International Journal of Health Sciences and Research
Vol.10; Issue: 6; June 2020
Website: www.ijhsr.org
Original Research Article *ISSN: 2249-9571*

The Effect of Dry Land Shoulder Girdle Strengthening Exercises on Aerobic Endurance of Swimmers

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ABSTRACT

Background: Swimming is characterized by a sequence of coordinated actions of the trunk and limbs, in a repeated, synchronous pattern. Swimming requires many sequential repetitive movements, with little opportunity for rest. Sufficient upper limb muscle endurance and strength are necessary in these athletes. The scapular muscles have an important function in swimming. Dry-land strength training is used for performance enhancement and injury prevention. Aerobic swimming test used in this study is Progressive Swim Test. The implementation of the Progressive Swim Test to assess the fitness level by increasing the load beep frequency with the number of laps performed.
Aim: To study the effect of dry-land shoulder girdle strengthening exercises on aerobic endurance of swimmers. Objective: To assess and compare the effect of dry-land shoulder girdle strengthening exercises and conventional exercises on aerobic endurance of swimmers using Progressive Swim Test.
Materials and methods: A total of 30 swimmers were selected as per the inclusion and exclusion criteria and consent was taken. All subjects were made to perform Progressive Swim Test. The subjects were randomly allocated in two groups i.e. experimental group and the control group. The control group received conservative rehabilitation and experimental group received strength training with Thera Band in addition to the conservative rehabilitation. After 4 weeks, all the subjects were again made to perform Progressive Swim Test. The values after the test were statistically analyzed for finding out the effect. Results: The study results show that there is significant improvement in the VO2max and RPE values in the experimental group but there is no significant difference when compared to control group.
Conclusion: The above study concludes dry-land shoulder girdle strengthening has beneficial effects on aerobic endurance primarily on VO2max and RPE in swimmers using the Progressive Swim Test.

Keywords: Swimming, Dry-land shoulder girdle strengthening, aerobic endurance, VO2max, RPE, Progressive Swim Test.

INTRODUCTON

Swimming is one of the most popular sports worldwide and promotes several benefits for body and health. [1] Swimming is characterized by a sequence of coordinated actions of the trunk and limbs, in a repeated, synchronous pattern. Arm action during each of the four competitive swimming strokes comprises specific phases. It is typical to define these phases according to the various sweeps of the arms, which are specific to each stroke (Figure 1) For example, down sweep; in sweep; and up sweep movements are completed during front crawl. [2] The shoulder complex is highly loaded during body propulsion in the

water, with repetitive movements and no time to rest, which may explain the high incidence of shoulder pain and injuries in swimmers. [1]

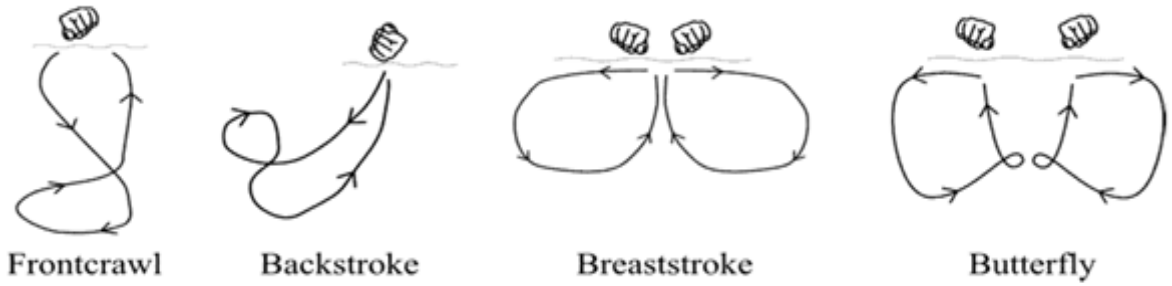


Figure 1-Representation of typical arm actions during swimming, highlighting the characteristic patterns of movement and sweeps of the arms for each of the four competitive strokes.

