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Effectiveness of a 4-week Exercise Training Program on Shoulder Range of Motion and Stability in Competitive Swimmers - An Experimental Study

Shaunak Sunil Prasade[1], Dr. Sanket Nagrale[2]

[1]Bachelor of Physiotherapy (Musculoskeletal Physiotherapy Department), PES Modern College of Physiotherapy, Pune, India
[2]HOD and Professor (Musculoskeletal Physiotherapy Department), PES Modern College of Physiotherapy, Pune, India

Corresponding Author: Shaunak Sunil Prasade

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ABSTRACT

Introduction: Competitive swimmers undergo a large amount of swim mileage per week. The upper limbs, especially the shoulder joint complex contributes to nearly 70-85% of the propulsive power used during swimming. These repetitive overhead actions lead to occurrence of overuse injuries, such as subacromial impingement.
Method: In this study, a total of 41 swimmers were selected and were given a 4-week exercise training program, which included resistance exercises and a dynamic stretch using elastic resistance bands. Pre and post shoulder horizontal Range of Motion and Isometric shoulder strength ratio were assessed using a long arm goniometer and a handheld dynamometer.
Results: Active Horizontal Range of Motion and Shoulder External rotation to Internal rotation strength ratios significantly improved (p=<0.0001). Analysis showed that the exercise protocol prescribed was effective in improving horizontal range of motion and ER:IR ratios in competitive swimmers.
Conclusion: The 4-week exercise training protocol designed for competitive swimmers was effective in improving shoulder range of motion and stability.

Keywords: [Competitive Swimmers, Exercise training program, Range of motion, Shoulder, Strength and Stability, Resistance training]

INTRODUCTION

Competitive swimmers (swimmers who have participated in State and National Level tournaments from the past 2 years) swim 4 strokes i.e., Freestyle, Butterfly, Backstroke & Breaststroke. These swimmers undergo a large amount of swim mileage per week, while training (15 to 40 km/ week).

Shoulders and upper extremities contribute nearly 70-85% of the propulsive power used during swimming.[1][2] This leads to occurrence of Shoulder injuries in the swimmers, which are very common and frequent. Stability of the shoulder joint is an important factor necessary in prevention of shoulder injuries.

The rotator cuff muscles provide the shoulder with the required stability. Shoulder pain in swimmers is usually caused by overuse, fatigue, repeated overhead biomechanics, hypomobility, and muscle imbalance. [5] Sub-acromial impingement is commonly seen, and is a condition known as Swimmer's shoulder. [3] It is characterized by a gradual onset due to repetitive loading at the AC joint.

Such injuries lead to breaks in training, which might affect the performance of the swimmer. Shoulder pain or injury results in reduced strength, impaired technique, loss of motivation, which ultimately leads to cessation of training for a considerable amount of time. In previous research done by Cejudo A. et al., Active horizontal shoulder abduction (AHSA) hypomobility is found to be one of the risk factors of shoulder injury.[2] Impaired isometric strength ratio of External Rotation to Internal Rotation of shoulder is also a predisposition to Shoulder pain.[1]

Due to lack of awareness, & competitive nature of the sport, these factors are ignored by the swimmers and their trainers. There is a lack of a structured exercise protocol for strengthening the shoulder in competitive swimmers, which may lead to shoulder problems in future training programs.[11] In horizontal shoulder abduction hypomobility, there is usually pectoral and anterior deltoid tightness, whereas rhomboids, trapezius and posterior deltoid are weak. In our structured exercise protocol, emphasis is given on strengthening rhomboids, trapezius and posterior fibers of deltoid, and dynamic stretching of pectoralis major and anterior deltoid.

