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# Effects of 8-week training on aerobic capacity and swimming performance of boys aged 12 years

Ryszard Zarzeczny [1], Mariusz Kuberski [1], Agnieszka Deska [1], Dorota Zarzeczna [1], Katarzyna Rydz [1], Anna Lewandowska [2], Tomasz Bałchanowski [3], Janusz Bosiacki [3]

[1] Institute of Physical Culture and Tourism, Jan Długosz University, Częstochowa; [2] Primary School No. 36, Częstochowa; [3] Primary School No. 48, Częstochowa, Poland

## Summary

*Study aim*: To assess the effects of 8-week endurance training in swimming on work capacity of boys aged 12 years.
*Material and methods*: The following groups of schoolboys aged 12 years were studied: untrained control (UC; n = 14) and those training swimming for two years. The latter ones were subjected to 8-week training in classical style (CS; n = 10) or free style (FS; n = 13). In all boys maximal oxygen uptake ($\dot{V}O_2$max) was determined, and the CS and FS groups were subjected to 6 tests: swimming at 50 and 400 m distances (time recorded) and to 12-min swimming (distance recorded), all by free and classical styles pre- and post-training. From swimming times at 50 and 400 m distances the so-called critical swimming speed (CSS) was computed: CSS = (400 – 50) / ($t_{400} - t_{50}$).
*Results*: No training-induced improvement in $\dot{V}O_2$max was noted in any group. Yet, boys subjected to classical style training significantly ($p<0.05$) improved their free-style swimming velocity at CSS and at the 400-m distance by about 6%, and their heart rate following the 12-min test in classical style decreased by nearly 16% ($p<0.001$) compared with the pre-training values.
*Conclusions*: The 8-week training in given swimming style does not negatively affect the performance in other style than the trained one. This may be of importance in competitive training.

Key words: Swimming – Critical velocity – Physical training – Work capacity – Boys

## Introduction

Anaerobic threshold, a widely used indicator of anaerobic capacity (AC) [5], has been considered more sensitive to changes in AC than maximal oxygen uptake ($\dot{V}O_2$max) [3]. Thus, anaerobic threshold, apart from reflecting the AC level, has been used in setting the training intensity which, at or slightly above the anaerobic threshold, is considered an efficient training stimulus in adults leading to augment their AC [7].

Toubekis *et al*. [10], who studied young male swimmers (mean age 12.9 years), reported a significant relationship between the so-called critical swimming speed (CSS), determined from swimming times at distances 50, 100, 200 and 400 m, and swimming speed at the lactate threshold; they suggested that CSS could be determined from two distances only – 50 and 400 m. The aim of this study was to assess the effects of 8-week training in clas-sical and free-style swimming at CSS-intensity on the performance of 12-year old boys.

## Material and Methods

*Subjects*: Two groups of boys aged 12 years were studied: untrained control group (UC; n = 14), consisting of boys who attended only the curricular physical education classes and practiced no sports, and swimming group consisting of members of school sport clubs who practiced swimming for two years. They were assigned into two subgroups: submitted to 8-week training in classical style (CS; n = 10) or in free style (FS; n = 13). All parents submitted their signed consents to participation of their sons in the study which was approved by the local Committee of Ethics.

*Methodology*: All boys were subjected to the Åstrand-Ryhming's cycle ergometer test before and just after the training period. Test results served to indirectly assess the boys' maximum oxygen uptake using the equation: $Y = 1.444 + 0.522 \cdot \dot{V}O_2\text{max}$ (from a nomogram) [11]. The swimmers were additionally subjected to 6 tests: swimming at 50 and 400 m distances (time recorded) and

Author's address Prof. Ryszard Zarzeczny, Institute of Physical Culture and Tourism, Jan Długosz University, Armii Krajowej 13/15, 42-200 Częstochowa, Poland r.zarzeczny@ajd.czest.pl

to 12-min swimming (distance recorded), all by free and classical styles [4]. Heart rate (HR) was recorded immediately following every test. From swimming times at 50 and 400 m distances the so-called critical swimming speed (CSS) was computed: CSS = (400 – 50) / ($t_{400} - t_{50}$).