During almost all swimming strokes, arm adduction and shoulder internal rotation are highly demanded. The muscles responsible for these movements become stronger than their antagonists, causing a possible muscle imbalance in these athletes. These changes in muscle balance may occur especially in internal and external rotators of the arm as these muscles help in the improvement of the swimming performance. Internal rotators and external rotators of the arm are responsible in providing stability and mobility to the glenohumeral, especially in overhead athletes. The rotator cuff muscles, the supraspinatus are one of the main muscles responsible for stabilizing the humeral head in the glenoid fossa. This muscle has also an important role in positioning the arm during the hand entry and exit in the water during the swimming, in association with the middle deltoid, helping in the arm elevation and abduction. [1]

Interventions to strengthen rotator cuff and scapular stabilizers and to increase flexibility resulted in increased strength during external and internal rotation. [3] Elastic bands are simple-to-use tools for multipurpose physical training. [4]

In this sport, the maximal oxygen uptake (VO2max) reveals itself as an important physiological parameter, expressing the swimmers' maximal metabolic aerobic performance that is one of the primary areas of interest in training and performance diagnosis. [5] Aerobic swimming tests were traditionally designed to control the intensity of exercise, using either the time or distance to be executed by the swimmer. Aerobic swimming test used in this study is Progressive Swim Test. The implementation of the Progressive Swim Test to assess the fitness level by increasing the load beep frequency with the number of laps performed. The results shown for before heart rate, after heart rate, rate of perceived exertion, and Number of laps performed by the Pearson's linear correlation, intraclass coefficient correlation, standard error of measurement, and the coefficient of variation demonstrated that this new test was stable across the intra-rater and interrater variations found. Study was done previously to verify the reproducibility of this test for aerobic endurance by nonexpert swimmers. [6]

Therefore, this study is an attempt to check the aerobic endurance of swimmers after performing dry-land strengthening of the shoulder girdle muscles.

MATERIALS AND METHODS

This study is single blinded randomized control trial. This study involved 30 swimmers chosen by simple random sampling technique from sports complex, Mumbai after permission of ethical committee and subjects who were willing to participate in the study and of age group 15-25 years and taking training for 1-2 hours daily for 1-2 years were included in the study and subjects who were medically not fit and with any recent musculoskeletal,

neurological or cardiovascular disease were excluded from the study. Consent was taken. The materials required for the study were pair of cones, speaker, pulse oximeter, stopwatch, whistle and set of Thera Band.

Figure 2: Materials used in the study

All subjects were made to perform Progressive Swim Test. Subjects were randomly allocated in 2 groups, i.e. experimental and control group, 15 in each group. Control group received conventional rehabilitation which involved relaxation, flexibility exercises, jumping jacks, drills in water and flutter board kicking. Experimental group received conventional rehabilitation along with strength training with TheraBand involving

1. Diagonal pattern D2- PNF pattern
2. External rotation with the arm at side
3. Internal rotation with the arm at side
4. Serratus anterior punches
5. Wall clock exercise
6. Shoulder extension
7. Shoulder abduction

This intervention includes 3 sets of 10 repetitions with 60 seconds rest interval between two sets and was given 3 times in a week for 4 weeks. Post intervention again all the subjects were made to perform Progressive Swim Test.

Progressive Swim Test: Each swimmer's heart rate was recorded before the test. The swimmer will remain in the pool. Following an announcement "Attention swimmer, prepare for the test", a short beep sounded, accompanied by a whistle by the evaluator to mark the beginning of the test. After completing each lap, another short beep will be given to indicate the start of the next lap. They increased their swimming speed on hearing a beep after every 25 meters. The swimmer will be instructed to try to keep to the rhythm sounded by the speaker so as to be always within the beginning/ending 5-meter zone when the short beep was heard. As identifiers for both the swimmer and the evaluator, cones will be placed along the edge of the testing lane. During the test, the evaluator will count the number of laps and also monitor the swimmer, giving verbal and visual signals of the progressive test pace. The test ends when the swimmer didn't reach the 5-meter zone preceding the edge of the pool two laps in a row. At this point, the evaluator will immediately measure the heart rate of the swimmer and present a rate of perceived exertion (RPE). Then, the evaluator will register the number of laps performed by the swimmer and body mass (BM) was noted. And VO2max is calculated using the formula [7]

VO2max= 14.085 + 1.858 (NLP) − 0.192 (BM) + 0.111 (AHR)
NLP- No. Of Laps Performed
BM- Body Mass
AHR- After Heart Rate

in ml/kg−1/min−1. If any swimmer, for any reason, were to stop during the test, their test would be aborted and not counted in the results.

