5-1-2007

Effect of a 12-Week Awimming-Training on Spirometric parametersVariables in Teenage Females

Maija Rumaka

Riga Stradins University, maija.rumaka@rsu.lv

Liga Abeberga-Augskalne

Riga Stradins University

Imants Upitis

Latvian Academy of Sports Education

Follow this and additional works at: <https://scholarworks.bgsu.edu/ijare>

How does access to this work benefit you? Let us know!

Recommended Citation

Rumaka, Maija; Abeberga-Augskalne, Liga; and Upitis, Imants (2007) "Effect of a 12-Week Awimming-Training on Spirometric parametersVariables in Teenage Females," *International Journal of Aquatic Research and Education*: Vol. 1: No. 2, Article 2.

DOI: <https://doi.org/10.25035/ijare.01.02.02>

Available at: <https://scholarworks.bgsu.edu/ijare/vol1/iss2/2>

This Research Article is brought to you for free and open access by the Journals at ScholarWorks@BGSU. It has been accepted for inclusion in International Journal of Aquatic Research and Education by an authorized editor of ScholarWorks@BGSU.

Effects of a 12-Week Swimming-Training Program on Spirometric Variables in Teenage Females

Maija Rumaka, Liga Aberberga-Augskalne, and Imants Uptis

The purpose of the study was to determine the changes in spirometric parameters resulting from a 12-wk swimming-instruction program. Fifty-one teenage female volunteers were divided into swimmers (S) and nonswimmers (NS). Spirometric investigation revealed greater inspiratory (VC) and forced vital capacity (FVC) and forced expiratory (FEV1) and inspiratory (FIV1) volume in 1 s in the S group than in NS. After a 12-wk swimming-training program, in the NS group VC, FVC, FEV1, FIV1 and maximal expiratory flow at 50% and 25% of VC in the lungs increased as a result of increased respiratory-muscle strength and endurance. Correlations between the swimming-skill evaluation marks and increases in VC, FVC, FEV1, and FIV1 after the swimming training indicate the potential importance of motor-learning skills in respiratory training.

Key Words: learning to swim, swimming instruction

Several investigations have found that swimmers have higher vital capacity (Cordain, Tucker, Moon, & Stager, 1990; Tzelepis, Kasas, & McCool, 1999) and flow rates (Bertholon, Carles, & Teillac, 1986; Doherty & Dimitriou, 1997) than land-based athletes. Authors have described the changes in spirometric parameters caused by swimming training for competitive swimmers (Bertholon et al.; Clanton, Dixon, Drake, & Gadek, 1987), but little is known about changes in lung volumes and flow rates related to swimming instruction for nonswimmers.

The purpose of the study was to determine whether changes occurred in spirometric parameters for nonswimmers as a result of a 12-week swimming-instruction program. Positive results could motivate using swimming instruction and respiratory training in the rehabilitation process for people with compromised lung function.

Method

Fifty-one healthy teenage female students at the Latvian Academy of Sports Education volunteered for this study. All were nonsmokers. Written informed consent was obtained from each student. Students were divided into two groups based on

Rumaka and Aberberga-Augskalne are with the Dept. of Physiology, Riga Stradins University, 16 Riga, Latvia-1007. Uptis is with the Latvian Academy of Sports Education.

Table 1 Participant Characteristics ($M \pm SD$)

Parameter	Nonswimmers' group ($n = 40$)	Swimmers' group ($n = 11$)
Age (years)	18.9 $\pm$ 0.9	19.0 $\pm$ 2.4
Height (cm)	171.9 $\pm$ 5.5	174.2 $\pm$ 6.0
Weight (kg)	63.98 $\pm$ 5.7	66.3 $\pm$ 6.3

their swimming skills: Group NS (nonswimmers), those who had not had previous regular swimming training, and Group S (swimmers), students who were already skilled and were training in swimming. Participant characteristics of both groups are given in Table 1. There were no statistically significant differences in age, height, or weight between the NS and S groups.

Spirometric investigation based on the American Thoracic Society's guidelines was conducted as a pretest for students of both groups. Inspiratory vital capacity (VC), forced vital capacity (FVC), forced expiratory volume in 1 s (FEV1), forced inspiratory volume in 1 s (FIV1), peak expiratory flow (PEF), maximal expiratory flow at 50% of VC (MEF50), and maximal expiratory flow at 25% of VC (MEF25) were analyzed. Group NS was engaged in a 12-week swimming-instruction program. They attended swimming classes for 90 min twice a week. Every session included exercising in the gymnasium and dry-land swimming-imitation movements for 30 min, followed by 60 min of swimming instruction in an indoor swimming pool to acquire basic skills in four strokes (crawl, butterfly, breaststroke, and backstroke). The goal was for the participants to be able to swim at least 50 m in a technically correct fashion in each of four swimming strokes (i.e., front crawl, back crawl, breaststroke, and butterfly). The intensity of swimming was maintained below aerobic threshold.

