PEDAGOGY of Physical Culture and Sports

ORIGINAL ARTICLE

# The effects of theraband training on respiratory parameters, upper extremity muscle strength and swimming performance

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection.

**Abstract**

*Purpose:* The aim of this study was to investigate the effect of 6 weeks theraband training on respiratory parameters, upper extremity muscle strength and 50-100m swimming performance in swimming athletes.

*Material:* Totally 12 male swimmers participated voluntarily and were divided into two groups as control group (n=6) and experimental group (n=6). Control group did only swimming training, experimental group did theraband exercises in addition to swimming exercises. Respiratory parameters, upper extremity anaerobic performance, shoulder extension/flexion strength and swimming performance were measured. Mann Whitney-U Test was used to determine the differences between two groups. Wilcoxon Test was used to determine intra-group differences.

*Results:* There was no statistically significant difference between the pre and post-test values of respiratory parameters, anaerobic performance values and swimming measurements of the experimental groups ($p>0.05$). There was a statistically significant difference between shoulder extension and flexion values ($p<0.05$). As for the statistical results between the pre and post-test values of the control group, no significant difference was found in any of the variables ($p>0.05$). There was a statistically significant difference between the post-test values of the experimental and control groups shoulder extension and flexion values ($p<0.05$). There was no statistically significant difference between respiratory function parameters, anaerobic performance values and 50-100m swimming degrees ($p>0.05$).

*Conclusions:* As a result of the findings, it can be said that theraband training which is done as a land work with swimming training leads to positive effects in the upper extremity muscle strength and swimming performance development of youth swimmers.

**Keywords**: swimmer, resistance band, isokinetic strength, anaerobic performance.

## Introduction

Swimming is a sports branch which is a combination of several factors such as high-level muscle strength, technical skills, rhythm requiring coordination, speed, explosive strength and correct technique [1-3]. The sport of swimming is very different than other sports due to training in a prone position and use of both arms and legs for propulsion, with 90% of the propulsive force supplied by the upper extremities [4-7]. Another main difference is that land-based sports use the ground as a reference point of movement, while swimming does not involve ground contact. Therefore, swimmers must use their core as the reference point of movement, which reinforces the need for swimmers to have a strong core to be successful in the sport [8].

The ability to apply force in water is crucial in competitive swimming [9, 10], particularly in short distances events [2, 11]. As well as high values of strength and power, mostly in the upper body, have been identified as a determinant factor for success in competitive swimming [1, 12]. Swimmers need to develop muscle strength in order to increase their swimming speed [13]. In addition to in-water exercises, dry-land strength training is used for performance enhancement and injury prevention [8, 9, 14]. Also, it can increase swimming force [1]. and technical parameters such as increased stroke length and stroke rate [15]. In land training, different materials and training methods are used to increase the strength and swimming performance of swimmers.

In swimming, there are training sessions carried out by using different materials (pedal, pallet, pull-buoy and resistance rubber) in the water in order for the swimmer to reach and maintain a higher speed. Strength training in the land, strength ball exercises, plyometric exercises, core training, body weight exercises, vasa trainer or isokinetic swim bench exercises where the isokinetic movement is applied, theraband and rubber exercises, trx training, foam-roll use and different many studies are used every semester [13]. Recently, theraband (resistance rubber) exercises have been used extensively in sports and rehabilitation medicine for increasing muscular strength and endurance [3]. Elastic bands are simple-to-use tools for multipurpose physical training. They are portable, inexpensive, and widely used to develop muscle strength and power [16].

Success in swimming, relies on swimmers' motoric properties (balance, power output, agility, jumping ability) and respiratory control. While swimming, upper limb muscles and trunk are engaged, either directly, to do hand-foot-breath coordination, or indirectly, to stabilize the core muscles along with the diaphragm, resulting in an increase in respiratory work and breathing perception [17]. Breathing has a big influence on swimming technique, balance and alignment of the body in the water,


doi:10.15561/26649837.2020.0607

propulsion and muscular effort and hydrodynamics and water resistance.

