Journal of Physical Education and Sport ® (JPES), Vol.20 (2), Art 88, pp. 599 - 604, 2020
online ISSN: 2247 - 806X; p-ISSN: 2247 – 8051; ISSN - L = 2247 - 8051 © JPES

Original Article

Effect of resistance isokinetic training on power and speed development in a group of competitive swimmers

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Published online: March 31, 2020
(Accepted for publication: February 03, 2020)
DOI:10.7752/jpes.2020.02088

Abstract:
The aim of this studyis to assess the efficiency of an 8-week isokinetic resistance form of load on changes in speed-power abilities in a group of performance swimmers. The group consisted of 14 swimmers (men), randomly assigned to an experimental and control group. The experimental group consisted of 7 swimmers with an average age of 24.3 ± 4.5 years and the control group of 7 swimmers with an average age of 23.6 ± 4.4 years. In the research, we used a two-stage time parallel experiment. The experimental group performed swimming with added externalisokinetic resistance and the control group swam under natural conditions without added external resistance.Swimming isokinetic dynamometer (SID) was used to measure maximal mean isokinetic power (Pmax) during 6 seconds and to create the isokinetic conditions. Both groups performed 6 second swimming with maximum effort. Swimmers performed 3 series of 3 repetitions with a rest interval of 3 minutes between repeats and 5 min between series with stimulation frequency 2 times per week (in total 16 training sessions). The trainings of the experimental and control groups were differed only in experimental and control stimulus during the period under review.The influence of the experimental and control factors was assessed using the following dependent variables: a complex swim speed of 12 m (max12) and 25 m (max25) and the highest average power (Pmax) achieved in watts at a swimming speed of 0.8 $m.s^{-1}$. Results: test max12, in theexperimental group there was an improvement by0.14 ± 0.02s (2.88 %, $p < 0.05$, ES = 0.634). In thecontrol group there was animprovement by0.07 ± 0.04 s (1.45 %, $p < 0.05$, ES = 0.587). Test max25, in the experimental groupthere wasan improvement by 0.35 ± 0.09 s (3.07 %, $p < 0.05$, ES = 0,632). In the control group 0.12 ± 0.12 s (1.09 % , $p < 0.05$, ES = 0.542). The Pmax test: in the experimental group there was an improvementby 11.99 ± 2.63 W (13.81 %, $p < 0.05$, ES = 0.632) and for the control group 1.78 ± 1.81 W (2.93 %, p = n.s., ES = 0.497). The results show that swimming in isokinetic mode was more effective in developing swimming velocity and speed-power capabilities compared to swimming in natural conditions without additional resistance.
Keywords: swimming velocity, isokinetic conditions, power.

Introduction:

Swimming is a sport for which there is a specific continuous strength output and the exerted force is high but not the maximum (Sedláček, 2010). Resistance training can be defined as the ability of a given muscle or a group of muscles to generate muscular force under specific conditions (Crowley et al., 2017).

To achieve maximum performance in swimming, a swimmer needs to use strengtheffectively becausethis strength determinespropulsive force. Top swimmers can use about 80% of their maximum level(Toussaint et al., 1988). The main benefits resulting from resistance training are metabolic and morphological changes in muscle adaptation. According to Ross and Leveritt (2001), enzymatic adaptation is the main metabolic adaptation and changes in muscle fiber type, sarcoplasmic reticulum and cross-section of muscle fiber, are the main reason for morphlogical adaptation.

Adaptation to a sprint training depends on the duration of a training, the rest interval, the total volume and the frequency of the training sessions. There are several studies (Girold, et al., 2006., Grznár, et al., 2018., Girold, et al., 2007., Mavridis, et al. 2006) that show increase swimming strength and speed using resisted swimming.What these studies have in common is swimming short distance using different types of resistance (parachute, elastic bands or a bowl) with maximal effort. Problem with this equipment can be that the swimming technique gets interrupted. This problem can be solved by using special ergometers, as for example power rack or swimming isokinetic dynamometer, where force and speed of swimming can be set individually for each swimmer.Gonzalez-Rave et al. (2018) use power rack in their study to examine effect of resisted swimming training on strength and power tests along with specific swimming tests. Following 6 weeks of intervention, the average maximum drag load increased ($p < 0.05$) by 13.94%. Scores for the 50-m competition style and 50-m crawl time trials improved by 0.32% and 0.78%. Those changes were not statistically significant. Although, it

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did not produce significant improvements in performance, the authors of the study said that the use of a strength-training program with a pyramidal organization can be recommended for specific strength-training to young swimmers during a preparatory period.