After 12 weeks of swimming training, a second posttest spirometric investigation was conducted only for Group NS. Because the S-group students had already acquired swimming skills in the four basic strokes, they were not engaged in the swimming program, and spirometric investigation was not performed after 12 weeks for these students. The swimming skills of each student in the NS group were evaluated by the instructor at pre- and posttests on a 10-point scale.

Data were analyzed using the SPSS statistical software program. The differences between the groups on the pretest were evaluated using an independent t test. The changes in the NS group between pre- and posttest of the spirometric parameters after swimming instruction were evaluated using a paired t test. The relationships between changes in spirometric parameters and changes in swimming skills were calculated using Pearson's product-moment correlation coefficients. An alpha level of $p \leq .05$ was required for statistical significance.

Results

The mean (and SEM) values of spirometric parameters for both groups are given in Table 2. Group S had statistically significantly higher VC, FVC, FEV1, and FIV1 than Group NS, but there were no differences in FEV1 %FVC, FIV1 %FVC,

PEF, MEF50, and MEF25 between groups (Table 2). Spirometric parameters at the beginning and end of swimming instruction are shown in Figures 1, 2, and 3.

VC and FVC (Figure 1) increased at the end of swimming training by about 5% ($p < .05$), and FEV1 and FIV1 (Figure 2) increased by about 7% from pre- to posttest.

Table 2 Spirometric Parameters ($M \pm SEM$) at Pretest

Parameter	Nonswimmers' group	Swimmers' group
VC (L)	4.21 $\pm$ 0.46	4.75 $\pm$ 0.26*
FVC (L)	4.45 $\pm$ 0.46	5.08 $\pm$ 0.30*
FEV1 (L)	3.89 $\pm$ 0.50	4.31 $\pm$ 0.33*
FEV1 %FVC (%)	87.3 $\pm$ 7.5	85.0 $\pm$ 6.4
FIV1 (L)	3.84 $\pm$ 0.61	4.70 $\pm$ 0.50*
FIV1 %FVC (%)	84.8 $\pm$ 9.1	92.8 $\pm$ 6.1
PEF (L/s)	6.70 $\pm$ 1.41	7.36 $\pm$ 1.31
MEF50 (L/s)	5.03 $\pm$ 0.93	5.13 $\pm$ 0.96
MEF25 (L/s)	2.41 $\pm$ 1.05	2.61 $\pm$ 0.96

Note. VC = inspiratory vital capacity; FVC = forced vital capacity; FEV1 = forced expiratory volume in 1 s; FEV1 %FVC = FEV1 in percentage from FVC; FIV1 = forced inspiratory flow in 1 s; FIV1 %FVC = FIV1 in percentage from FVC; PEF = peak expiratory flow; MEF50 = maximal expiratory flow at 50% of VC; MEF25 = maximal expiratory flow at 25% of VC.

* $p < .05$ vs. nonswimmers, unpaired t test.

Figure 1 — Inspiratory (VC) and forced (FVC) vital capacity of the nonswimmers' group at the beginning (pre) and end (post) of the swimming-instruction program ($M \pm SEM$). * $p < .05$, paired t test.

Figure 2 — Forced expiratory (FEV1) and inspiratory (FIV1) volume in 1 s of the non-swimmers' group at the beginning (pre) and end (post) of the swimming-instruction program ($M \pm SEM$). * $p < .05$, paired t test.

Figure 3 — Peak expiratory flow (PEF), maximal expiratory flow at 50% of inspiratory vital capacity VC (MEF50), and maximal expiratory flow at 25% of inspiratory vital capacity (MEF25) of the nonswimmers' group at the beginning (pre) and end (post) of the swimming-instruction program ($M \pm SEM$). * $p < .05$, paired t test.

The swimming-training program led to an increase of flow rates—MEF50 for 6% and MEF25 for 16%—but there were essentially no changes in PEF (Figure 3).

Correlation coefficients between the swimming-skill evaluation marks at the end of the 12-week swimming-instruction program and spirometric parameters were as follows: ΔVC .54, ΔFVC .44, $\Delta FEV1$.48, and $\Delta FIV1$.75 ($p < .05$).