One of the issues that many coaches are curious about is the differences in strength performance of athletes in addition to the dry-land training as well as the training done by using additional resistances (foot-hand) in the sets that swimming in the training. Knowing the use of resistance, that is, the differences that can be made in resistance training and swimming speed, is important in writing and practicing training. Therefore, this study was conducted to determine the effects of theraband training on respiratory parameters, upper extremity muscle strength and swimming performance in swimming athletes.

**Material and Methods**

*Participants*

This study was conducted on 12 male swimmers who training in Mavi Bilgi College Sports Club 6 experimental group (average age; 16 ± 1,41 years, mean body height; 172 ± 0,05 cm, mean body mass; 64,25 ± 6,59 kg) and 6 control group (average age; 15,5 ± 0,58 years, mean body height; 177,1 ± 0,04 cm, mean body mass; 66,43 ± 5,14 kg) participated in this study voluntarily. Exclusion criteria consisted of smoker athletes, athletes with any severe musculoskeletal, respiratory, cardiac and/or neurological pathology and athletes who did not complete 80% of the exercise sessions. The subjects were informed about the possible risks and benefits of the study and gave their informed consent to participate in this study, which was approved by the Clinical Research Ethical Committee of Pamukkale University.

*Experimental Design*

The swimmers were categorized into the control group (n=6) and experimental group (n=6) according to their 50 m swimming degrees. Control group did swimming training only three times a week for six weeks. In addition to swimming exercises, experimental group did theraband exercises consisting of 10 movements to the upper extremities. The study was conducted over a 1-week period, during which the players did not participate in any other training. On the first day, anthropometric measurements, respiratory measurements and 50-100 m swimming performance were done respectively. On the third day, players underwent isokinetic leg strength tests. On the fifth day, players performed the Wingate anaerobic test.

All subject's height and body mass were recorded before completing any testing. The height of the subjects was measured with a stadiometer (Seca, Germany) with a sensitivity of 1 mm and body weight measurements with a sensitivity of 0.1 kg. In the anatomical posture, the heels were combined, holding the breath, and the head was positioned in the frontal plane with the overhead table touching the vertex point and the measurement was recorded as 'cm' and 'kg'.

*Anaerobic Performance Evaluation*

For the Wingate test, a Monarch 894E (made in Sweden) arm and leg bike ergometer that is modified for computer connection and a compatible software were used. For each athlete, the load to be applied as external resistance in the arm ergometer during the test was calculated as 50 gr/kg. Athletes were subjected to a 5-minute warming protocol with two or three sprints of 4-8 seconds at 60-70 rev/min pedals with 20% of the calculated test load of bicycle ergometer. They were given passive rest for 3-5 minutes after warming. Athletes were asked to reach the highest pedalling speed as soon as possible without resistance. When the maximum speed was reached, the load previously calculated as 50 gr/kg was released and the test was started. The athletes pedalled against this resistance at the highest speed for 30 seconds. Athletes were encouraged verbally throughout the test. Peak power (PP) and mean power (MP) was calculated automatically by the Wingate Anaerobic Test computer program. A fatigue index was calculated by using the following equation [18]:

Fatigue Index (FI) = (PP) − (MinP) / (MP) × 100

PP is the peak power, and MinP is the minimum power that was determined during the WAnT test.

*Isokinetic Testing Protocol*

Participants warmed up prior to the isokinetic testing on an arm cycle ergometer pedalling at a work rate of 20 watts at 55-65 rpm for 7-minutes. An isokinetic dynamometer (Cybex Humac Norm 770, USA) was used to measure shoulder flexion and extension peak torque. The isokinetic dynamometer was calibrated at the beginning of test day. The tests were carried out in a supine position on the unit's special seat. After giving preliminary information about the test, the anthropometric data were input to the Cybex apparatus which was to be measured by the players, and the device was adjusted. Isokinetic concentric muscle strength tests were performed without gravity for specified joint movements. Participants were verbally encouraged during each test to perform at their best and participants were also allowed visual feedback during the testing. Followed by 3 repetitions submaximal trial, 5 maximal concentric contractions performed at 60°/s angular velocity. A 30 s time interval was provided between repetitions.

