



The Effect of Twelve Dry-land Resistance Training of Performance in Young Recreational Swimmers of Islamshahr

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ABSTRACT

Resistance training is one of the training methods that leads to muscle growth, functional improvement and injury prevention for athletes. The aim of the present study was to investigate the effect of twelve weeks dry-land resistance training improving swimmers records. The Present study was semi-experimental. The implementation of the present study, 60 young swimmers were selected and randomly divided into two training and control groups. The exercise group performed resistance exercises for twelve weeks. Absolute power, relative power, lower limb power and 100m free style record were analyzed. Multivariate analysis of variance (MANCOVA) test was used to compare the pre-test and post-test of two groups. Also, in order to compare the post-test of two groups, the correlated t-test was used. Paired t-test was also used to compare the pre-test and post-test of the training group to obtain the effect of resistance training. All statistical tests were performed in SPSS version 26.

The results showed that exercise group that performed resistance exercises with weight s for twelve weeks had a significant increase compared to the control group. Also, the factors of absolute strength, relative strength, lower limb strength and telemetry of limbs had a significant increase. In addition, the athletes in the training group had lower sprint records. Resistance training increases hypertrophy in muscles and increases power in swimmers. Possibly, increasing the absolute and relative strength of the lower limb muscles can affect the anaerobic system and improve the swimming record. However, more research is needed on the volume and intensity of swimmers' resistance training.

Keywords

Power, Swimming, Strength, Record

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1. Introduction

Success in sports performance is related to several factors, of which training is considered a main part (1). Success and progress in swimming performance and records, like other sports, are done with different physical, technical and tactical goals. In swimming, the role of physical and physiological factors is very prominent. Swimming is one of the most attractive events, which has distances of 25, 50, 100, 200 meters, and the performance of athletes in this event is decisive (2). Due to the fact that swimming is one of the record breaking sports, on this basis, some swimming coaches believe that people are able to perform better by doing strength training (increasing muscle strength and endurance) (3). Due to the nature of this discipline, athletes who are at high levels of muscle strength are more successful, so athletes spend a lot of time to increase muscle strength in order to record better records (4). On the other hand, the use of resistance training has a history of thousands of years, but in recent years, the use of resistance training has received more attention by following a number of athletes and improving sports records. Recently, many people have turned to resistance training to increase anaerobic power and increase muscle tension, and as a result, to help increase muscle strength and reduce sprint records (5). Optimum performance of muscles through resistance training, can lead to optimal performance of activity at higher levels with minimum expenditure of energy in a shorter period of time (5). Resistance training is any activity that involves skeletal muscles. These exercises can be done with or without weights (body weight). Resistance exercises with continuous application of loads cause muscle contraction and ultimately lead to an increase in contraction proteins, muscle cross-sectional area, improvement in anaerobic power and speed (6), increase in strength and hypertrophy (7), muscle endurance and motor performance. It plays an important role in improving sports performance (8). Research has shown in this regard, investigated the effect of twelve weeks of resistance and endurance training on the physiological, functional and record factors of elite swimmers. The results showed that the heart rate and blood pressure of athletes increased after resistance and endurance training. Probably the cause of this increase was due to the duration of the exercises, the nature of the exercises and the heaviness of the exercises with short rest intervals between the exercises (9).

The importance of increasing the strength of the lower limb muscles and its relationship with reducing the sprint record is very wide. The effects of resistance training on sports performance depend on the intensity and duration of the training protocol, methods of training loads (training systems), lactate threshold speed, maximum oxygen consumption (VO_{2max}), heredity and gender (10-12). Based on previous studies, it has been proven that in addition to strengthening the anaerobic system, paying attention to factors such as: endurance, muscle strength and flexibility affects the sprint record (16-13). Therefore, according to the research in this field, it may be useful for swimming if they improve their neuromuscular characteristics, strength and anaerobic power with strength training, many studies have shown that the increase in initial performance after Traditional heavy resistance training is mostly the result of neuromuscular adaptation (hypertrophy) (17). Research in this field has shown that following resistance training, neuromuscular characteristics, aerobic and anaerobic capacity, movement efficiency, and maximum speed improve in trained swimmers (18,19).