By summing force and speed we get power in watts. When applied to swimming, we talk about so-called. 'power training' (Maglischo 2003) which is achieved by swimming with ultra-short strokes that stimulate both strength and the speed of muscle fiber contraction. The aim of this training is to increase 'stroke power'(summing up stroke force and speed of stroking). It is the result of the force developed by the swimmer and the speed of application of this force. Johnson et al. (1993) studied on performance swimmers (n = 29) the relationships between levels of maximum strength on dry land, stroking power and 25 m free style maximum sprint. The authors, among other things, found a statistically significant correlation at the level from r = 0.84 to r = 0.87 between the stroking power and the swimming sprint performance. It is important to pay attention to the force gradient in relation to faster swimming. According to Maglischo (2003), the power gradient is an indicator of how quickly the athlete can develop almost the maximum strength values right after the beginning of the exercises. The aim of our research is to assess the effect of isokinetic resistance swimming training on power changes measured in watts and swim velocity of 12 and 25 m in free style.

Material and Methods

Participants:

Fourteen male performance swimmers were randomly assigned to one of two groups. In the experimental group: 7 swimmers with average age of 24.3 ± 4.5 years, body height of 184 ± 4.1 cm and weight of 80.5 ± 7.15 kg andthe control group: 7 swimmers with average age of 23.6 ± 4.4 years, body height of 183.3 ± 4.7 cm and weight of 78.1 ± 5.3 kg. Each of the involved swimmers had been practicing competitive swimming for at least 8 years. The swimmers were instructed not to perform any other resistance training exercises during the course of the study.

Training protocol:

The experiment was performed in both the experimental and control group concurrently twice per week(total 16 TS) during 8 weeks of training.The load consisted of swimming with maximum effortfor six seconds. The experimental group swam with maximum effort with added isokinetic loadusing velocity of swimming where the swimmers reached the maximum power value Pmax in initial testing. The control group swam with maximum effort without added resistance in natural conditions.The training stimulus of two groups consisted of three series and three repetitions with load, each with duration of six seconds. The rest between the repetitions was 3 min. and between series 5 min.

Swimming isokinetic conditions:

At the beginning of our study we assigned to every swimmer a velocity in which he reached Pmax. To create isokinetic conditions we used swimming isokinetic dynamometer. This device registers the force (F) that the swimmer creates at the specified velocity (v). Once we know the force and velocity, we can calculate the power (P = F .v) in watts (W) by using software Fitro-swim.

Test protocol

Swimming power measurement:

We used the swimming isokinetic dynamometer (SID) to determine Pmax. We monitored the power values achieved in the isokinetic mode at a swimming speed of 0,8 $m.^{-1}$ (Matúš, 2009; Janič, 2009).The test in water lasts 6 seconds. The swimmer fastens the belt around the waist and on start signal began to swim with maximal effort. The second sound signal was at the end of the test (Figure 1). Each swimmer performed 2 repetitions at the beginning and end of the experiment. The rest interval between each test was 5 minutes. In our study we used the better result from two repetitions..