*Swimming Measurements*

The 50 m and 100 m freestyle swimming performances of the swimmers were measured with a hand stopwatch (Casio, Japan) measuring 0.01 seconds. The swimmers were warmed for 5 minutes on land and 10 minutes in water. Each freestyle swimming test started with ready-exit command by pushing the wall of the pool with its feet and when the distances was completed, the test was terminated.

*Respiratory Parameters Measurements*

BTL-08 Spirometer device was used to measure the respiratory parameters of the participants. Respiratory function characteristic was evaluated by forced vital capacity (FVC), forced expiratory volume in one second (FEV1), the ratio of FEV1 to FVC (the Tiffeneau index) and maximum voluntary ventilation (MVV). In spirometry measurements were made while the subject was sitting with the subjects' nose closed with a latch.

*Training Programme*

Subjects used There-Bands elastic resistance bands. The initial training resistance was determined during two adaptation sessions with elastic bands and training techniques. Red elastic bands were determined the initial load. All swimmers executed three sets of each exercise. The first two sets involved 20 repetitions each, with the last set performed until exhaustion. If swimmers were able to reach 30 repetitions in the final set, the level of training was increased by selecting the next resistance level (colour) of the elastic bands [19]. This procedure was independently conducted for each exercise. All subjects became familiar with the testing procedures that took place approximately one week prior to training programme. The training programme was held three times a week for 6 weeks and consisted of ten different exercises. These movements are: a) shoulder horizontal adduction, b) shoulder horizontal abduction, c) shoulder adduction, d) shoulder abduction, e) shoulder flexion, f) shoulder extension, g) shoulder internal rotation, h) shoulder external rotation, i) elbow flexion j) elbow extension. Subjects were given rest 1 minute between each set and 2 minutes between each new exercise. Set and in-set time of the exercise programme are as follows: 1st and 2nd week 3x15 sec, 3rd and 4th week 3x30 sec, 5th and 6th week 3x45 sec.

*Statistical Analysis*

In the statistical analysis of the data, descriptive analyses of test measurements of swimmers were calculated as mean and standard deviation. The Shapiro-Wilk Test was used to determine whether the data were normally distributed before the statistical procedures were examined. The difference between in-group test values was tested by Wilcoxon analysis. Mann Whitney U analysis was used to test the difference between the groups. The data obtained were evaluated with SPSS 23.0 program and the statistical significance was set at $p<0.05$.

**Results**

Table 1 shows the pre and post-test analysis of respiratory parameters, anaerobic performance, isokinetic strength and swimming measurements of the experimental groups.

There was no statistically significant difference between the pre and post-test values of respiratory parameters, anaerobic performance values and swimming measurements of the experimental groups ($p>0.05$). There was a statistically significant difference between shoulder extension and flexion values ($p<0.05$). Table 2 shows the pre and post-test analysis of respiratory parameters, anaerobic performance, isokinetic strength and swimming measurements of the control groups.

As for the statistical results between the pre and post-test values of the control group, no significant difference was found in any of the variables ($p>0.05$).