Swimming speed over various distances has improved significantly over the past few decades, leading to higher demands not only on oxygen uptake and utilization, but also on the neuromuscular system for power generation. Swimming ability and anaerobic characteristics may also benefit the competitive performance especially when swimming at the end of a race (20). But these adaptations may include increasing strength, increasing the call of motor units, improving mechanical efficiency and coordination of muscles (17, 21, 22). A key component of the swimming record is the ability to store and recover elastic energy from eccentric contraction (23). Several studies have shown the improvement of swimming record as a result of various types of training (24, 25). The positive effect of resistance training leads to an increase in the stiffness of the lower body muscles-tendon, the degree of nerve input to the muscle, an increase in muscle strength and elastic return, and an improvement in the coordination of the motor unit (24, 26). Research has shown in this regard resistance training in football players accelerates the process of muscle hypertrophy, strength and improves performance (4). Also, the improvements resulting from any form of resistance training may strengthen swimming mechanics, and cause more muscle fiber recruitment and leg muscle coordination, leading to a reduction in relative workload (27, 28). The combination of improved neuromuscular efficiency and strength is likely to reduce oxygen consumption, resulting in record and ultimately improved performance. Indeed, resistance training may facilitate further improvements in swimming economy through the accumulation of adaptations previously observed when high-intensity training is performed. Considering the importance of knowing the effects of resistance exercises for the use of athletes and national heroes, it is very important and this is while the research done in this field is limited (29).

Studies have shown that swimmers have used resistance training to improve strength, power, balance. However, despite this research has not measured the effects of resistance training taking into account the subjects' body weight in terms of absolute and relative strength on the swimming index, despite the various researches, there are different opinions that can It is probably due to the difference in the characteristics of the training, the frequency range and the method of using the training protocol, the intensity of the volume and the type of training, or the performance level of the subjects (30). In competitive activities, different body systems are always under intense physical pressure and high arousal, and along with the reduction of capabilities such as speed, strength, power, and balance coordination, the athlete reaches the border of fatigue to the point of paralysis. In this situation, due to the lack of a resistance training program, athletes, get injured due to the continuous application of body weight on the lower limbs, as a result, it is important to use resistance training methods to recover energy and maintain the strength and muscle mass of athletes (31). For this reason, the present research aimed of the present study was to investigate the effect of twelve weeks dry-land resistance training improving swimmers records.

2- Materials and Methods

2-1. Study design and population

The statistical population of this research was teenage swimmers (teenage boys who had at least 2 years of training experience). Participants participated in resistance exercises for twelve weeks voluntarily in this research. First, the subjects completed the general health medical form and the consent form from the parents, which was approved by the Faculty of Physical Education and Sports Sciences of Mohaghegh University and its Health and Wellness Center. Also, in order to familiarize the subjects with the laboratory environment and measuring devices, an initial test (pilot) was conducted. The number of subjects was 60 teenage male swimmers with at least 2 years of sports experience, and they were divided into two resistance and control groups based on the statistical indicators of height, weight and specific body mass index. During several separate sessions, the subjects were familiarized with the correct technique of performing the movements and test methods. The muscle strength and muscle

volume of the subjects were measured in two phases before and after the 12-week training period. After determining the muscle size, a 10-minute warm-up including softening and stretching movements for the subjects using a test of one maximum repetition in the movements and muscle endurance, also using the maximum possible repetitions up to the limit of voluntary fatigue at an intensity of 57 percent of 1RM repetitions took. Due to the boring nature of the muscle strength test, the maximum repetition test was always performed at the beginning of the work, and after completing the intended measurements in the pre-test phase, the subjects participated in the training program for 12 weeks and three days a week.

2-2. Measuring tools: validity and reliability

Each training session consisted of one upper body movement (pressing) and four lower body movements (leg squat, leg press, front leg and back leg). After 10 minutes of warm-up with light stretching and stretching movements, the subjects performed a warm-up session with 12-14 repetitions before each movement, and in the form of two groups, pre-test and post-test were performed in one round and three rounds. The training intensity was the same for both groups and the maximum was 8 repetitions. In the first training session, the amount of load for all movements was set to 70 percent of a maximum repetition, and from the second session onwards, the intensity of the exercise was equal to the amount of weight that the subject was only able to repeat 8 (times) 8 repetitions of the maximum. The amount of weight was increased in such a way that if a subject could perform the movement in question 8 times in each session, in the next session the amount of exercise load would be increased by 2-5% so that the subject could only perform 8. At the end, the subjects did 5 minutes of cooling down by performing stretching movements. A maximum repetition test was used to obtain the athletes' absolute strength. If the subjects were not able to do one maximum repetition, their absolute power was obtained from the sub-maximal test with 4 repetitions and putting it in the calculation formula of one maximum repetition. By dividing the absolute strength by the weight of the subjects, the relative strength will also be obtained. A tape measure was used to measure chest circumference and thigh circumference. Also, two standard Sarget vertical jump and long jump tests were used to measure lower limb power. All the tests were performed in two stages, pre-test and post-test, in three repetitions. During the training program, the subjects were asked to refrain from doing regular sports activities and consuming food and pharmaceutical supplements and not to make significant changes in their diet.