Both subgroups of swimmers trained 3 days a week, every 60-min session consisting of standard warm-up (10 min), 3 bouts of swimming at CSS, 10 min each, separated by 5-min intermissions for discussing technical errors, and relaxation (10 min).

*Data analysis*: The results were subjected to one- or two-way ANOVA with repeated measures followed by the Newman-Keuls' *post-hoc* test. The level of $p \leq 0.05$ was considered significant.

## Results

As shown in Table 1, some significant differences were noted in body height and mass of boys over the 8-week period. Interestingly, $\dot{V}O_2max$ (maximal oxygen uptake), both absolute and relative, tended to decrease in all groups.

**Table 1**. Mean values (±SD) of body height and mass, and maximal oxygen uptake ($\dot{V}O_2max$) of boys aged 12 years, and of individual changes (Δ) following 8-week period (sedentary or training)

| Group / Variable | Control (n = 14) Pre | Control (n = 14) Δ | Free style (n = 13) Pre | Free style (n = 13) Δ | Classical style (n = 10) Pre | Classical style (n = 10) Δ |
|---|---|---|---|---|---|---|
| Body height (cm) | 154.6 ± 9.7 | 1.8 ± 6.7** | 159.5 ± 8.3 | 1.2 ± 1.1* | 156.1 ± 9.2 | 2.6 ±1.3*** |
| Body mass (kg) | 49.2 ± 14.7 | 0.5 ± 1.7 | 49.7 ± 8.3 | 1.3 ± 2.1* | 46.4 ± 13.3 | 0.5 ± 1.8 |
| $\dot{V}O_2max$ (l/min) | 2.32 ± 0.11 | -0.08 ± 0.11* | 2.41 ± 0.14 | 0.01 ± 0.13 | 2.41 ± 0.17 | -0.07 ± 0.24 |
| (ml/min/kg) | 50.8 ± 14.2 | -1.70 ± 1.93** | 48.9 ± 7.6 | -0.42 ± 3.16 | 54.9 ± 12.2 | -1.74 ± 6.50 |

* p<0.05; ** p<0.01; *** p<0.001

**Table 2**. Mean values (±SD) of free-style swimming velocities and post-exercise heart rates, and of the respective individual changes (Δ) following 8-week period (sedentary or training), in boys aged 12 years

| Group / Variable | Free style (n = 13) Pre | Free style (n = 13) Δ | Classical style (n = 10) Pre | Classical style (n = 10) Δ |
|---|---|---|---|---|
| CSS (m/s) | 0.89 ± 0.12 | 0.01 ± 0.07 | 0.83 ± 0.14 | 0.05 ± 0.07* |
| 50 m (m/s) | 1.31 ± 0.14 | -0.01 ± 0.06 | 1.24 ± 0.21 | 0.01 ± 0.08 |
| $HR_{post}$ (bpm) | 160.7 ± 13.1 | -5.7 ± 23.2 | 147.6 ± 23.5 | 23.4 ± 24.2 |
| 400 m (m/s) | 0.93 ± 0.12 | 0.01 ± 0.06 | 0.86 ± 0.14 | 0.05 ± 0.07* |
| $HR_{post}$ (bpm) | 182.6 ± 13.7 | -12.4 ± 18.6* | 174.0 ± 24.8 | 3.0 ± 26.6 |

* p<0.05

**Table 3**. Mean values (±SD) of classical style swimming velocities and post-exercise heart rates, and of the respective individual changes (Δ) following 8-week period (sedentary or training), in boys aged 12 years

| Group / Variable | Free style (n = 13) Pre | Free style (n = 13) Δ | Classical style (n = 10) Pre | Classical style (n = 10) Δ |
|---|---|---|---|---|
| CSS (m/s) | 0.78 ± 0.09 | -0.02 ± 0.04 | 0.75 ± 0.08 | 0.01 ± 0.05 |
| 50 m (m/s) | 0.95 ± 0.12 | 0.03 ± 0.10 | 0.94 ± 0.12 | 0.04 ± 0.04 |
| $HR_{post}$ (bpm) | 165.9 ± 15.0 | -0.9 ± 21.5 | 139.2 ± 29.6 | 50.0 ± 36.2*** |
| 400 m (m/s) | 0.80 ± 0.09 | -0.02 ± 0.03 | 0.77 ± 0.09 | 0.01 ± 0.05 |
| $HR_{post}$ (bpm) | 168.0 ± 10.6 | 6.1 ± 18.1 | 174.6 ± 14.6 | -7.2 ± 19.1 |