MATERIALS & METHODS

An exercise program of 4 weeks (3 days/week) was prescribed to a total of 41 competitive swimmers. This study was approved by the ethical committee. Swimmers were selected based on the inclusion and exclusion criteria. The selected swimmers were explained about the exercise program and written consent was obtained prior to the initiation of the study. Pre protocol assessment of Shoulder Horizontal Range of Motion (AHSA) was done using a long arm goniometer. Stability of the shoulder rotators was assessed using ER:IR as the outcome measure with a handheld dynamometer.[4][6][7]

Inclusion Criteria:

1. Participants between the age group of 14-18 years.
2. Both males and females are included.
3. Minimum 8 hours of training per week.
4. Not involved in another stretching/strengthening regime related to shoulder, apart from exercises performed daily pre- and post-workout.
5. No clinical history of upper limb disorders
6. Active Horizontal Shoulder Abduction (AHSA) range < 39° [2]
7. ER:IR strength < 0.65
8. NPRS < 4 on activity

Exclusion Criteria:

1. History of cervical or thoracic pathology
2. Previous shoulder surgery
3. Acute shoulder pain that prevents correct execution of tests and performance of exercises.
4. History of shoulder injury in the past 6 months
5. Under treatment for Shoulder Pain

Exercise Program:

1. Rowing
   Resistance band is attached to a stable support
   (Pole, closed door handle, etc.)
   Band is held at neutral length with shoulders abducted to 90°.
   Elbows are pulled behind beyond the thorax.
2. Shoulder press
   Band is held under feet.
   Shoulder is abducted 90°, externally rotated, and elbow flexed 90° and band is held in neutral length.
   Arm is abducted and elbow is straightened.
3. Upright rows
   Band is placed under both feet and held in hands closed together
   The band is pulled upwards towards the shoulders
4. External rotation
   Resistance band is attached to a stable support (Pole, closed door handle, etc.)

Band is held in hands and shoulders are abducted; elbow is flexed to 90°
Shoulders are externally rotated.

5. Pectoralis and deltoid stretch
   Hold the band overhead with hands held at more than shoulder width apart.
   Arms are slowly rolled backwards towards the hip, and then brought back to the original position.

Repetitions and level of resistance

The resistance level of a resistance band is denoted by its colour. Appropriate colour of band is selected on the basis of whether the swimmer can complete 30 repetitions of that particular exercise without fatigue. If 30 reps are possible comfortably, then the swimmer was asked to move on to the next level of resistance. 20×3 repetitions of each exercise are performed after usual warm-up routine.[1] This specific number of repetitions of each exercise was given as swimming demands repetitive overhead motions of the shoulder.[9] This exercise protocol was to be followed for 3 alternate days per week, for 4 weeks. Any pain, discomfort, or injury was to be reported immediately. Post protocol assessment was done and changes in the shoulder range of motion and strength ratio were noted.

STATISTICAL ANALYSIS

The data collected was statistically analysed using Microsoft excel and GraphPad InStat 3.

Effectiveness of the 4 Week program on the Stability and Strength of Competitive swimmers was analysed using appropriate parametric tests.

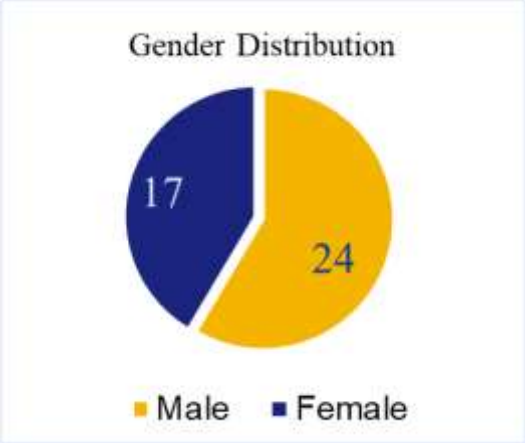
Paired t-tests and Wilcoxon matched-pairs signed-ranks tests were used to obtain the difference between Pre- and Post-Protocol values of shoulder horizontal abduction and strength ratio (ER:IR).