2-3. Inclusion and exclusion criteria

In this research, the inclusion criteria are: having more than 2 years of training experience in the field of swimming speed, without musculoskeletal injuries and being young group. Also, the exit criteria are: unwillingness to continue cooperation and being injured during training.

2-4. Data Analyses

In order to analyze the data, SPSS version 26 statistical software was used. To implement the MANCOVA model, the homogeneity of the covariances of the two groups was checked using the box test. And after accepting the homogeneity of the covariances of the two groups, Wilk's lambda test was used and the results were checked at a significance level of $P < 0.05$.

3- Results

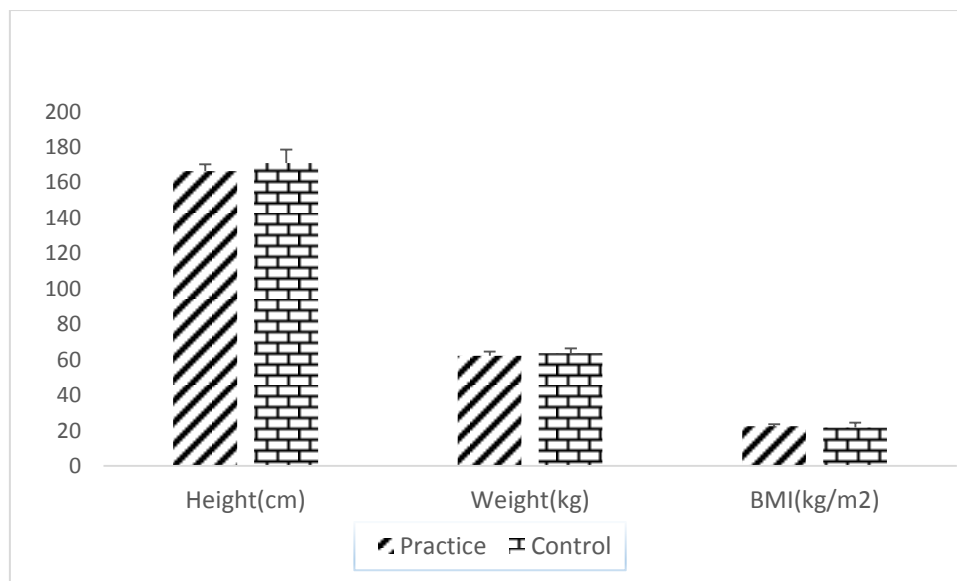
First, the descriptive statistics related to the demographic characteristics of the participants, including their height, weight, and body mass index, separated into two control and training groups, are reported in Table 1. According to the results of the independent T test (Table 1), the null hypothesis of equality of the averages of the two variables of weight and body mass index in the two training and control groups was not rejected ($P > 0.05$). But the equality of the average height of people in the two training and control groups was rejected ($P \leq 0.05$). In addition, according to Levene's test (Table 1), there was no significant difference between the variances of the three variables in the two training and control groups ($P > 0.05$) and the groups

were homogeneously divided. Therefore, to control the effect of the height variable, it is necessary to include this variable as an auxiliary variable in the subsequent tests. For more intuition, the bar chart of the average height , weight and body mass index is drawn separately for the training and control groups in chart 1.

Table 1. Statistical indices of height , weight and body mass index.

Specifications	Practice	Control	The significance of equality of means	Significance of Lone test
Height (cm)	186.21± 8.40	191.26 ± 5.85	0.020*	0.458
Weight (kg)	78.29 ± 2.36	77.62 ± 2.68	0.195	0.548
Body Mass Index (kg/m2)	22.52 ± 1.36	21.27 ± 2.68	0.112	0.925

* Significant difference between groups, $p < 0.05$



Graph 1. Bar chart of average height , weight , and body mass index by exercise and control group.

First, in order to have an overview of the data, the mean and standard deviation of the pre-test and post-test values of the research variables separately for the control and training groups are reported in Table 2. For more intuition, the average graph of these variables is also drawn in Figure 1-4 and Figure 2.

Table 2. The mean and standard deviation of the pre-test and post-test values of the research variables separately for the Control and training groups.