Collected data was entered in Ms. Excel and analyzed using a software package SPSS for windows, version 19.0 and results were calculated at 0.005 level of significance. Normal distribution of data was tested for all baseline parameters using Shapiro Wilk test. Non-parametric tests were used to analyze the data of RPE as the data was not homogeneous. Parametric tests were used to analyze the data of VO2max as the data was homogeneous. Since it was a pre and post measures design within and between the group, by using the Wilcoxon

Test for within the group pre and post data for RPE was analyzed. By using Paired T Test for within the group pre and post data for VO2max was analyzed. By using the Mann Whitney Test for between the group pre and post data for RPE data was analyzed. By using Unpaired T Test for between the group pre and post data for VO2max was analyzed.

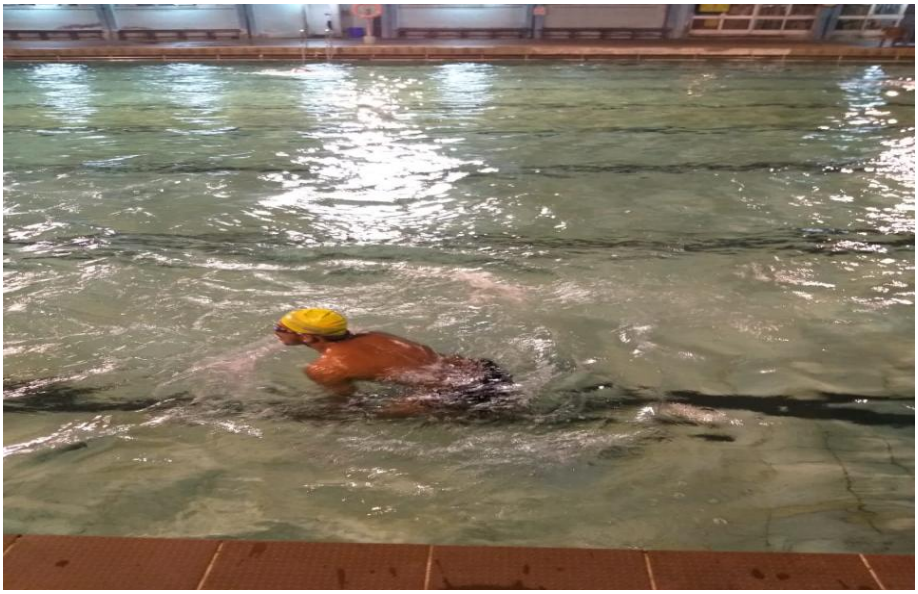


Figure 3: Swimmer performing Progressive Swim Test

RESULT

The demographic data of the subjects are presented in table 1.