Various statistical measures such as Mean, Standard Deviation (SD), and the test of significance were utilised to analyse the data. The data analysis was done with regards to age, gender, hand dominance

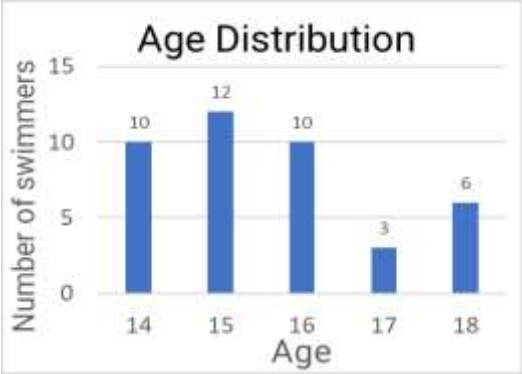
The data was represented in both tabular and graph format.

Demographic Data:

1. Gender Distribution



2. Age Distribution



3. Hand Dominance

Active Horizontal Shoulder Abduction

1. Right AHSA

Parameters	Pre-Test		Post test		T value	P value	Result
Right AHSA	Mean	SD	Mean	SD			
	35.976	±1.197	41.976	±1.81	28.636	< 0.0001	Extremely Significant

2. Left AHSA

Parameters	Pre-Test		Post test		T value	P value	Result
Left AHSA	Mean	SD	Mean	SD			
	35.683	±1.877	41.683	±1.65	21.647	< 0.0001	Extremely Significant

Strength Ratio (ER:IR)

1. Right ER:IR

Parameters	Pre-Test		Post test		T value	P value	Result
Right ER:IR	Mean	SD	Mean	SD			
	0.6119	±0.02575	0.711	±0.04392	16.063	< 0.0001	Extremely Significant

2. Left ER:IR

Parameters	Pre-Test		Post test		T value	P value	Result
Left ER:IR	Mean	SD	Mean	SD			
	0.6058	±0.03077	0.715	±0.05316	15.607	< 0.0001	Extremely Significant

Dominance Analysis

1. AHSA

a) Dominant hand AHSA

Parameters	Pre-Test		Post test		P value	Result
Dominant AHSA	Mean	SD	Mean	SD		
	35.902	±2.154	42.024	±1.782	< 0.0001	Extremely Significant

b) Non-Dominant hand AHSA

Parameters	Pre-Test		Post test		P value	Result
Non-Dominant AHSA	Mean	SD	Mean	SD		
	35.756	±1.609	41.634	±1.67	< 0.0001	Extremely Significant

2. Strength Ratio (ER:IR)

a) Dominant side Strength

Parameters	Pre-Test		Post test		P value	Result
Dominant ER:IR	Mean	SD	Mean	SD		
	0.6166	±0.01944	0.7186	±0.04424	< 0.0001	Extremely Significant

b) Non-Dominant side Strength

Parameters	Pre-Test		Post test		P value	Result
Non-Dominant ER:IR	Mean	SD	Mean	SD		
	0.601	±0.03356	0.6166	±0.01944	0.0029	Very Significant

RESULT

The results of this experimental study were as follows:

There was a mean increase of 6 degrees (Right & Left) AHSA post completion of the exercise program. The p-value for both the paired t-tests was <0.0001; and hence the comparative study was extremely significant. The ER:IR ratio improved by a mean of 0.0991 (Right) and 0.1092 (Left). The p- value for both paired t-tests was <0.0001; and hence the comparative study was extremely significant.

Dominant side analysis:

There was a mean increase of 6 degrees (Right & Left) AHSA post completion of the exercise program. The p-value for both the paired t-tests was <0.0001; and hence the comparative study was extremely significant. The ER:IR ratio improved by a mean of 0.0991 (Right) and 0.1092 (Left).

The p- value for both paired t-tests was <0.0001; and hence the comparative study was extremely significant.