Discussion

Respiratory muscles can be trained just as other skeletal muscles can. Swimming makes respiratory-muscle contractions stronger and faster. These changes are represented by the spirometric parameters measured in this study. Several authors have found that respiratory-muscle strength and endurance influence the values of FVC, FEV1, and PEF for females and for males (Harik-Khan, Wise, & Fozard, 1998; Leech, Ghezzi, Stevens, & Becklake, 1983). Investigations involving male volunteers have shown that flow rates during inspiration and expiration depend on respiratory-muscle contraction speed (Sonneti, Wetter, Pegelow, & Dempsey, 2001; Tzelepis, Vega, et al., 1999). Other authors suggest that force generated by expiratory muscles, primarily abdominal, could be one of the factors that determine expiratory flow (Quanjer, Lebowitz, Gregg, Miller, & Pedersen, 1997).

Enhanced respiratory-muscle strength and power explain the relatively large VC reported for the competitive swimmers. Studies comparing respiratory function among people engaged in different sports found that female and male swimmers have higher VC and FVC than athletes of other sports, as well as sedentary controls (Cordain et al., 1990; Kesavachandran, Nair, & Shashidhar, 2001; Phervani, Desai, & Solepure, 1989). It was found that flow rates such as PEF, MEF50, and MEF 25 are higher for male and female swimmers than others, and the swimmers showed increased conductivity of large and small airways and higher speeds of respiratory-muscle contraction (Bertholon et al., 1986; Phervani et al.). Bertholon et al. found that FEV1 is higher in athletes than sedentary controls. Doherty and Dimitriou (1997) found that male and female swimmers have higher FEV1 than land-based athletes and controls. These findings are supported by the investigations of other authors (Kesavachandran et al.; Phervani et al.). Higher FEV1 for swimmers indicates higher conductivity of large airways as a result of increased VC, which allows greater airflow through the airways during the first second of expiration and inspiration (Bertholon et al.; Wells, Pyle, Thomas, Goodman, & Duffin, 2005). Higher FIV1 indicates important adaptations of the respiratory system that enable a swimmer to inhale more air during a short time while swimming. Data from our study agree with these findings and showed better development of the respiratory system in swimmers than nonswimmers.

Changes in lung volumes and flow rates resulting from training are somewhat controversial. Some authors have found that VC and FVC increase after specific respiratory-muscle training for 5–12 weeks (Clanton et al., 1987; Sonneti et al., 2001; Wells et al., 2005), but others report no such changes (Hanel & Secher, 1991; Inbar, Weiner, Azgad, Rostein, & Weinstein, 2000; Romer & McConnell, 2000; Williams, Wongsathikun, Boon, & Acevedo, 2002). Most of these studies included highly trained female and male athletes for whom additional respiratory-muscle training does not improve lung volume. This indicates that vigorous training is sufficient for optimal development of the respiratory system. This is also true for changes in FEV1. Some authors found increases within 12 weeks in concurrent inspiratory- and expiratory-muscle training in competitive female and male swimmers (Wells et al.) and 6–10 months of respiratory-muscle training in athletes of different sports (Bertholon et al., 1986), whereas others reported no effects (Hanel & Secher; Inbar et al.; Romer & McConnell). VC is one of the determining factors for FEV1 in healthy adults, so the investigations that found no changes in VC mostly reported no change in FEV1.

Wells et al. (2005) reported a 16% increase in FIV1 and a 24% increase in FEV1 as a result of 12 weeks of swimming combined with concurrent inspiratory- and expiratory-muscle training for competitive adolescent female and male swimmers. The smaller changes in these parameters in our study could be explained by the older age of their participants. Our data are more consistent with those described by Clanton et al. (1987) and Sonetti et al. (2001). Clanton et al. found that a 12-week swimming-training program increased VC by about 0.25 L for competitive female swimmers, irrespective of additional inspiratory-muscle training. Sonetti et al. showed a 4% increase in FVC after additional respiratory-muscle training in competitive male swimmers. Bertholon et al. (1986) found a 14% increase in PEF, a 7% increase in FEV1, and a 5% increase in MEF75 for adolescents within 7–10 months of training, whereas there was no effect on high-level athletes.

This investigation did not take into account possible genetic variations in the lung volumes between swimmers and nonswimmers that could account for natural selection of athletes in different kinds of sports. People with larger hereditary lung volumes might have an advantage over those with smaller lung volumes in competitive swimming. This could facilitate self-selection for athletes to the sports in which they could get better results.

Conclusions

The results of the present study demonstrate that female swimmers have greater development in variables associated with the respiratory system than do nonswimming controls.

