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Original Article

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

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Abstract:
The aim of the work was to assess the efficiency of the 8-week resistance form of load on changes in speed-power abilities in the group of performance swimmers. The group consisted of 15 swimmers (men), assigned by intentional random choice to the experimental and control group. The experimental group consisted of 8 swimmers with an average age of 22.4 ± 4.6 years and a control group of 7 swimmers with an average age of 21.7 ± 3.9 years. In the research, we used a two-stage time parallel experiment. The experimental group performed swimming with added external resistance (parachute) and the control group swim under natural conditions without added external resistance. Both groups performed a repeated 6 second load 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 per weekly (total 16 training sessions). The training of the experimental and control groups differed only in experimental and control stimulus during the period under review. The influence of 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 $m.s^{-1}$. In test max12, the experimental group was improved by 0.17 ± 0.06 s (3.5 %, $p < 0.05$, Effect size (ES) = 0.63) and control group by 0.06 ± 0.04 (1.6 %, $p < 0.05$, ES = 0.58). In the max25 test, the experimental group was improved by 0.45 ± 0.13 s (3.7 %, $p < 0.05$, ES = 0,63) and the control group by 0.19 ± 0.12 s (1.6 % , $p < 0.05$, ES = 0.53). In the Pmax test experimental group improved by 10.25 ± 2.87 W (11.2 %, $p < 0.01$, ES = 0.63) and control group 2.86 ± 4.05 W (3.1 %, p = n.s., ES = 0.50). The results show that swimming with swimming parachute was more effective in developing speed and speed-power capabilities when compared to swimming in natural conditions. Taking advantage of such a form of load is therefore appropriate for developing swim speeds by increasing special power capabilities.
Key words: physical activity; attitude; motivation; institutionalised elderly..

Introduction

Physical Swimming is a sport for which there is a specific continuous strength output and the exerted force is high but not the maximum (Sedlacek, 2003). The swimming performance of humans is weak compared to animals living in the aquatic environment. The maximum swim speed is approximately 2,5 $m.s^{-1}$ which is about only 24 % speed achieved by moving on a ground surface. One of the main reasons for this speed difference is the resistance of the aquatic environment that puts water on the body when the swimmer is moving (Toussaint et al. 2004). For achieve maximum performance in swimming, swimmer need to use strength effectively this strength determine propulsive force. Top swimmers can use about 80% of their maximum level (Toussaint et al., 1988).

According to Ross and Leveritt (2001) we differentiate metabolic and morphological changes in muscle adaptation to speed training. Enzymatic adaptation is the main metabolic adaptation for the speed load. Morphological adaptation includes changes in muscle fiber type, sarcoplasmic reticulum and cross-section of muscle fiber. Adaptation to speed training depends on the duration of the speed load, the rest interval, the total volume and the frequency of the training sessions.

There is the summation of the muscle strength load and speed of execution of movements in swimming.

By summing this force and speed we get power in watts. In the swim, we talk about so-called. „power training“ (Maglischo 2003) which is achieved by swimming of 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 strokong). 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) 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 sprinter performance. It is important to pay attention to the force gradient in

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relation to fastest swimming. According to Maglisch (2003), the power gradient is a measure of how quickly the athlete can develop almost the maximum strength values right after the beginning of the exercises.

Most common aid for achieving additional negative drag in swimming is „swimming parachute". he advantage of swimming with a parachute as opposed to swimming on a hinge is that during swimming, the swimmer has a constant load and the swimmer does not stay "hanging" in one place. According to Schnitzler et al. (2011) the use of swimming parachute in the training process is beneficial especially for swimming at a speed close to the maximum.

The aim of our research is to assess the impact of swimming training with the parachute on power changes measured in watts and swim speeds of 12 and 25 m in free style.