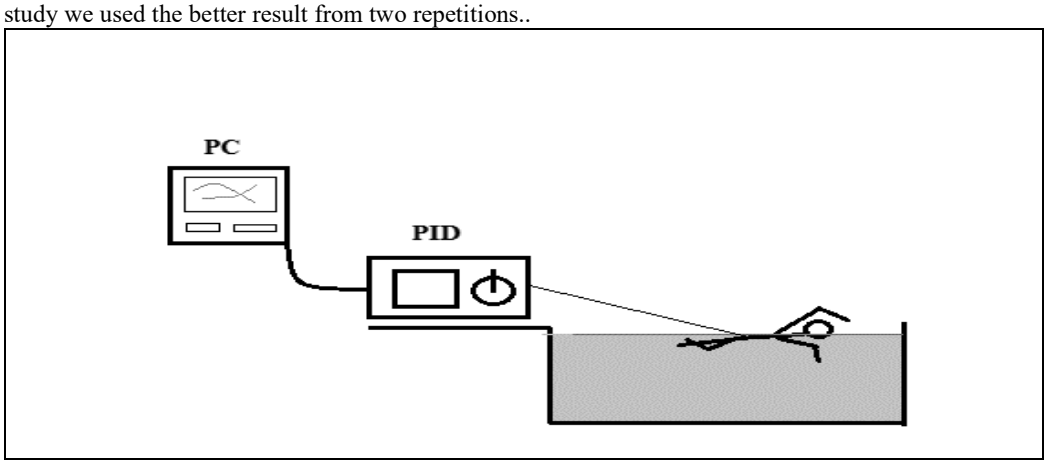

Figure 1. Graphic representation of the performance peak test on a swimming isokinetic dynamometer at a swim speed of 0.8 $m.s^{-1}$

Characteristics of the swimming isokinetic dynamometer:

The device consists of a pulley system through which the strand passes on one side connected to the test person and on the other side attached to the machine.The cord is unwound from the roll and passes through a pulley that is anchored directly to the strain gauge.The pulley is coupled to an optical speed sensor that regulates the unwinding speed with a agnetic brake. The magnetic brake is activated whenever the cord unwinding speed exceeds the specified speed.All information about the power, velocity and performance are recorded to a computer in real time. Strain gauge measured to 1 N, and an optical speed sensor is accurate to $0.01 m.s^{-1}$ (Putala, 2009).

Interclass correlation coefficient (ICC) of this device is 0.964.

Swimming performance tests:

To evaluate the maximum speed changes, we used swimming tests at 12 (max12) and 25 (max25) m. Test max12 was performed without underwater kicking (straight to surface) and with start from water (without starting jump). After a push from the wall and transition to the level of water surface, swimming with maximum effort continues. The max25 test was performed with a standard start jump and underwater part according to the valid FINA swimming rules. To measure the time in both tests, we used the Omega Electronic Timer. The test started with a sound signal and ended with a touch of the timer plate. Swimmers completed 2 repetitions at the maximum intensity in both tests and we stored the faster results. The rest interval between the tests was 5 min.

Statistical analysis:

We used IBM SPSS Statistical 20 to process and evaluate the data we obtained (IBM, Armonk, NY – USA). To compare the statistical significance of input and output values of the dependent groups, anonparametric Friedman test for repeated measures with post hoc analysis using the paired Wilcoxon test was used.

To measure the material and for practical significance, the effect of the methods used, according to Cohen (1994) and Maher et al. (2013),we calculated the effect coefficient "r" - Effect Size (ES). Differences were considered statistically significant if $p<0.05$.

Results

After the 8-week training program we made the following changes: in the max12 test, the experimental group improved from 5.01 ± 0.18 s to 4.87 ± 0.17 s, which was an improvement of 0.14 ± 0.02 s (2.88 %, $p < 0.05$, ES = 0.63, Fig. 2). The control group, that performed swimming without added external resistance, improved from 5.04 ± 0.16 s to 4.96 ± 0.18 s. The improvement in this case was 0.07 ± 0.04 s (1.45%, $p<0.05$, ES = 0.58Fig.2).