**Table 1.** The comparison of pre and post-test results of experimental group

| Variables | Test | Mean ± Sd | z | p |
|---|---|---|---|---|
| FVC (L) | Pre Test | 5.35 ± 1.15 | -0.36 | 0.71 |
| | Post Test | 5.23 ± 1.23 | | |
| FEV1 (L) | Pre Test | 3.68 ± 0.94 | -1.46 | 0.14 |
| | Post Test | 4.51 ± 0.59 | | |
| FEV1/FVC | Pre Test | 71.29 ± 21.3 | -1.82 | 0.06 |
| | Post Test | 88.42 ± 14.04 | | |
| MVV (L/min) | Pre Test | 111.23±36.81 | -1.09 | 0.27 |
| | Post Test | 89.53 ± 12.59 | | |
| Peak Power (W) | Pre Test | 338.8±122.65 | -1.82 | 0.06 |
| | Post Test | 486.21±162.84 | | |
| Mean Power (W) | Pre Test | 229.11 ± 68.96 | -1.82 | 0.06 |
| | Post Test | 274.01 ± 56.25 | | |
| Minumum Power (W) | Pre Test | 95.26 ± 57.61 | -0.36 | 0.71 |
| | Post Test | 99.55 ± 59.66 | | |
| Fatigue Index (%) | Pre Test | 73.91 ± 13.72 | -1.82 | 0.06 |
| | Post Test | 80.08 ± 13.21 | | |
| 50 m (s) | Pre Test | 27.43 ± 1.28 | -1.82 | 0.06 |
| | Post Test | 26.63 ± 1.07 | | |
| 100 m (s) | Pre Test | 59.13 ± 3.13 | -1.82 | 0.06 |
| | Post Test | 57.67 ± 2.21 | | |
| Shoulder Flexion (Nm) | Pre Test | 67.56 ± 10.61 | -1.82 | 0.02* |
| | Post Test | 79.12± 13.72 | | |
| Shoulder Extension (Nm) | Pre Test | 99.72 ± 25.33 | -1.82 | 0.01* |
| | Post Test | 144.01±42.81 | | |

*p<0.05

At the beginning of the study, groups divided into the homogeneous.

There was no statistically significant difference between the post-test values of the experimental and control groups between respiratory function parameters, peak power, average power, minimum power, fatigue index and 50-100 m swimming degrees (p>0.05). There was a statistically significant difference between shoulder extension and flexion values (p<0.05) (Table 3).

**Table 2.** The comparison of pre and post-test results of control group

| Variables | Test | Mean ± Sd | z | p |
|---|---|---|---|---|
| FVC (L) | Pre Test<br>Post Test | 5 ± 0.46<br>5.02 ± 0.62 | 0 | 1 |
| FEV1 (L) | Pre Test<br>Post Test | 4.22 ± 0.32<br>3.91 ± 0.49 | -0.73 | 0.465 |
| FEV1/FVC | Pre Test<br>Post Test | 84.65 ± 7.42<br>78.33 ± 12.01 | -0.73 | 0.465 |
| MVV (L/min) | Pre Test<br>Post Test | 96.24 ± 30.87<br>88.75 ± 29.55 | 0 | 1 |
| Peak Power (W) | Pre Test<br>Post Test | 371.25 ± 114.17<br>407.37 ± 156.9 | -1.095 | 0.273 |
| Mean Power (W) | Pre Test<br>Post Test | 240.37 ± 80.49<br>255.87 ± 72.7 | -1.826 | 0.68 |
| Minumum Power (W) | Pre Test<br>Post Test | 122.42 ± 52.13<br>98.5 ± 35.19 | -0.365 | 0.715 |
| Fatigue Index (%) | Pre Test<br>Post Test | 67.94 ± 4.53<br>73.27 ± 11.47 | -0.365 | 0.715 |
| 50 m (s) | Pre Test<br>Post Test | 30.48 ± 2.99<br>30.37 ± 4 | -0.365 | 0.715 |
| 100 m (s) | Pre Test<br>Post Test | 63.32 ± 4.99<br>62.15 ± 6.68 | -0.73 | 0.465 |
| Shoulder Flexion (Nm) | Pre Test<br>Post Test | 62.56 ± 10.61<br>61.12± 9.72 | -0.365 | 0.715 |
| Shoulder Extension (Nm) | Pre Test<br>Post Test | 79.52 ± 25.33<br>81.01±42.81 | -0.365 | 0.715 |