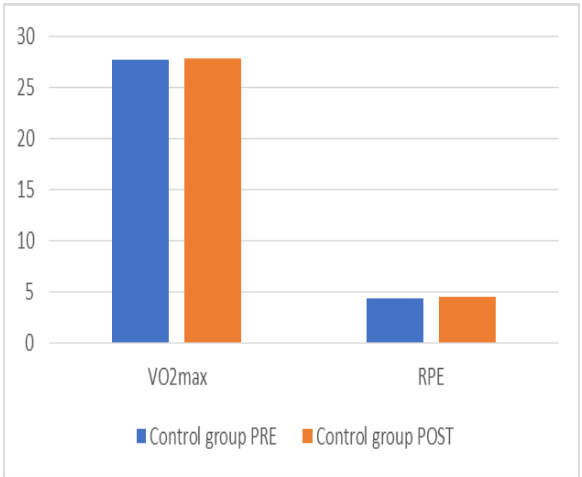
Table 1: Descriptive Characteristics

Sr. No.				Mean	Standard Deviation
Age	Experimental			17.4	±1.6388
	Control			17	±2.6992
Gender	Experimental	Male	10		
		Female	5		
	Control	Male	8		
		Female	7		
No. Of years training taken	Experimental			2.533	±0.9155
	Control			3	±2.0354
No. Of hours of daily practise	Experimental			1.533	±0.6399
	Control			1.533	±0.6399

Table 2 shows that the score of RPE is statistically highly significant in pre and post study but not in VO2max score of control group.

Table 2: Measures of Parameters in Control group (Pre test Vs Post test)

Parameters	Test	P value	Significance
VO2max	Paired t test	P= 0.6770	No
RPE	Wilcoxon test	P= 0.0001	Significant

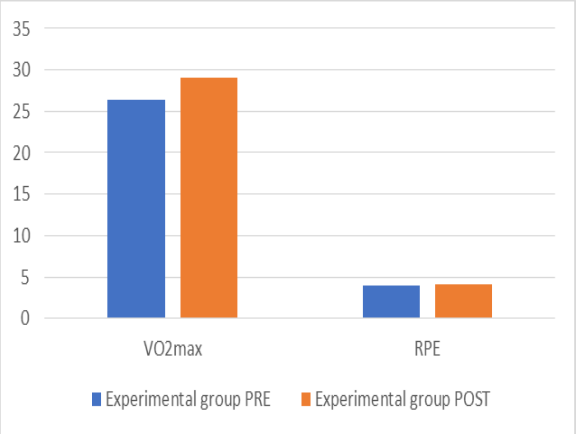


Graph 1- The above table and graph shows pre and post test data in control group.

Table 3 shows that the score of VO2max and RPE are statistically significant in pre and post study of experimental group.

Table 3: Measures of Parameters in Experiment group (Pre test Vs Post test)

Parameters	Test	P value	Significance
VO2max	Paired t test	P<0.0001	Significant
RPE	Wilcoxon test	P= 0.0001	Significant

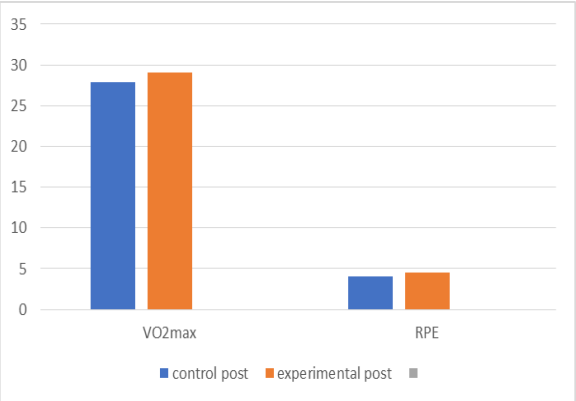


Graph-2: The above table and graph shows pre and post test data in experimental group.

Table 4 shows that there is a statistically significant difference found in RPE while no statistically significant difference found in VO2max score on comparison of post study between experiment group Vs control group.

Table 4: Measures of Parameters of Experiment group Vs Control group

Parameters	Test	P value	Significance
VO2max	Unpaired t test	P= 0.1093	No
RPE	Mann Whitney test	P=0.0001	Significant



Graph 3: The above table and graph shows post test data of control vs experimental group.

DISCUSSION

Although several studies have analyzed shoulder girdle strength in swimmers, to our knowledge this is the first study to study the effect of shoulder girdle strengthening exercises on aerobic endurance of swimmers. The study results show that there is improvement in aerobic endurance in swimmers after dry-land shoulder girdle strengthening exercises reflected by significant p values of respective tests.

