰ درجه) قبل و بعد از اجرای مداخله ارزیابی شد. نتایج نشان داد بین میانگین متغیرهای اندازه گیری شده در دو گروه تجربی و کنترل قبل و بعد از اجرای پروتکل تمرینی اختلاف معنی دار مشاهده شد (p< ۰/۰۰۱). میانگین شدت درد در گروه تجربی نسبت به قبل از تمرین کاهش داشته است که این کاهش از نظر آماری معناداری بود (p< ۰/۰۰۱)، همچنین تغییرات آماری معنادار در گروه کنترل مشاهده نشد. علاوه بر آن چرخش خارجی و چرخش، فلکشن و ابداکشن شانه در گروه تجربی نسبت به قبل از تمرین افزایش داشته است که این میزان از نظر آماری معنادار بود (p< ۰/۰۰۱)، در این بخش تغییرات آماری معنادار در گروه کنترل مشاهده نشد. همچنین نتایج نشان دهنده بهبود معنی‌دار حس عمقی در گروه تجربی در مقایسه با گروه کنترل است (p< ۰/۰۰۱). بر اساس نتایج برنامه هشت هفته‌ای تمرین در آب بر بهبود درد مفصل، دامنه حرکتی و حس عمقی زنان شناگر مبتلا به گیرافتادگی شانه موثر واقع شد. این مساله را می‌توان با توجه به بهبود عدم تعادل عضلانی بین تثبیت کننده‌های دینامیک کمپلکس شانه و حفظ شدن فضای ساب آکرمیال توجیه نمود به گونه‌ای که این عملکرد از گیرافتادگی بافت نرم جلوگیری کرده، و موجب کاهش درد و متعاقب آن افزایش دامنه حرکتی و بهبود حس عمقی در افراد مبتلا به این عارضه می‌شود.

واژه‌های کلیدی: تمرین در آب، شنا، سندرم گیرافتادگی شانه، درد