Indicator	Variable	Control group		experimental group	
		Pre-test	Post-test	Pre-test	Post-test
Absolute Strength (kg)	chest press	59.42 ± 5.10	60.02 ± 1.02	57.84 ± 4.28	62.57 ± 1.13
	Squat	72.73 ± 6.92	73.2 ± 1.98	74.34 ± 4.33	77.08 ± 1.20
	Leg Extensions	64.52 ± 4.58	66.22 ± 1.19	64.52 ± 4.94	67.50 ± 1.24
	Leg Curl	63.02 ± 4.83	65.39 ± 1.45	62.66 ± 3.73	65.47 ± 0.10

Indicator	Variable	Control group		experimental group	
		Pre-test	Post-test	Pre-test	Post-test
Relative Strength (kg/m)	chest press	1.76 ± 0.17	1.81 ± 0.42	1.78 ± 0.20	1.81 ± 0.12
	Squat	1.98 ± 0.22	1.99 ± 0.21	1.03 ± 0.16	1.07 ± 0.12
	Leg Extensions	1.85 ± 0.17	1.88 ± 0.18	1.87 ± 0.18	1.92 ± 0.12
	Leg Curl	1.83 ± 0.17	1.87 ± 0.17	1.84 ± 0.15	1.88 ± 0.12
Somatometry (cm)	chest girth	79.39 ± 1.91	81.68 ± 0.85	80.47 ± 2.75	84.52 ± 0.82
	Leg girth	57.57 ± 3.75	58.43 ± 0.17	56.67 ± 3.33	58.94 ± 0.89
lower extremities power (cm)	Vertical Jump	46.93 ± 2.69	48.56 ± 0.27	48.50 ± 2.34	50.52 ± 0.69
	long jump	143.93 ± 3.66	145.56 ± 0.18	145.65 ± 3.90	149.0 ± 0.96
100 meters record (s)		83.37 ± 0.48	83.18 ± 0.19	78.49 ± 0.33	75.57 ± 0.31

* Significant difference between groups, $p < 0.05$

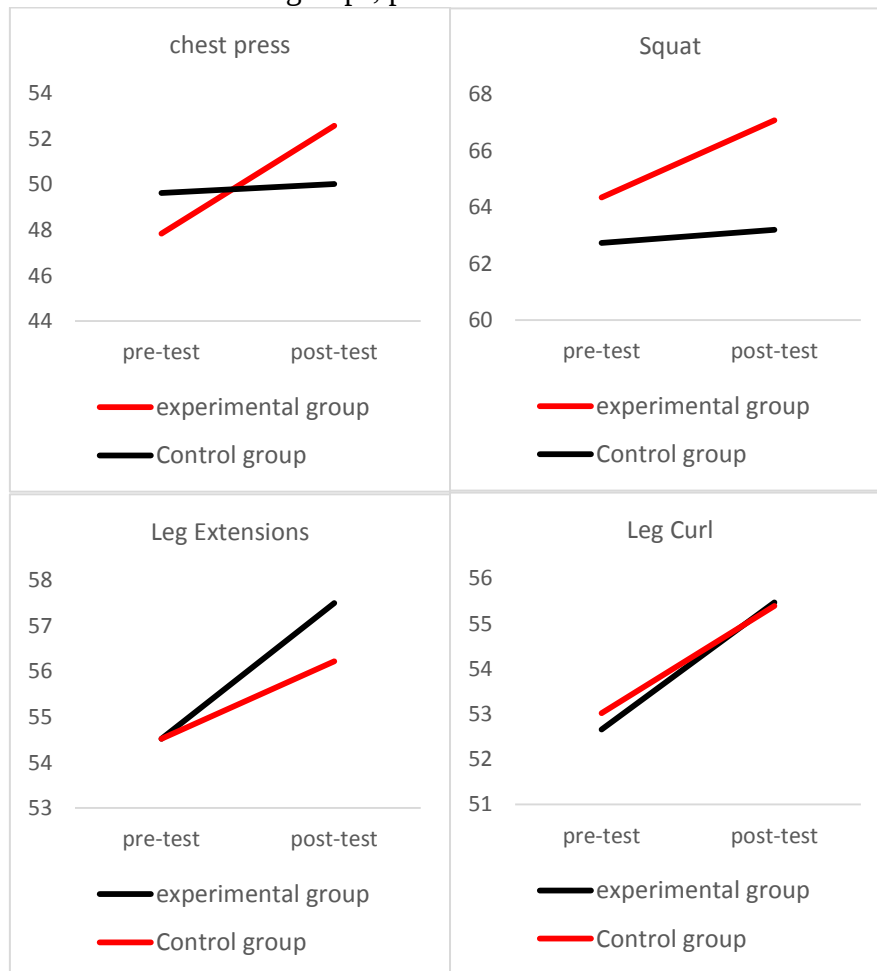


Figure 1. Linear graph of average absolute strength (kg), of training and control groups.