*p<0.05

**Table 3.** The Mann Whitney U analysis of post-test respiratory parameters, anaerobic performance, isokinetic strength, swimming measurements of experimental and control groups

| Variables | Groups | Mean ± Sd | U | p |
|---|---|---|---|---|
| FVC (L) | Experimental<br>Control | 5.23 ± 1,23<br>5.02 ± 0,62 | 7 | 0.886 |
| FEV1 (L) | Experimental<br>Control | 4.51 ± 0.59<br>3.91 ± 0.49 | 3 | 0.2 |
| FEV1/FVC | Experimental<br>Control | 88.42 ± 14.04<br>78.33 ± 12.01 | 4 | 0.343 |
| MVV (L/min) | Experimental<br>Control | 89.53 ± 12.59<br>88.75 ± 29.55 | 7 | 0.886 |
| Peak Power (W) | Experimental<br>Control | 486.21 ± 162.84<br>407.37 ± 156.9 | 4 | 0.343 |
| Mean Power (W) | Experimental<br>Control | 274.01 ± 56.25<br>255.87 ± 72.7 | 6 | 0.686 |
| Minumum Power (W) | Experimental<br>Control | 99.55 ± 59.66<br>98.5 ± 35.19 | 7 | 0.886 |
| Fatigue Index (%) | Experimental<br>Control | 80.08 ± 13.21<br>73.27 ± 11.47 | 5 | 0.486 |
| 50 m (s) | Experimental<br>Control | 26.63 ± 1.07<br>30.37 ± 4 | 4 | 0.343 |
| 100 m (s) | Experimental<br>Control | 57.67 ± 2.21<br>62.15 ± 6.68 | 4 | 0.343 |
| Shoulder Flexion (Nm) | Experimental<br>Control | 79.12± 13.72<br>61.12± 9.72 | 5 | 0.004* |
| Shoulder Extension (Nm) | Experimental<br>Control | 144.01±42.81<br>81.01±42.81 | 4 | 0.003* |

*p<0.05

**Discussion**

The aim of this study was to investigate the effect of 6 weeks theraband training on respiratory parameters, upper extremity muscle strength and 50-100 m swimming performance in swimming athletes. The main findings to emerge from the study were that there was a statistically significant difference between the post-test values of the experimental and control groups between shoulder extension and flexion values (p<0.05).

Strength training is necessary to improve the performance of swimmers and ensure continued success in competitions [20]. Strength training with resistance exercises have been shown to have performance-enhancing and injury-reducing benefits in youth athletes [20, 21]. The awareness of such benefits is demonstrated by an increasing number of swimming coaches working with different age groups that incorporate dry-land training, including theraband training, into their swimming programmes [22]. A number of studies have found a positive relationship between strength, power and swimming performance. For example, Keiner et al. [13] investigated the influence of maximal strength performance on sprint swimming performances in male and female youth swimmers (17.5 ± 2.0 years) and found there to be strong negative correlations between leg strength (1 RM squat), speed-strength and swim performance particularly for short distances (up to 25 m). They also found a correlation between the strength tests of the upper body and swim performance. The authors therefore concluded that maximal strength of both the upper and lower body can be good predictors of swim performance. Aspenes and Karlsen [4] investigated the effect of combined strength and endurance training on swimming performance in competitive swimmers. Following an 11 week training programme, the intervention group improved 400 m freestyle performance by around 4 seconds (p<0.05), tethered swim force (p<0.05) and maximal strength in bilateral shoulder extension (p<0.05). Shoulder rotation strength and the ratio of internal to external rotation strength are as important as relative strength measures in elevated positions, which include flexion and extension, is effective in swimming performance for the young swimmer. In this study, it is possible to say that, theraband training provided positive improvements on shoulder strength development in swimmers.