Material and methods

Participants

The experiment was attended by 15 performance swimmers, men, who were divided with intentional random choice to the experimental and control group. After initial testing, we swap the swimmers intentionally into pairs with similar values in the max12 test and then randomly into the control and experimental group. In the experimental group, there were 8 swimmers with an average age of 22.4 ± 4.6 years, a body height of 185 ± 4.4 cm and a weight of 79.5 ± 7.95 kg. The control group consisted of 7 swimmers with an average age of 21.7 ± 3.9 years, a body height of 184.3 ± 4.9 cm and a weight of 78.2 ± 6.3 kg. Each of the involved swimmers had been practicing sports for at least 8 years.

Training protocol

The experiment was performed in the experimental and control group concurrently with the frequency of stimuli twice a week (total 16 TS) and duration of 8 weeks. The load consisted of swimming with maximum effort for six seconds. Swimmers have been instructed to make every effort to reach the highest possible speed throughout the duration of the load. The experimental group performed a maximum effort effort with added parachute resistance. The control group swam with maximum effort without added parachute in natural conditions. The training stimulus of two groups consist of three series of three repetitions with a load duration of six seconds. The rest between the repeats was 3 min and between the 5 mins.

Swimming parachute

For our research we chose a parachute with dimensions 20.32 x 20.32 cm. The size of the parachute resulted in a 10.94 ± 3.2% seconds deceleration in a 25-meter freestyle in a parachute-free swim.

Test protocol

Swimming power measurement

We used the swimming isokinetic dynamometer (SID) to determine the maximum power value Pmax. We monitored the power values achieved in the isokinetic mode at a swim speed of 0,8 $m.^{-1}$ (Matúš, 2009; Janič, 2009). The test in water lasts 6 seconds. The swimmer fastened his belt around his waist and began to swim freely. On the sound signal swimmer swam maximum 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. We scored a better result from two reps.

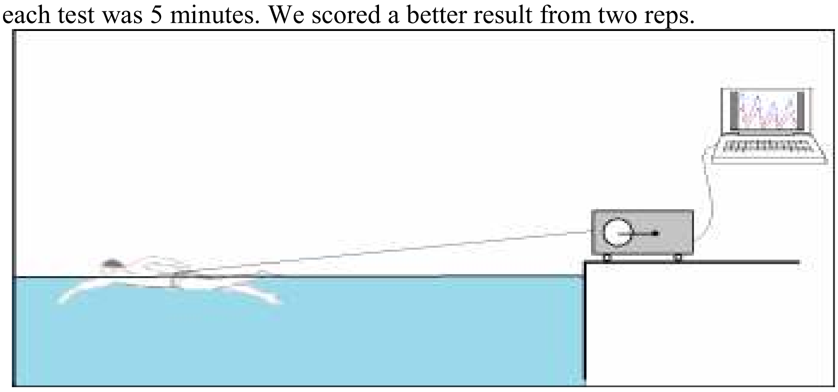

Fig. 1. Graphic representation of the performance peak test on a swimming isokinetic dynamometer at a swim speed of 0.8 $m.s^{-1}$

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 the magnetic brake. The magnetic brake is activated whenever the cord unwinding speed exceeds the specified speed. All information about the power, speed and performance are recorded to a computer in real time. Strain gauge measured to 1 N, and an optical speed sensor is accurate to 0.01m.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 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 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, an nonparametric Friedman test for repeated measures with post hoc analysis using the paired Wilcoxon test was used. To measure the material and practical significance, the effect of the methods used, 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 4.9 ± 0.20 s to 4.73 ± 0.16 s, which was an improvement of 0.17 ± 0.06 s (3.5%, $p<0.05$, Fig. 11). The control group that performed swimming without added external resistance improved from 4.93 ± 0.21 s to 4.87 ± 0.18 s. The improvement in this case was 0.06 ± 0.04 s (1.6 %, $p<0.05$, Fig.2).