DISCUSSION

Profile of Shoulder Flexibility

The first aim of this study was to determine the effect of an exercise program on the Active Horizontal Shoulder Abduction (AHSA) in swimmers. The ROM of swimmers is higher than the range observed in the general population. This is due to the musculoskeletal adaptations as a consequence of the physical and technical demands of swimming. [2] But, even in these ranges of motion, a lower range (<39^o) predisposes a swimmer to shoulder injury. [2] In this study, swimmers with AHSA Range of Motion <39^o, on both shoulders, were identified. In this study dynamic stretch of the pectoral muscles was administered. Dynamic Stretching is a controlled movement, which involves the performance of a movement progressively increasing the range of motion through successive repetitive motions till the end of the range is achieved. [12] At the end of the range, additional forces are applied on the fibers, increasing the tension.

As the tension increases, the collagen fibers in the connective tissue align themselves along the same line of force as the tension. Therefore, during the stretch, the muscle fiber is pulled out to its full length, sarcomere by sarcomere, and then the connective tissue takes up the remaining slack.

In our study, increased Shoulder Horizontal Abduction ROM is seen after stretching, which can be attributed to better stretch tolerance and improved extensibility of the muscle.

Strength and Stability of Shoulder rotators

The propulsion of a body in the water while swimming is majorly done by the upper limbs, mainly the shoulder joint complex. [3]

The muscles used in 'pulling' phase experience a greater resistance offered by water, than the muscles used in the 'recovery' phase in air.

As a result, the 'pulling' muscles i.e., latissimus dorsi, pectoralis major and minor, teres major, anterior fibers of deltoid develop a good amount of strength.

Comparatively, the 'recovery' muscles i.e., infraspinatus, middle and lower fibers of trapezius, rhomboids, posterior fibers of deltoid do not develop as much strength because of lack of resistance despite equally repetitive motions.

This is the most probable cause of muscle imbalance, and resultantly, injuries to the shoulder.

The second aim of this study was to improve strength and stability at the Shoulder joint, in the swimmers.

Previous studies have reported that the ER:IR ratio assessment can be a useful measure to identify muscle imbalances in the swimmers' shoulders, also being associated with possible injuries. [9]

In these studies, the normative data deemed as adequate ER:IR ratios between 0.66 and 0.75 [8][9]

In our study, exercises that were given to swimmers were targeted to increase the strength of muscles of shoulder complex joint which includes mainly, trapezius (middle and lower fibers), rhomboids (major and minor), infraspinatus, deltoid (posterior fibers) etc.

These exercises were prescribed for 4 weeks.

Swimmers generally perform a variety of dry-land exercises, usually on the pool deck or in the gym, to enhance and optimize their performance in water. [1][10]

A typical dry-land workout consists of a warm up, mobility and strengthening exercises and a cooldown.

The strengthening exercises are done for a specific group of muscles facing more resistance from the water during swimming, i.e., the 'pulling' muscles.

In the exercise program developed for this study, exercises are given to improve strength of the 'recovery' muscles.
Resistance training causes hypertrophy through an increase of myofibril size and the number of fast and slow-twitch fibers.
Moreover, the recruitment pathway of muscle fibers become more effective.
Resistance training thus leads to greater force development of the trained muscles.
The exercises prescribed in this study improved the strength of the targeted muscles.
This helped in bringing stability to the repetitive actions performed by the swimmers in the pool thus increasing the strength ratio of ER:IR muscles
A high number of repetitions (3 sets of 30 repetitions) of each exercise was given to meet the specificity of swimming, which requires muscular endurance capacity and to obtain a larger solicitation by the rotator cuff muscles. [9]

CONCLUSION

The Exercise program designed to improve Shoulder Range and Stability has proven to be effective.

LIMITATIONS

The following limitations were experienced during the course of the study:

1. The study was performed on a small population.
2. ER:IR ratio could be performed on an isokinetic dynamometer for better specificity.

FUTURE SCOPE OF STUDY

The future scope of study with reference to this experimental study is

1. Study population can be changed, with respect to age and location.
2. Study can be performed on a larger population.
3. Comparative studies can be performed.

Declaration by Authors

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