Although, strength has usually been measured through isometric and isokinetic tests, more recently, exercises that are commonly found in dryland strength training programs are being studied as predictors of swimming performance [15]. In this study, there was no statistically significant difference between the pre and post-test values of the experimental and control groups between 50-100 m swimming degrees, although showed a positive increase following the theraband training programme. It can be said that theraband trainings have positive effects on swimming performances depending on the fact that they provide muscular strength development to the athletes. There are a number of previous studies which have investigated the effect of dry-land training programmes on swimming performance with varying results. Kalva-Filho et al. [23] investigated the relationship between 50 m sprint development and strength training, and found that muscle strength acquired during 8-week strength training was an important factor for 50 m sprint capacity. Yapıcı et al. [3] investigated the effect of 6-week land and resistance training on lower extremity isokinetic strength values and swimming performance in 22 swimmers in the 13-16 age group. As a result of the study, it was determined that knee extensor and flexor muscle strength increased at 60 °/s, 180 °/s and 240 °/s after 6 weeks of training and 25 m, 50 m and 100 m freestyle swimming degrees improved. Amaro et al. [9] who found that a 6-week strength and conditioning programme significantly improved dry-land performance (vertical jump and ball throw) in male prepubescent swimmers. No significant improvements in swim performance (50 m freestyle) were found immediately following the 6-week programme, however, after a 4-week adaptation period the experimental group did improve their swimming performance (p=0.03). Sadowski et al. [24] implemented a 6 week dry-land power training programme in youth swimmers there were no significant improvements in 25 m freestyle swimming performance in either the experimental or control group (p>0.05). The duration of the training programme within this investigation, suggesting that a longer duration is needed to elicit significant improvements in swimming performance.

The anaerobic contribution has been demonstrated to be important for swimming performance especially short distance swimming branches (50 m, 100 m) [25, 23]. Considering that about 80% of swimming events are shorter than 2 min duration, the anaerobic metabolism can be considered as paramount in swimming. In fact, the anaerobic metabolism prevails in the 50 and 100 m swimming events, continuing to be of great importance in the 200 m [26, 27]. Increasing the anaerobic training emerges as a necessity to enhance training specificity and swimmers' performance in short events. In this study, there was no statistically significant difference between the pre and post-test values of the experimental and control groups between peak power, average power, minimum power, fatigue index. Stager and Coyle [11] and Kalva-Filho et al. [23], for example, found the following values, respectively: peak power 526.8 W and 513.4 W and mean power 421.0 W and 425.05 W. These values are higher than are the ones reported in the present study.

The use of theraband during training also has an important place for strength development in youth swimmers. In swimming, increased breathing frequency during exercise causes the respiratory muscles to use oxygen more [28]. Swimmers used to physical strain due to repeated exercise, more efficient ventilation is highlighted [29]. The increase of vital capacity is mostly influenced by aerobic stimuli, whereas the increase of air-flow speed is mostly influenced by anaerobic stimuli [30]. In this study, there was no statistically significant difference between the post-test values of the experimental and control groups between respiratory function parameters. Swimmers used to physical strain due to repeated exercise, more efficient ventilation is highlighted. But we can say that theraband exercises have been used with swimming training, improves respiratory function parameters. Weston et al. [8] found that the values of 17 swimmers (FIV1, FEV1) increased after inspiratory and expiratory muscle training compared to the control group. Respiratory muscle training with theraband programs have been reported to increase the performance of elite swimmers by 1% in studies [15] elite rowers and cycling athletes were found to increase performance. Gosselink et al. [28] it is observed that theraband training increases respiratory muscle strength. In one study, 28 young fin-swimmers reported significant improvement in inspiratory muscles after dry-land training [31].

**Conclusion**

As a result of the findings, it can be said that theraband training which is done as a land work with swimming training leads to positive effects in the upper extremity muscle strength and swimming performance development of youth swimmers. It can be recommended that swimming coaches should be involved in strength training as well as season training, taking into account the possible strength increase effects of theraband training programs on swimmers.

**Acknowledgments**

The author would like to thank all players for their willingness to participate in this study.

**Conflicts of Interest**

The authors state no conflicts of interest.