* p<0.05; ** p<0.01; *** p<0.001

**Table 4**. Mean values (±SD) of distances covered in 12-min swimming tests and post-exercise heart rates, and of the respective individual changes (Δ) following an 8-week period (sedentary or training), in boys aged 12 years

| Group / Variable | Free style (n = 13) Pre | Δ | Classical style (n = 10) Pre | Δ |
|---|---|---|---|---|
| 12-min FS-Test (m) | 642.5 ± 109.0 | -32.9 ± 76.0 | 575.6 ± 71.7 | -4.1 ± 35.1 |
| $HR_{post}$ (bpm) | 168.0 ± 23.1 | -16.2 ± 26.3 | 176.0 ± 16.4 | -14.0 ± 15.2 |
| 12-min CS-Test (m) | 526.2 ± 93.3 | 4.6 ± 54.6 | 513.9 ± 62.0 | 30.8 ± 40.0 |
| $HR_{post}$ (bpm) | 156.9 ± 13.2 | -7.4 ± 15.7 | 183.4 ± 14.9 $^{\#\#}$ | -28.6 ± 23.2*** |

*** Significant increment (p<0.001); $^{\#\#}$ Significantly (p<0.01) different from the respective value in free-style group

Only few significant between-group differences were noted in the studied variables (Tables 1 – 4); boys subjected to classical style training significantly (p<0.05) improved their free-style swimming velocity at CSS and at the 400-m distance by about 6% (Table 2), and their heart rate following the 12-min test in classical style decreased by nearly 16% (p<0.001) compared with the pre-training values. Moreover, their heart rate following that latter test was significantly (p<0.01 higher pre-training than in FS group (Table 4).

## Discussion

Endurance training brings about many adaptive changes in adults reflected in an increased $\dot{V}O_2$max and in the anaerobic threshold [5]. A 10-week swimming training applied to young men increased their $\dot{V}O_2$max in swimming tests but not in treadmill tests [6]. Those effects were attributed to differences in the environmental (position, water/land environment) and cardiorespiratory conditions and to a specific adaptation to those conditions in the training process. Those reports were not fully confirmed by the presented results which showed no improvement in swimming performance of 12-year old boys subjected to 8-week training at steady swimming speed, equivalent to the critical one (CSS), in free and classical styles; yet, that 8-week training in given style did not affect swimming performance in the test in other, untrained style.

Our results are difficult to explain unequivocally. Endurance training induces increases in $\dot{V}O_2$max ranging 15 – 30% in adults [9] but in children such changes are none or do not exceed 6% [1]. Such small relative changes in children may be attributed to an inadequate training stimulus [1] or to insufficient motivation for regular training [8]. A random monitoring of heart rate during training (140 – 160 bpm) and immediately after having completed the 12-min swimming tests showed that the postulated [1] intensity of 80% of HRmax, necessary to increase aerobic capacity, had not been attained. It ought to be emphasised that the boys were voluntary, ambitious members of school sport clubs and the study was explained to them as part of between-club competition, thus a reduced motivation seemed rather unlikely. Still, the relatively short training period (8 weeks) might have been one of the factors responsible for the low improvement.

Training-induced effects are known to be expressed more strongly when the same kind of exercise (e.g. running) was applied throughout the training and to determining $\dot{V}O_2$max, compared with mixed exercises, both in adults and in children [1]. In this study, two swimming styles were applied for 8-week training due to the difference in energy expenditures – 0.79 and 1.29 kJ/m for the free and classical styles, respectively [2]. This, combined with the fact that the performance depends (physiologically and biomechanically) on the functional capacity and movement technique [5], led to the presumption that boys training classical style swimming would improve their performance. Such improvement was actually noted in boys training classical style swimming but only in the 400-m test performed in free style. The 8-week training in given swimming style did not negatively affect the performance in other style than the trained one; thus, the results seem to point to a general improvement in physical fitness and not in swimming technique. This may be of importance in competitive training.

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