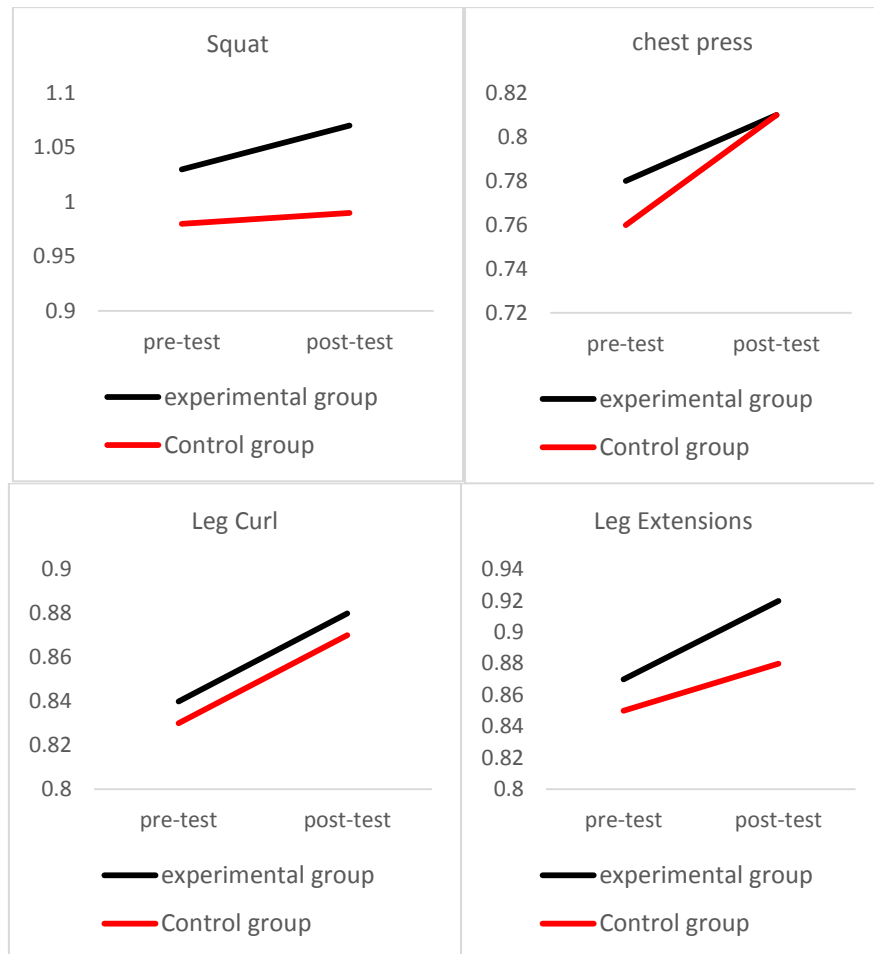


Figure 2. Linear diagram of average relative strength (kg/m), of training and control group.

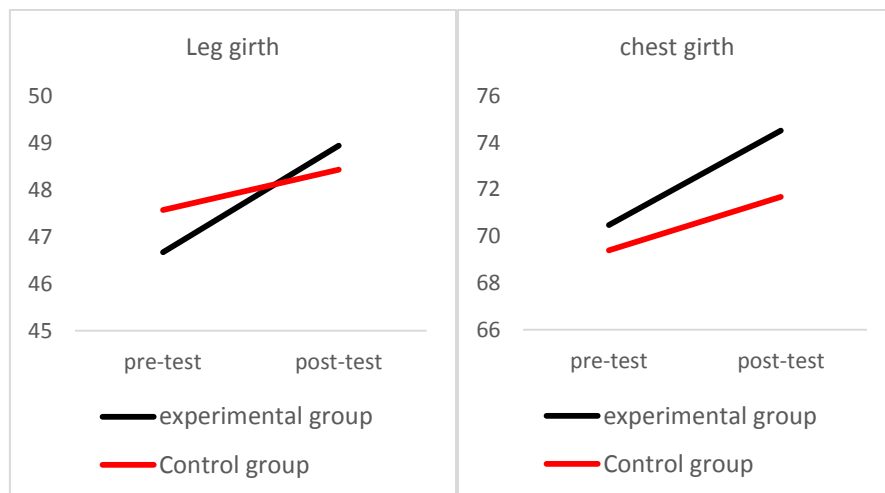


Figure 3. Linear graph of average distance measurement (cm), of training and control group.