**References**

1. Garrido N, Marinho DA, Barbosa TM, Costa AM, Silva AJ, Perez-Turpin JA, Marques MC. Relationship between dry-land strength, power variables and short sprint ostoperformance in young competitive swimmers. *Offical Journal of the Area of Physical Education and Sport.* 2010; 5(2):240–249. https://doi.org/10.4100/jhse.2010.52.12
2. Morouco PG, Marinho DA, Amaro NM, Peréz-Turpin JA, Marques MC. Effects of dry-land strength training on swimming performance: A brief review. *Journal of Human Sport and Exercise.* 2012; 7(2): 553–559. https://doi.org/10.4100/jhse.2012.72.18
3. Yapıcı A, Maden B, Fındıkoğlu G. The effect of a 6-week land and resistance training of 13-16 years old swimmers groups tolower limb isokinetic strength values and to swimming performance. *Journal of Human Sciences.* 2016; 13(3): 5269–5281. https://doi.org/ 10.14687/jhs.v13i3.4158
4. Aspenes ST, Karlsen T. Exercise-Training Intervention Studies in Competitive Swimming. *Sports Medicine.* 2012; 42(6): 527–543. https://doi.org/10.2165/11630760-000000000-00000
5. Heinlein SA, Cosgarea AJ. Biomechanical Considerations in the Competitive Swimmer's Shoulder. *Sports Health: A Multidisciplinary Approach.* 2010; 2(6): 519–525. https://doi.org/10.1177/1941738110377611
6. Hibberd EE, Oyama S, Spang JT, Prentice W, Myers JB. Effect of a 6-Week Strengthening Program on Shoulder and Scapular-Stabilizer Strength and Scapular Kinematics in Division I Collegiate Swimmers. *Journal of Sport Rehabilitation*, 2012;21:253–65. https://doi.org/10.1123/jsr.21.3.253
7. Kluemper M, Uhl T, Hazelrigg H. Effect of Stretching and Strengthening Shoulder Muscles on Forward Shoulder Posture in Competitive Swimmers. *Journal of Sport Rehabilitation*, 2006;15:58–70. https://doi.org/10.1123/jsr.15.1.58
8. Weston M, Hibbs A, Thompson K, Spears I. Isolated core training improves sprint performance in national-level junior swimmers. *Internationa Journal Sports Physiology and Performance.* 2015; 10(2):204–10. https://doi.org/10.1123/ijspp.2013-0488
9. Amaro NM, Marinho DA, Marques MC, Nuno B, Morouco PG. Effects of dry-land strength and conditioning programs in age group swimmers. *Journal of Strength & Conditioning Research*. 2017; 31(9):2447–2454. https:// doi.org/10.1519/JSC.0000000000001709
10. Newton RU, Jones J, Kraemer WJ, Wardle H. Strength and power training of Australian olympic swimmers. *Journal of Strength & Conditioning Research.* 2002; 24(3):7–15. https://doi.org/10.1519/00126548-200206000-00001
11. Stager JM, Coyle MA. Energy Systems. In: Stager JM, Tanner DA, editors. *Handbook of Sports Medicine and Science: Swimming*. UK: Blackwell Science Ltd; 2008. P.1–19. https://doi.org/10.1002/9780470698761.ch1
12. Guex K, Daucourt C, Borloz S. Validity and reliability of maximal-strength assessment of knee flexors and extensorsusing elastic bands. *Journal of Sport Rehabilitation.* 2015; 24(2): 151–155. https://doi.org/10.1123/jsr.2013-0131
13. Keiner M, Yaghobi D, Sander A, Wirt, Hartmann H. The influence of maximal strength performance of upper and lower extremities and trunk muscle on different sprint swim performances in adolescent swimmers. *Science and Sports.* 2015; 30: 147–154. https://doi.org/10.1016/j.scispo.2015.05.001
14. Bishop D, Smith R, Smith M, Rigby H. Effect of plyometric training on swimming block start performance in adolescents. *Journal of Strength & Conditioning Research.* 2009; 23(7): 2137–43. https://doi.org/10.1519/JSC.0b013e3181b866d0
15. Pyne D, Tresin C, Hopkins W. Progression and variability of competitive performance of olympic swimmers. *Journal of Sports Sciences.* 2004; 22(7): 613–620. https://doi.org/10.1080/02640410310001655822
16. Uchida MC, Nishida MM, Sampaio RA, Moritani T, Arai H. Thera-band® elastic band tension: reference values for physical activity. *Journal of Physical Therapy Science.* 2016; 28: 1266–1271. https://doi.org/10.1589/jpts.28.1266
17. McConnell A. *Breathe strong, perform better.* (1st ed.), Human Kinetics, Champaign; 2011.
18. Inbar OB, Skinner J. *The Wingate Anaerobic Test.* Human Kinetic, Champaign; 1996.
19. Batalha N, Raimunda A, Pablo TC, Joao P, Roberto S, Antonio JS. Does a land-based compensatory strength-training programme influences the rotator cuff balance of young competitive swimmers? *European Journal of Sport Science.* 2015;15:764–72. https://doi.org/10.1080/17461391.2015.1051132