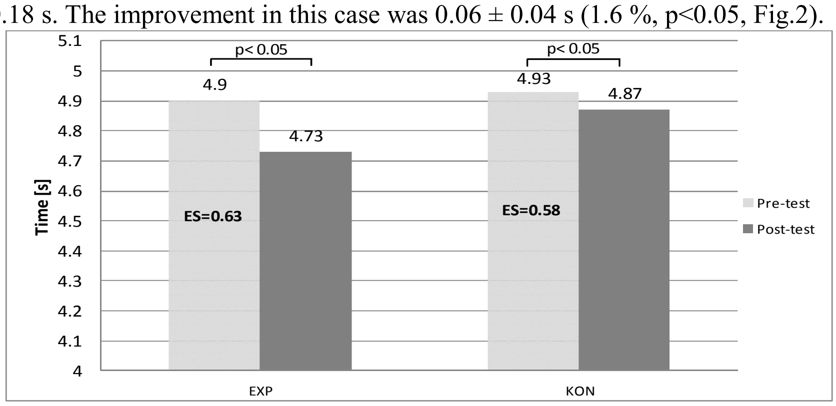

Fig. 2 Significance of differences between Pre-test and post-test measurements in test max12 and effect size (ES) in the control (CON) and experimental (EXP) group

The size of the effect of the chosen methods, expressed by the coefficient of effect "r", was for the experimental group ES = 0.63, according to Cohen (1994) and Maher et al. (2013) is a great effect. In the control group, it achieved a lower ES value of 0.58, which also represents a large effect (Fig. 2).

In the max25 test, the experimental group improved from 12.03 ± 0.66 s to 11.58 ± 0.60 s, which was an improvement of 0.45 s ± 0.13 (3.7 %, $p < 0.05$, Fig 3). The control group, after application of training without added external resistance, improved from 11.93 ± 0.61 s to 11.74 ± 0.56 s (Tab. 4), which represented an improvement of 0.19 ± 0.12 s (1.6 %, $p < 0.05$, Fig.3).

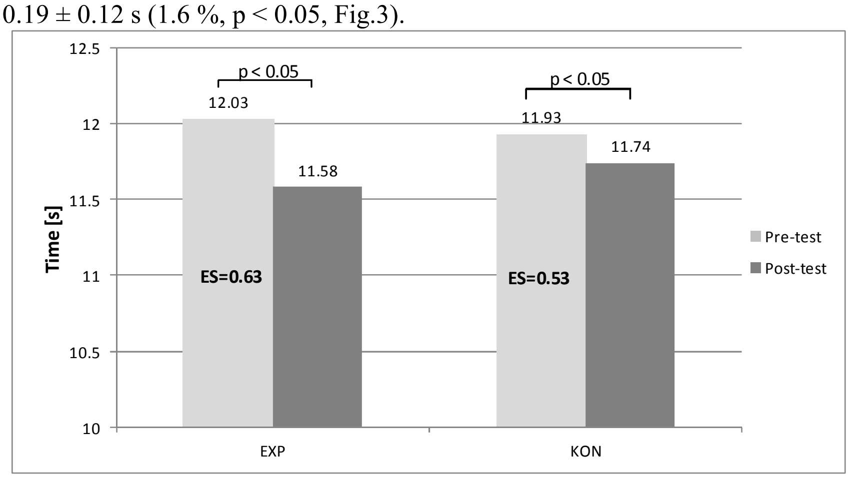

Fig. 3. Significance of differences between Pre-test and Post-test measurements in the max25 and effect size (ES) in the control (CON) and experimental (EXP) group

The size of the effect was for the experimental group ES = 0.63 and for control group ES = 0.53 (Fig. 3). Both of these values represent a large effect on the swim velocity changes in the max25 test.

In the Pmax test, the experimental group improved from 92.12 ± 10.53 W to 102.37 ± 12.49, representing an improvement of 10.25 ± 2.87 W (11.2 %, $p < 0.05$, ES=0.63, Fig. 4). The control group improved from 91.71 ± 12.06 W to 94.57 ± 11.72 W, bringing an improvement of 2.86 ± 4.05 W (3.1%, p = n.s., ES=0.50, Fig.4).

