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# Anaerobic endurance of young swimmers aged 12 years

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## Summary

*Study aim*: To assess the effects of swimming training on anaerobic endurance, swimming velocity and chest girth in children aged 12 years.
*Material and methods*: Two groups of children aged 12 years were studied. Group S (14 boys and 6 girls) training swimming at a sport-oriented school 3 days a week, 90 min per session, and Group R (6 boys and 6 girls) engaged in competitive swimming for 4 years. Children from Group S were subjected twice (in September and in February) to a swimming test consisting of 6 bouts of swimming the 12.5-m distance, spaced by 30-s intermissions. Mean and maximum swimming velocities in the entire test were recorded together with their ratio (Performance Index, PI). In children from Group R the swimming velocity at one 12.5-distance was recorded.
*Results*: Apart from somatic indices, significant increases over the 5-month training period were noted in mean swimming velocity in boys and girls ($p<0.001$) and in maximum velocity in boys ($p<0.01$). No significant changes were noted in the performance index or in heart rate.
*Conclusions*: Performance index as a measure of anaerobic endurance may serve as a useful tool in assessing the adaptive performance changes in young swimmers.

Key words: Swimming – Endurance – Training – Work capacity

## Introduction

Swimming even not intense, practiced by children and youths, enhances the development of the respiratory system and increases lung volume [9]. Swimming exercise forces the control of inspiration and expiration, as well as maintaining relatively long periods of apnoea. The hydrostatic pressure facilitates expiration but exerts some resistance to inspiration; in effect, the strength of respiratory muscles and chest mobility increase. Swimming is an example of the so-called early sports in which high training loads, especially the endurance ones, ought to be applied in the period of growth in order to achieve high results [4,5,10,11,13,20]. Endurance training applied in the pre-adolescence period may increase the $\dot{V}O_2max$ in swimmers by as much as 20 – 30%. Thus, steady monitoring of the effects of anaerobic and aerobic stimuli provides valuable information on metabolic reserves and of their potential shaping [3]. However, an assessment of changes in the aerobic capacity of children, especially under a regular endurance training, is not easy [6], due to the growth-related changes in skeletal muscle mass [8].

This study attempted at assessing the anaerobic capacity in 12-year old children attending curricular swimming classes in a sport-oriented school. Of particular interest were the effects of swimming training on anaerobic endurance, swimming velocity and chest girth.

## Material and Methods

A group of 14 boys and 6 girls aged 12 years, attending sport-oriented school of swimming profile, volunteered to participate in the study (Group S); they attended curricular swimming classes (90 min each) 3 days a week. Another group of 6 boys and 6 girls aged 12 years, engaged in competitive swimming for 4 years, served as reference (Group R); they trained 6 days a week and among them were Polish champions in that age category. The parents of children submitted their written consents; the study was approved by the local Committee of Ethics.

Children from Group S were examined twice – in September and February; they were subjected to a swimming test consisting of 6 bouts of swimming the 12.5-m distance, spaced by 30-s intermissions. Heart rates (HR) were

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determined using SportTester devices (Polar Electro, Finland) immediately before and after every swimming bout. Swimming times were converted to velocities; from all 6 bouts, maximum ($V_{max}$) and mean ($V_{av}$) velocities were recorded and from these the so-called Performance Index (PI) was computed [15] using the formula $PI = V_{av} / V_{max}$. Children from Group R were examined only once to determine the swimming velocity at 12.5-m distance. This served as a reference for the data recorded in Group S.

Body height was measured with the use of a standard anthropometer (accuracy – 0.1 cm) and body mass – using medical scales (accuracy 0.1 kg) Chest girth was measured using anthropometric tape (mean value of measurements at maximum inspiration and expiration was recorded) in children from Group S.

The data of Group S were subjected to two-way ANOVA. Student's *t*-test for dependent (between examinations) or independent (between groups) data was applied. The level of $p \leq 0.05$ was considered significant.

## Results

The results of somatic and swimming performance variables in Group S, measured before and after a 5-month training period, are presented in Table 1. Body height and mass, BMI and chest girth increased over that period as expected. Mean swimming velocities in the consecutive bouts of swimming the 12.5-m distance are presented in Fig. 1. Maximum velocity was attained in all subjects in the first bout and in boys was significantly ($p<0.01$) higher on second than on the first examinations. Mean velocity computed from all 6 bouts was slightly (by 2%) but significantly ($p<0.001$) higher in all subjects on second examination. Yet, the performance index reflecting the anaerobic endurance did not differ significantly either between examinations or between genders. The same was true for heart rates (HR) recorded immediately after 6 swimming bouts and for the differences between HR values post-bout and immediately before the following bout; only in boys that difference in the first test was significantly ($p<0.05$) lower than on second examination or in girls (Table 1 and Fig. 2).