20. Faigenbaum AD, Lloyd RS, Myer GD. Youth resistance training: past practices, new perspectives, and future directions. *Pediatric Exercise Science*. 2013; 25: 591–604. https://doi.org/10.1123/pes.25.4.591
21. Legerlotz K, Marzilger R, Bohm S, Arampatzis A. Physiological adaptations following resistance training in youth athletes - a narrative review. *Pediatric Exercise Science*. 2016; 28: 501–520. https://doi.org/10.1123/pes.2016-0023
22. Krabak BJ, Hancock KJ, Drake S. Comparison of dry-land training programs between age groups of swimmers. *PM&R*. 2013; 5: 303–309. https://doi.org/10.1016/j.pmrj.2012.11.003
23. Kalva-Filho C, Campos E, Andrade V, Silva A, Zagatto A, Lima M, et al. Relationship of aerobic and anaerobic parameters with 400 m front crawl swimming performance. *Biology of Sport*. 2015; 32: 333–337. https://doi.org/10.5604/20831862.1188611
24. Sadowski J, Mastalerz A, Gromisz W, NiŸnikowski T. Effectiveness of the power dry-land training programmes in youth swimmers. *Journal of Human Kinetics*. 2012; 32: 77–86. https://doi.org/10.2478/v10078-012-0025-5
25. Figueiredo P, Zamparo P, Sousa A, Vilas-Boas JP, Fernandes RJ. An energy balance of the 200 m front crawl race. *European Journal of Applied Physiology*. 2011; 111: 767–777. https://doi.org/10.1007/s00421-010-1696
26. Ogita F. Energetics in competitive swimming and its application for training. *Revista Portuguesa de Ciencias do Desporto*. 2006; 6: 117–182.
27. Olbrecht J. (ed). *The Science of Winning. Planning, Periodizing and Optimizing Swim Training*. Luton, England: Swimshop; 2000.
28. Gosselink R, Kovacs L, Ketelaer P, Carton H, Decramer M. Respiratory muscle weakness and respiratory muscle training in severely disabled multiple sclerosiss patients. *Archives of physical medicine and rehabilitation*. 2008; 81(6): 747–51. https://doi.org/10.1053/apmr.2000.5616
29. Prakash S, Meshram S, Ramtekkar U. Athletes, yogis and individuals with sedentary lifestyles; do their lung functions differ? *Indian Journal of Physiology and Pharmacology*. 2007; 51: 76–80.
30. Attene G, Pizzolato F, Calcagno G, Ibba G, Pinna M, Salernitano G, Padulo J. Sprint vs. intermittent training in young female basketball players. *The Journal of Sports Medicine and Physical Fitness*. 2014; 54(2): 154–61.
31. Vašíčková J, Neumannová K, Svozil Z. The effect of respiratory muscle training on finswimmers'performance. *Journal of Sports Science and Medicine*. 2017; 16: 521–526. https://doi.org/10.23736/S0025

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Cite this article as:
Yapıcı-Öksüzoğlu A. The effects of theraband training on respiratory parameters, upper extremity muscle strength and swimming performance. *Pedagogy of Physical Culture and Sports,* 2020;24(6):316-322.
https://doi.org/10.15561/26649837.2020.0607



Received: 18.04.2020
Accepted: 28.05.2020; Published: 30.12.2020