The Progressive Swim Test assessed the fitness levels with the no. of laps performed. It also assessed Before Heart Rate (BHR), After Heart Rate (AHR), RPE and VO2max. Beneficial effect on aerobic endurance was seen after 4 weeks, assessed using VO2max and RPE in the Progressive Swim Test.

VO2max: In swimming, the maximal oxygen uptake (VO2max) reveals itself as an important physiological parameter expressing the swimmers' maximal metabolic aerobic performance i.e. one of the primary areas of interest in training and performance diagnosis. [5]

The present study showed that there is increase in the VO2max values in the experimental group. In the study the intra group analysis for VO2max experimental group showed significant results ($p< 0.0001$). However, the intra group analysis for VO2max control group showed no significant results as per table 2. The inter group analysis for VO2max at post 4th week of exercises showed no significant results as per table 4.

The increase in VO2max observed in experimental group could be due to various reasons. Strength training using dry-land regimens may enhance the ability to produce propulsive forces in water, especially in short distance events. Increase in cardiac output and VO2 difference contributes to the resistance training improvement of VO2max. Increases in muscle mass in exercising muscle and blood flow to the exercising muscle are other possible factors that improve VO2max. [8]

The increase in VO2max is mainly induced by an increase in capillary density

and myoglobin concentration of muscle as well as increase in muscle mitochondria content and enzyme activity. In addition, changes in peripheral vascular resistance which is involved in increasing muscular blood flow in working muscle, may contribute to the increase in VO2max following strength training. Thus, shoulder girdle strengthening may improve aerobic capacity due to improvements in the capillary to fiber ratio and mitochondria enzyme activity. [8]

Strength training is a potent stimulus for muscle hypertrophy and strength gain. The strengthening induced increase in VO2max may be associated with an improvement in the ability of oxygen to be utilized in hypertrophied muscles. Thus, strength training can be expected to improve concurrently both muscular (muscle hypertrophy and functional ability) and cardiovascular (VO2max) fitness with a single mode of resistance training. [8]

RPE: To measure the level of subjective physical workload, RPE scale is used. [9] Borg's rating of perceived exertion (RPE) is a widely used psycho-physical tool to assess subjective perception of effort during exercise. [10]

The present study showed that there is increase in the RPE score in both the groups. In the study the intra group analysis showed significant results (p=0.0001) for both experimental as well as control group. The inter group analysis for RPE post 4th week of exercise showed significant results (p<0.001)

One of the reasons for RPE to be significant is that RPE is related to aerobic endurance and that the possibility of sustaining a high percentage of maximal aerobic power during a general exercise is mainly related to local muscular factors. [11]

It is a simple strengthening protocol that can be added to the daily practice of all swimmers. Addition of dry land shoulder girdle strengthening along with the conventional rehabilitation is beneficial for both muscular and cardiovascular fitness. Also, strength training using dry-land regimens may enhance the ability to produce propulsive forces in-water. The main limitation of the study was that the swimmers using different strokes were not segregated. Future studies can do measurement of VO2max after swimming on the basis of expired air samples or with the use of gas analyzer and mask.

CONCLUSION

Dry-land shoulder girdle strengthening has beneficial effects on aerobic endurance primarily on VO2max and RPE in swimmers using the Progressive Swim Test but no significant difference when compared to Control group.

Abbreviations

NLP- No. Of Laps Performed
BM- Body Mass
AHR- After Heart Rate
BHR- Before Heart Rate

COMPETING INTERESTS

The authors declare no conflicts of work.

ACKNOWLEDGEMENTS

I express my deep sense of gratitude and sincere thanks to our respected sir Dr. Ajay Kumar and Guide Dr. Manali Akre who immensely helped me with sincere guidance, untiring cooperation, valuable advice and endless inspiration during the course of the study. I also take this opportunity to thank my family members and friends for their help and support.

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How to cite this article: Ladgaonkar S, Akre M, Chogle R et.al. The effect of dry land shoulder girdle strengthening exercises on aerobic endurance of swimmers. Int J Health Sci Res. 2020; 10(6):68-74.

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