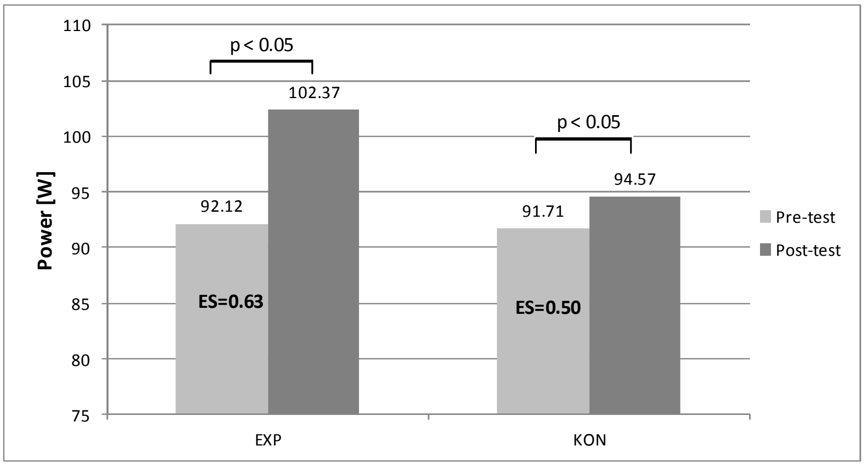

Fig. 4. Significance of differences between Pre-test and Post-test measurements in the Pmax test and the effect size (ES) in the control (CON) and experimental (EXP) group

Discussion

Special exercises with added water resistance are increasingly popular in training practice. Their correct use helps trainer and swimmer make the training process more efficient. However, precise mechanisms for increasing swimming performance using water-resistance devices are still unclear and indirect.

In our work, we have identified differences in speed and performance development efficiency using sprinter training with added resistance and resistance. We found that there were statistically significant changes in maximum swim speed in the two monitored sets after an 8-week training program. The power indicator, measured in watts, we experienced a statistically significant improvement only in the group that exercised sprint training with added resistance. In the experimental group, due to the increased external resistance, we impacted not only on the speed but also on the force component of the power itself. We predict that the increase in the stroke force was largely due to the neuroregulation mechanisms of activation and synchronization of motor units (Aagaard et al., 2000, Fry et al. 1994).

The finding that the Sprint training program with added resistance and the classic Sprint training program without added resistance has an impact on changes in swim speed is confirmed by the findings of other authors (Kojima, 2014, Girold et. al, 2006, Mavridis et.al, 2006). In our case, interventions with a high intensity and a duration of 6 seconds were involved. According to the authors Agnus a Leveritt (2001) the main adaptation mechanism for improvement in short duration high intensity load up to 10 s is mainly the increase of the activity of the key regulatory enzymes of the energy systems involved in the sprint performance. We assume that this mechanism was involved in adapting to the training load in both experimental and control groups.

Based on the findings of our work, we can express the opinion that the special force capabilities play an important role in the development of the swimming speed. These arguments support the authors' results Vorontsov et al (2006) who investigated the relationship of stroke force with the power on the 100m freestyle. These relationships have been observed not only for swimming on a fixed hitch (zero speed) but also for different swim speeds. They found that the stroke force values achieved during swimming at higher velocities had 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 speeds (0.6-1.0 $m.s^{-1}$) indicates strength potential of swimmers. Therefore, in speed training, it is important to develop also special force in swimming and transfer the power potential gain by resistive training on swimming parachutes to the speed of swimming.

Conclusion

A special sprinter training program with or without the use of resistive swimming significantly influences the changes in swimming speed. When evaluating power measured in watts, we only notice significant improvement after applying the program with added resistance. Based on the results, we believe that parachute swimming is good for increasing the force of strokes. Greater stroke force is a potentially more efficient propulsion and consequently better swimming performance. However, further scientific verification is required for these claims.

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