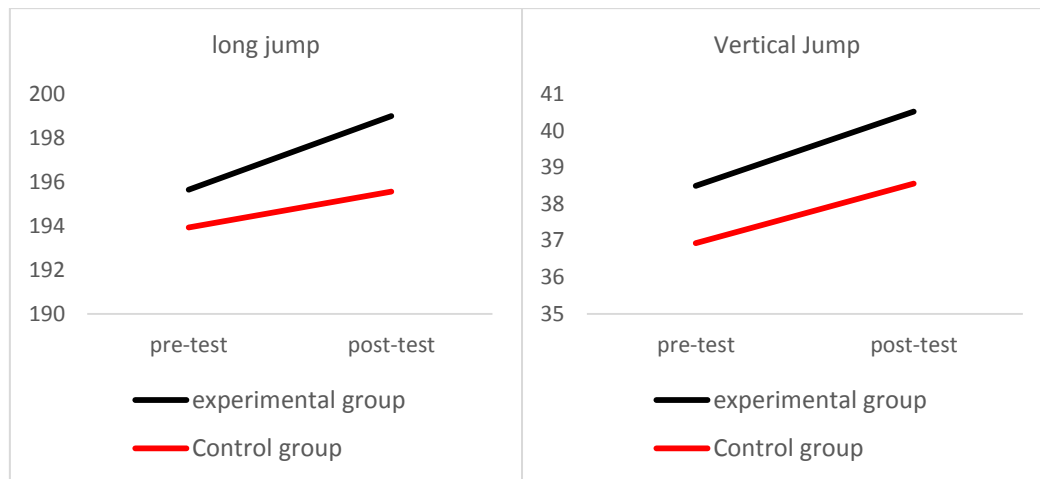


Figure 4. Linear diagram of the average power of the lower limbs (cm), of separated from the training and control groups.

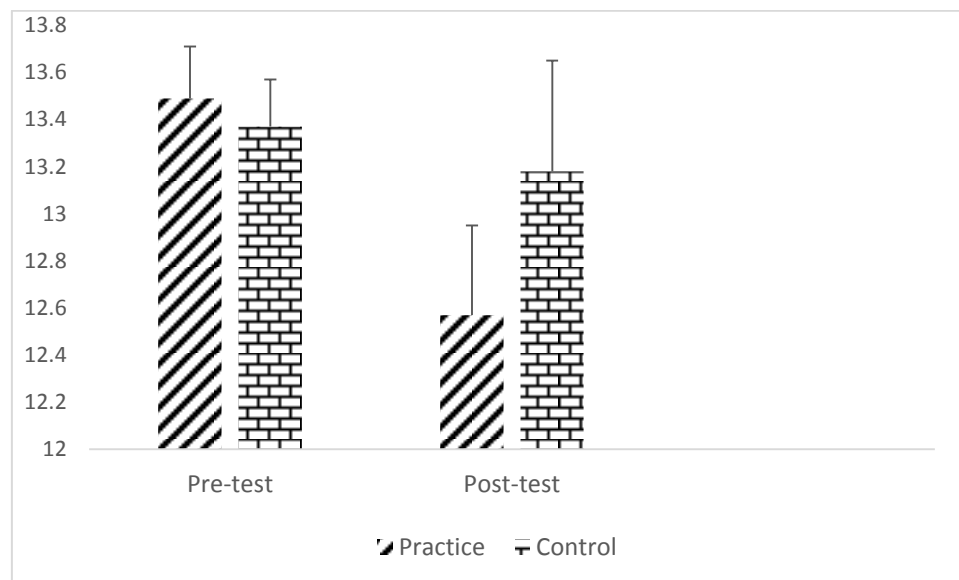


Diagram 2. Bar graph of average record (s), of two 100m training and control group.