The 12-week swimming-instruction program induced significant increases in static and dynamic lung volumes. We think that improvement in the flow–volume relationship of the students was related to increases in respiratory-muscle strength and speed of contraction. Significant positive correlations between the 10-point swimming-skill evaluation marks and VC, FVC, FEV1, and FIV1 indicate that better development of the respiratory system appears to be related to better acquisition of swimming skills. The students who developed better swimming abilities had greater increases in lung volume and flow rate, probably because they could swim longer distances with increased pulmonary ventilation. Therefore, the first step in swimming training should be the development and acquisition of proficient swimming strokes that allow athletes to train respiratory muscles to a greater extent while swimming. Increases in respiratory-muscle strength and speed of contraction further should lead to better results in competitive swimming.

Acknowledgment

This investigation was sponsored by ESF National Program No. 2004/0005/VPD1/ESF/PIAA/ 04/NP/3.2.3.1./0004/0066.

References

- Bertholon, J.F., Carles, J., & Teillac, A. (1986). Assessment of ventilatory performance of athletes using the maximal expiratory flow-volume curve. *International Journal of Sports Medicine*, 7(2), 80-85.

- Clanton, T.L., Dixon, G.F., Drake, J., & Gadek, J.E. (1987). Effects of swim training on lung volumes and inspiratory muscle conditioning. *Journal of Applied Physiology*, 62(1), 39-46.
- Cordain, L., Tucker, A., Moon, D., & Stager, J.M. (1990). Lung volumes and maximal respiratory pressures in collegiate swimmers and runners. *Research Quarterly for Exercise and Sport*, 61(1), 70-74.
- Doherty, M., & Dimitriou, L. (1997). Comparison of lung volume in Greek swimmers, land based athletes, and sedentary controls using allometric scaling. *British Journal of Sports Medicine*, 31(4), 337-341.
- Hanel, B., & Secher, N.H. (1991). Maximal oxygen uptake and work capacity after inspiratory muscle training: Controlled study. *Journal of Sports Sciences*, 9(1), 43-52.
- Harik-Khan, R.I., Wise, R.A., & Fozard, J.L. (1998). Determinants of maximal inspiratory pressure. *American Journal of Respiratory and Critical Care Medicine*, 158, 1459-1464.
- Inbar, O., Weiner, P., Azgad, Y., Rostein, A., & Weinstein, Y. (2000). Specific inspiratory muscle training in well-trained endurance athletes. *Medicine and Science in Sports and Exercise*, 32(7), 1233-1237.
- Kesavachandran, C., Nair, H.R., & Shashidhar, S. (2001). Lung volumes in swimmers performing different styles of swimming. *Indian Journal of Medical Sciences*, 55(12), 669-676.
- Leech, J.A., Ghezze, H., Stevens, D., & Becklake, M.R. (1983). Respiratory pressures and function in young adults. *American Review of Respiratory Disease*, 128(1), 17-23.
- Phervani, A.V., Desai, A.G., & Solepure, A.B. (1989). A study of pulmonary function of competitive swimmers. *Indian Journal of Physiology and Pharmacology*, 33(4), 228-232.
- Quanjer, P.H., Lebowitz, M.D., Gregg, I., Miller, M.R., & Pedersen, O.F. (1997). Peak expiratory flow: Conclusions and recommendations of a working party of the European Respiratory Society. *European Respiratory Journal*, 10(Suppl. 24), 2s-8s.
- Romer, L.M., & McConnell, A.K. (2000). Specificity and reversibility of inspiratory muscle training. *Medicine and Science in Sports and Exercise*, 35(2), 237-244.
- Sonneti, D.A., Wetter, T.J., Pegelow, D.F., & Dempsey, J.A. (2001). Effects of respiratory muscle training versus placebo on endurance exercise performance. *Respiration Physiology*, 127, 185-199.
- Tzelepis, G.E., Kasas, V., & McCool, F.D. (1999). Inspiratory muscle adaptations following pressure or flow training in humans. *European Journal of Applied Physiology and Occupational Physiology*, 79(6), 467-471.
- Tzelepis, G.E., Vega, D.L., Cohen, M.E., Fulambarker, A.M., Patel, K.K., & McCool, F.D. (1999). Pressure-flow specificity of inspiratory muscle training. *Journal of Applied Physiology*, 77(2), 795-801.
- Wells, G.D., Plyley, M., Thomas, S., Goodman, L., & Duffin, J. (2005). Effects of concurrent inspiratory and expiratory muscle training on respiratory and exercise performance in competitive swimmers. *European Journal of Applied Physiology*, 94, 527-540.
- Williams, J.S., Wongsathikun, J., Boon, S.M., & Acevedo, E.O. (2002). Inspiratory muscle training fails to improve endurance capacity in athletes. *Medicine and Science in Sports and Exercise*, 34(7), 1194-1198.