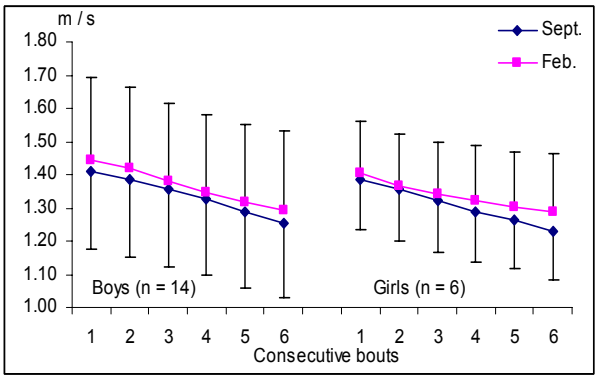



**Fig. 1**. Swimming velocities (means ±SD) recorded for 6 swimming bouts (12.5-m distance) spaced by 30-s intermissions before (Sept.) and after (Feb.) a 5-month training period

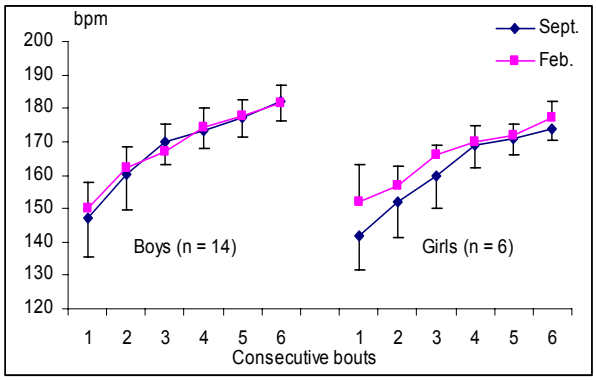



**Fig. 2**. Heart rates (means ±SD) recorded immediately after 6 swimming bouts (12.5-m distance) spaced by 30-s intermissions before (Sept.) and after (Feb.) a 5-month training period

**Table 1**. Mean values (±SD) of somatic and swimming performance variables in trained children aged 12 years (Group S) before (I) and after (II) a 5-month training period

| Variable | Group | Boys (n = 14) | | Girls (n = 6) | |
|---|---|---|---|---|---|
| | Period | I | II | I | II |
| Body height (cm) | | 153.8 ± 10.9 | 159.3 ± 11.9 | 156.1 ± 1.7 | 160.9 ± 1.8 |
| Body mass (kg) | | 47.0 ± 12.6 | 52.5 ± 13.9 | 42.9 ± 5.7 | 49.4 ± 6.6 |
| BMI | | 19.6 ± 3.7 | 20.5 ± 3.7 | 17.6 ± 2.2 | 19.1 ± 2.6 |
| Mean chest girth (cm) | | 77.3 ± 8.3 | 81.8 ± 7.8 | 73.7 ± 3.9 | 81.4 ± 6.1 |
| Maximum velocity (m/s) | | 1.41 ± 0.24 | 1.44 ± 0.25** | 1.39 ± 0.15 | 1.41 ± 0.16 |
| Mean velocity (m/s) | | 1.34 ± 0.23 | 1.37 ± 0.24*** | 1.31 ± 0.15 | 1.34 ± 0.16*** |
| Performance index (PI) | | 0.947 ± 0.018 | 0.948 ± 0.017 | 0.943 ± 0.021 | 0.951 ± 0.017 |
| Mean HR decrease (bpm) | | 25.6 ± 8.1 | 27.8 ± 9.2* | 27.2 ± 6.2 | 28.3 ± 5.8 |
| Post-exercise HR (bpm) | | 181.8 ± 6.0 | 181.8 ± 5.0 | 174.0 ± 3.8 | 177.0 ± 5.0 |

Significantly different from Period I (by ANOVA): * $p<0.05$; ** $p<0.01$; All somatic changes were significant ($p<0.001$)

When compared with competitive, elite swimmers of that age (Group R; Table 2), the non-competitive ones (Groups S) had comparable body height, body mass and BMI, although that latter tended to be lower in girls from Group R (p=0.07). On the other hand, mean swimming velocity attained by children from Group R was significantly higher than in Group S: 1.66 ± 0.04 vs. 1.44 ± 0.25 (p<0.05) in boys and 1.63 ± 0.04 vs. 1.41 ± 0.16 m/s (p<0.01) in girls, respectively. Yet, 3 boys from Group S were comparable with those from Group R with respect to swimming velocity they attained in the first bout, as their velocities ranged from 1.64 to 1.72 m/s and two of them attained very high PI values (0.948 and 0.972). The relationship between swimming velocity in the first bout on Examination II (Vmax) and the performance index (PI) in boys and girls from Group S is presented in Fig. 3.