In the following, in order to investigate the effect of twelve weeks of resistance training on the record of teenage swimmers, since the number of dependent variables in the research is more than one variable and we have several auxiliary variables, multivariate analysis of covariance (MANCOVA) is used. In this analysis, the dependent variables are equal to the absolute power record of swimmers (including the four variables of chest press, squat, front thigh and back thigh), the relative strength record of swimmers (including the four variables of chest press, squat, front thigh and back thigh), the distance measurement record of swimmers (including chest circumference and thigh circumference), lower limb power record (including Sargent's jump and long jump) and 100m sprint record of swimmers. Also, the height of the swimmers along with the pre-test record of these variables are considered as auxiliary variables. One of the necessary conditions for performing multivariate covariance analysis is the normality of model residuals. By using the Kolmogorov-Smirnov test, since the significance of this test was greater than 0.05 for all the balances, therefore, all the balances have a normal distribution and this assumption is valid for multivariate covariance analysis. In the case of this study, the significance of the Box test is equal to 0.013 and less than 0.05, so the assumption of homogeneity of the variance-covariance matrix is rejected at the 95% confidence level. In this research, since the specific values differ greatly, the maximum root was used in the multivariate test. The results of this test are reported in Table 3. Because the

significance of the multivariate test is less than 0.05 for all the variables except for the relative forefoot variable, therefore, considering each of the previously measured variables, except for the relative forefoot variable, as an auxiliary variable. There is a significant difference between a linear combination of variables measured later between the control and training groups. In other words, there is no significant difference between any linear combination of variables measured later between the two control and training groups, considering the previous relative anterior thigh variable as a covariate. The values of the partial eta square, which indicates the effect size of each variable, are reported in Table 4. For example, the effect size for the thigh circumference variable was 0.995 and it shows that 99.5% of the thigh circumference changes are due to Twelve weeks of resistance training. According to the obtained partial eta squared values, among the variables that have changed significantly after Twelve weeks of resistance training are thigh circumference, Sargent's jump, 100 meters swimming record, long jump, chest circumference and absolute squat, respectively, with an effect size of 0.995, 0.986, 0.932, 0.930, 0.904 and 0.865 were the most to least effective. In summary, by applying Twelve weeks of resistance training to teenage swimmers, distance measurements, lower limb power, squat variable of absolute power index and their 100m swimming record have improved significantly. Regarding the index of relative strength and three other variables of absolute strength, because the significance of all twelve variables related to them was less than 0.05, therefore, twelve weeks of resistance training did not have a significant effect on them.

Table 3. The root of the maximum and its significance for multivariate models.

Indicator	Model covariate	Maximum zinc root	Significance
Absolute Strength (kg)	Height and chest press pre	997.94	0.013
	Height and Squat pre	1065.781	0.017
	Height and Leg Extensions pre	53.235	0.024
	Height and Leg Curl pre	1243.569	0.011
Relative Strength (kg/m)	Height and chest press pre	956.271	0.017
	Height and Squat pre	959.62	0.025
	Height and Leg Extensions pre	27.352	0.142
	Height and Leg Curl pre	1257.58	0.013
Somatometry (cm)	Height and chest girth pre	837.574	0.028
	Height and Leg girth pre	897.623	0.018
Lower Extremities Power (cm)	Height and Vertical Jump pre	1391.103	0.028
	Height and long jump pre	1146.925	0.018
Height and Record of Swimming 100 meters pre (s)		1189.203	0.001

* Significant difference between groups, $p < 0.05$

Table 4. The results of intergroup effects and the effect size of research variables.

Indicator	Model	Dependent variable	Statistics F	Significance	Effect size (eta squared)
Absolute Strength (kg)	Group* Height * chest press pre	chest press post	0.116	0.852	0.218
	Group* Height * Squat pre	Squat post	0.878	0.0497*	9.632
	Group* Height * Leg Extensions pre	Leg Extensions post	0.709	0.172	3.479
	Group* Height * Leg Curl pre	Leg Curl post	0.014	1.002	0.047
Relative strength (kg/m)	Group* Height * chest press pre	chest press post	0.11	0.863	0.205
	Group* Height * Squat pre	Squat post	0.843	0.074	7.35
	Group* Height * Leg Extensions pre	Leg Extensions post	0.465	0.409	1.284
	Group* Height * Leg Curl pre	Leg Curl post	0.026	0.985	0.065
Somatometry (cm)	Group* Height * chest girth pre	chest girth post	0.917	0.030*	14.129
	Group* Height * Leg girth pre	Leg girth post	0.511	0.000*	0.555
Lower Extremities Power (cm)	Group* Height * Vertical Jump pre	Vertical Jump post	0.212	0.042*	0.526
	Group* Height * long jump pre	long jump post	0.418	0.029*	0.180
Group* Height *	record of 100 meters pre	record 100 post	0.289	0.034*	0.118