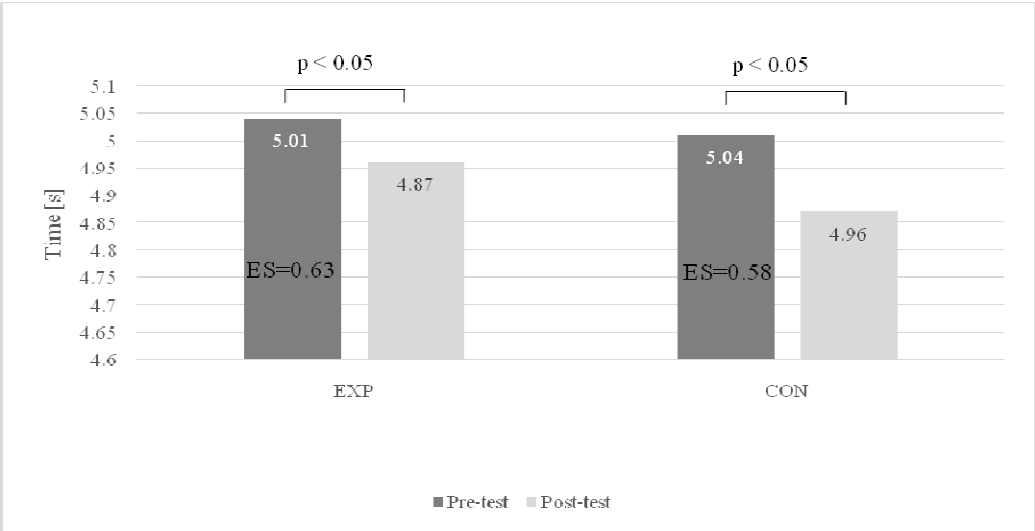

Figure 2 Significance of differences between Pre-test and Post-test measurements in test max12 and effect size (ES) in the control (CON) and experimental (EXP) group

In the max25 test, the experimental group improved from 11.66 ± 0.50 s to 11.30 ± 0.42 s, which was an improvement of 0.35 ± 0.09(3.07%, $p < 0.05$,ES = 0.63,Fig. 3). The control group, after application of training without added external resistance, improved from 11.81 ± 0.49 s to 11.68 ± 0.48 s (Fig. 3), which represented an improvement of 0.12 ± 0.12 s (1.09 %, $p < 0.05$, ES = 0.58, Fig.3).

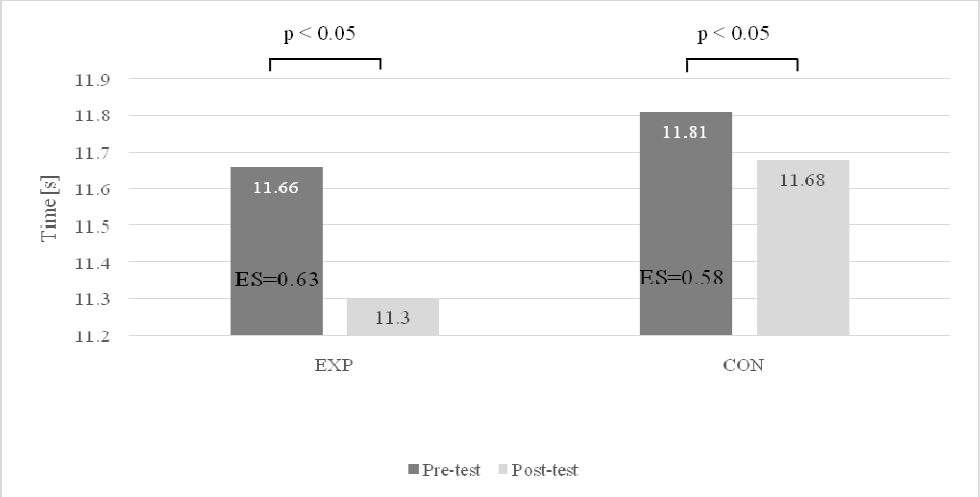

Figure 3 Significance of differences between Pre-test and Post-test measurements in the max25 and effect size (ES) in the control (CON) and experimental (EXP) group

In the Pmax test, the experimental group improved from 78.92 ± 7.58 W to 90.91 ± 7.50, representing an improvement of 11.99 ± 2.63 W (13.81 %, $p < 0.05$, ES=0.63, Fig. 4). The control group improved from 79.23 ± 8.37 W to 81,02 ± 8,36 W, bringing an improvement of 1,78 ± 1,81 W (2.93 %, p = n.s.,ES=0.49,Fig.4).