**Table 2**. Mean values (±SD) of somatic variables and of swimming velocity in children aged 12 years engaged in competitive swimming (Group R)

| Group<br>Variable | Boys<br>n = 6 | Girls<br>n = 6 |
|---|---|---|
| Body height (cm) | 159.9 ± 1.9 | 162.9 ± 4.7 |
| Body mass (kg) | 46.5 ± 2.6 | 42.7 ± 2.8 |
| BMI | 18.3 ± 0.6 | 16.9 ± 0.3 |
| Max. velocity (m/s) | 1.66 ± 0.04* | 1.63 ± 0.04** |

Significantly higher compared with Group S: * p<0.05; ** p<0.01

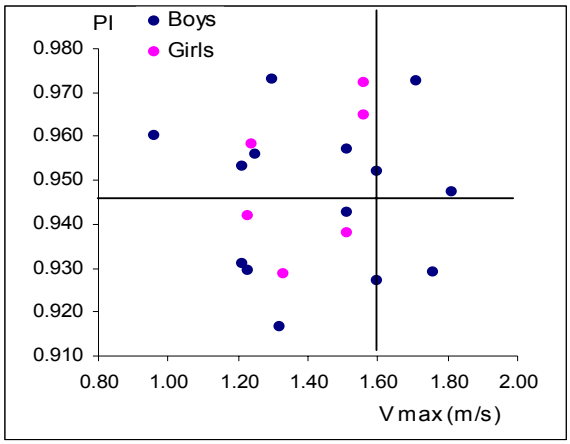



**Fig. 3**. Relationship between swimming velocity in the first bout on Examination II ($V_{max}$) and the performance index (PI) in boys (n = 14) and girls (n = 6) from Group S
Vertical line corresponds to lowest velocity recorded in Group R; Horizontal line corresponds to the mean PI value for boys and girls combined

When the results of mean chest girth were combined for boys and girls and analysed allometrically (log chest girth vs. log body mass), the post-training values proved to be by about 3% higher compared to the pre-training ones (p<0.05). This followed from the allometric regression computed for the pre-training values which was then applied to the post-training ones. Mean deviation of post-training values from that regression amounted to 0.011, i.e. over 2.5% (Fig. 4). On the other hand, no significant difference was found between the post- and pre-training states of the allometric relation between body mass and height.

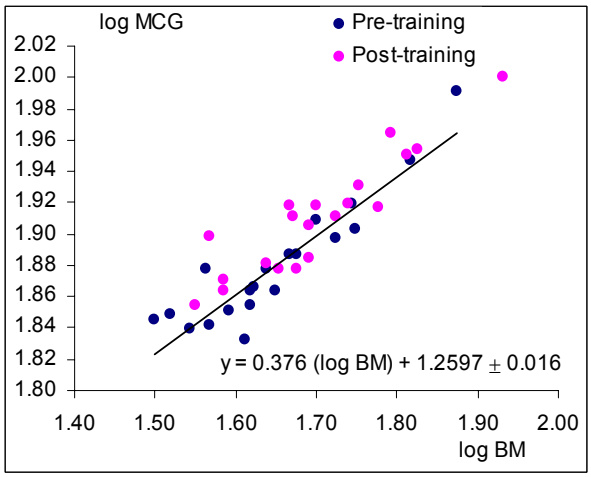



**Fig. 4**. Allometric relation between mean chest girth (MCG) and body mass (BM) in young male and female swimmers combined

## Discussion

Sport training often includes repeated maximal bouts of exercise but their assessment with respect maintaining a high performance, i.e. anaerobic endurance [15,16, 19], is usually neglected. The presented results suggest that measuring anaerobic endurance enables the assessment of adaptive performance changes in young swimmers. Inasmuch maximum swimming velocity, i.e. that attained in the first out of 6 repeated bouts of swimming the 12.5-m distance, significantly improved over the 5 months of training only in boys, the mean velocity determined from all 6 bouts significantly improved in both boys and girls. Moreover, girls tended to exhibit a higher stability of results than boys, as reflected by SD values and as reported by Åstrand [1].

Like reported by other authors [1,2,7,8,17], no training-induced somatic changes were noted except chest girth which slightly but significantly increased in relation to body mass. Similar changes were reported by others [9,13] in the early phase of swimming training.

The applied performance index (PI) enabled identifying those subjects (2 boys and 2 girls) who may portend well for the future as they attained both high swimming velocities and high performance in repeated swimming bouts. In practice, the intensity of exertion rating

of sports takes place primarily on the basis of observation of heart rate, so the performance index as a measure of anaerobic endurance may serve as a useful tool in assessing the adaptive performance changes in young swimmers.

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