* Significant difference between groups, $p < 0.05$ **4- Discussion**

The aim of the present study was to investigate the effect of twelve weeks dry-land resistance training improving swimmers records. Twelve weeks of resistance training with weight had a significant decrease on the record of the lower limb power index, which was evaluated using two long jump and Sargent's jump tests. The effects of resistance training on strength, power, balance and to the extent of few studies on speed and agility have been shown, but in this field there are almost contradictory opinions which can be due to the difference in the training characteristics of the frequency range and the method of application of the training protocol, intensity, volume and The type of training or the performance level of the subjects (30). When we examine the performance of athletes, lower limb strength is a vital tool (32, 33). In this regard, McBride et al, in a research, compared the effects of 8 weeks (twice a week), light and heavy squat jumps on increasing peak power in 26 male athletes with resistance training experience. The results showed a significant improvement in the peak power increase in the squat jump test with 30 and 80% of a maximum repetition (34). Also, researchers attribute the improvement of lower body explosive power due to performing ballistic resistance exercises to factors such as: better coordination of muscles or the ability of opposing and agreeing muscles to cooperate effectively in the execution of a movement (35), the presence of some local muscle changes (36), coordination of movement patterns. and the stimulation of more motor units (32), significant change in speed-force relationship, jump mechanics, muscle structure and nerve activation (37), have been attributed. The results of the present study also showed that swimming in resistance training after performing exercises with weight, including performing squats in two long jump and Sargent's jump tests, which measures the explosive power of the lower limbs, compared to the control group, which includes swimmers who They didn't do any exercises, they were able to perform better and we recorded a significant difference between the two groups. It can be concluded that probably resistance training exercises can improve the explosive power of the lower limbs and in a discipline like swim one of the most important factors of physical fitness, it can improve performance and record better records.

The results of the current research on absolute and relative strength showed that twelve weeks of resistance training with with weight only improved the record of the squat movement and in the record of other movements such as chest press, front leg and back leg, despite the average increase in the case sample. The study had no significant effect. In addition, regarding the relative strength, the results of the research showed that despite the average increase in the studied sample, twelve weeks of resistance training with with weight did not have a significant effect on the record of any of the chest press, squat, front thigh, and back thigh movements. Based on these findings, it seems that the neuromuscular improvements observed in the current swimmers can be primarily explained by neurological adaptations. This is consistent with studies conducted in adult and young endurance athletes. Although the 1-RM changes in the resistance training group were small in some movements, the training loads used were significantly increased.

Another finding of this research is measuring the circumference around the chest and around the thigh, which can be indicators for changes in body composition. The area around the chest and around the thigh are important because they can indicate subcutaneous and subcutaneous fat. This means that with the increase of subcutaneous fat, the area around the chest (for the upper body) and around the thigh (for the lower body) also change. In this regard, many studies have also shown that there is a positive relationship between body fat percentage and chest circumference and thigh circumference. Even some researches have provided equations to calculate the body fat percentage, and some of the most important key parameters in the prediction formulas presented in these studies are the amount of chest circumference and thigh circumference. In the upcoming research, the amount of circumference around the chest and circumference around the thigh increased significantly after twelve weeks of resistance

training. It has caused an increase in the circumference of the chest and thighs, which indicates the effectiveness of these strength exercises on the fat-free and muscle mass of the body.

Regarding the swimming record, the results of the present study showed that the training group that had done resistance training for twelve weeks recorded a better swimming record than the control group. In line with the results of the present study, Ronstad et al. (2008) showed improvement in 40-meter swimming speed after a resistance training program for 7 weeks (twice a week) in professional soccer players (38). The reasons for speed improvement have been reported in various researches, significant improvement in peak power and force development rate. Because the maximal inward action of the extensor muscles of the lower limb is important for jumping (especially during the acceleration phase). Therefore, it seems logical that resistance exercises and performing movements such as squats and knee extensions using gym equipment are better for improving functional activities 'because every throwing activity involves part of the body's (39). In addition, in line with the results of Wisløff et al, they reported a strong correlation between the power test of one maximum squat repetition in soccer players (40). The results of the present study also showed that swimmers who participated in twelve weeks of resistance training, the absolute strength of their leg muscles, which was measured using the submaximal squat test, had a significant increase compared to before. had a test and also the sprint record of these athletes has also decreased. Therefore, the results of our research are in line with the mentioned research. Probably, increasing the absolute strength of the lower limb muscles can affect the anaerobic system, and improve the record of swimming.

5- Conclusion

It seems that resistance training can lead to improvement in indicators such as absolute strength, relative strength, chest distance measurement, power and reduction of the swim record. Therefore, it is suggested that swimming do resistance training during their preparation.

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Conflicts of Interest

All co-authors have seen and agree with the contents of the manuscript and there is no financial interest to report. We certify that the submission is original work and is not under review at any other publication.

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