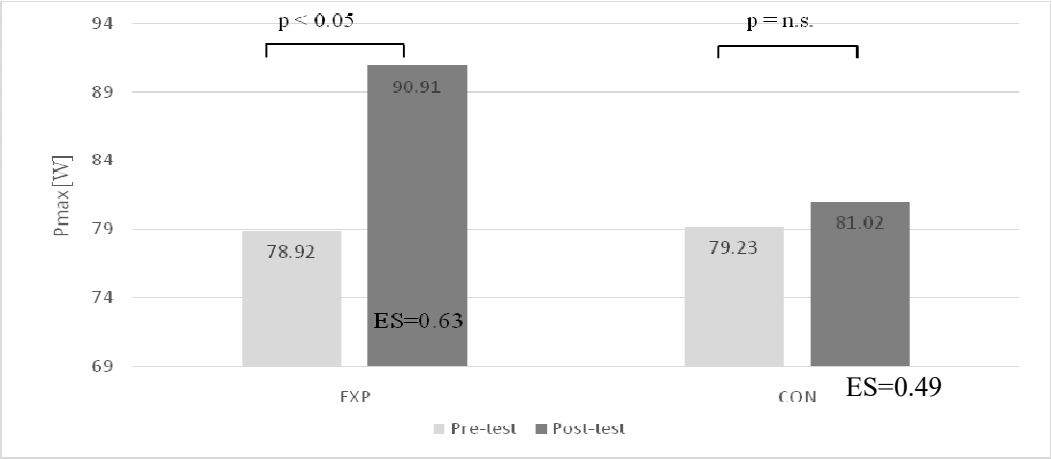

Figure 4Significance of differences between Pre-test and Post-test measurements in the Pmax test and the effect size (ES) in the control (CON) and experimental (EXP) group

Discussion

The application of this model of sprint-resisted training using an isokinetic mode of swimming was superior compared toswimming training without additional resistance for the improvement of the time to swim 12m, 25 m tests and Pmax test. Our results showed that swimmers in experimental group achieve significant changes in both max12 (2.88 %, $p < 0.05$, ES = 0.63) and max25 (3.07%, $p < 0.05$, ES = 0.63) tests compared to the results in control group where the gains in swimming velocity were smaller 1.45%, $p < 0.05$, ES = 0.58 for max12 and 1.09 %, $p < 0.05$, ES = 0.58 for max25 but still significant. This results are in accordance with other authors (Kojima, 2014, Girold et. al, 2006, Mavridis et.al, 2006, Grznár, et.al, 2018) that have confirmed that sprint-resisted swimming training are more effective to develop swimming velocity than training without additional resistance.

We assume that better results in experimental group are closely connected with stroke force expressed by improvements in Pmax test (13.81 %, $p < 0.05$, ES = 0.63) compared to non-significant improvement (2.93 %, p = n.s., ES = 0.49) in control group. One possible reason for this improvement could be that the stroke force was largely due to the neuroregulation mechanisms of activation and synchronization of motor units that are improving after sprint training (Aagaard et al., 2000, Fry et al. 1994). According to the authors Agnus a Leveritt (2001); Thorstensson, et al. (1975); Dawson, et al. (1998)another reason of this improvement can be can be an increase of the energy system key regulatory enzymes activity involved in the sprint performance.

Our findings support the results of Vorontsov et.al. (2006) according to witch there is a relation between stroke force and the powerfor 100m freestyle.This relation has been observed not onlyin swimming on a fixed

hitch (zero speed) but also in different swim velocities. Their findings say that the stroke force values achieved during swimming at higher velocities has high correlations from r = 0.816 at a speed of 1.4 $m.s^{-1}$ to r = 0.840 at a speed of 1.7 $m.s^{-1}$. The authors point out that force values at higher swim speeds (1.4-1.7 $m.s^{-1}$) are characterized by a special force readiness (the ability to efficiently utilize propulsion efficiency), while swimming at lower velocities (0.6-1.0 $m.s^{-1}$) indicates strength potential of swimmers. Therefore, in sprinttraining it is important to develop also a special strength in specific water condition and transfer the power potential into swimming velocity.

Conclusion

A special sprint training program using isokinetic conditions can be an effective way to improve swimming performance. Compared to classic resistive training, using swimming parachute, elastic band or bowl havethe advantage of using swimming isokinetic dynamometer that you can set for each swimmer directly the swimming velocity in which they reached Pmax. Based on the results, we believe that swimming in isokinetic mode is good for increasing the force of strokes. Greater stroke force is a potentially more efficient propulsion and consequently results in better swimming performance. However, further scientific verification is required for these claims.

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