Comparison of aerobic capacity in various groups of adolescent athletes

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B Data Collection
C Statistical Analysis
D Manuscript Preparation
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Abstract

Background and Study Aim: Aerobic capacity in children and youth should be stimulated by training according to the rhythm and direction of the children's biological development. The aim of this study was to determine the aerobic capacity of young trained boys.

Material/Methods: The subjects of this study were both untrained individuals as well as athletes training regularly in the following sports: judokas (n=15, mean age 14.1), soccer players (n=12, mean age 13.8), swimmers (n=12, mean age 14.2), gymnasts (n=9, mean age 13.7) and untrained (n=12, mean age 15.0), on the basis of anaerobic threshold (AT) specified as RER=1 and of $\dot{V}O_2$max.The subjects performed the test until exhaustion. Gas analyzer EOS Sprint (Jaeger) and the cycloergometer (Jaeger) were used in the study. The continuous progressive intensity protocol started at 1.5 $W \cdot kg^{-1}$ for 6 min (v=55 rpm) and increased 25 W every 1 minute until exhaustion.

Results: The highest values of $\dot{V}O_2$max (3.2 $L \cdot min^{-1}$; 59.42 $mL \cdot kg^{-1} \cdot min^{-1}$) were obtained by the swimmers, whereas the lowest (2.5 $L \cdot min^{-1}$; 49.4 $mL \cdot kg^{-1} \cdot min^{-1}$) were obtained by the gymnasts. While the swimmers obtained RER=1 at 69% of $\dot{V}O_2$max, the gymnasts' AT level was at 57% of $\dot{V}O_2$max. The differences were statistically significant ($p<0.001$).

Conclusions: The significant differences probably result from the character of conducted training in the considered disciplines.

Key words: aerobic capacity • anaerobic threshold • respiratory exchange ratio • young athletes

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Introduction

Aerobic capacity in children and youth should be stimulated by training according to the rhythm and direction of the children's biological development. However, it should be kept in mind that the pace of development of aerobic capacity during an individual's biological development is not the same. The research of Kaczor et al. [1] indicates the activities of the anaerobic enzymes (creatine kinase, adenylate kinase and lactate dehydrogenase) in children were lower than adults. According to Kraemer [2] and Perini et al. [3], 14–15 years-old boys should be subjects to more advanced youth programs in resistance exercise that add sport-specific components and emphasize skill (the proper technique) and increased volume.

Aerobic capacity – maximal capacity for oxygen consumption by the body during maximal exertion. It is also known as aerobic power, maximal oxygen intake and cardiorespiratory endurance capacity.

Anaerobic threshold (AT) – the intensity of work load or oxygen consumption in which anaerobic metabolism is accelerated.

The **anaerobic threshold (AT)**, a measure that have been introduced into the diagnostics of the amount of work in sport training is an additional indicator of the level of aerobic effort abilities, and is undoubtedly a significant source of information about the aerobic performance of an athlete. The anaerobic threshold is defined as the intensity of work load or oxygen consumption in which anaerobic metabolism is accelerated [4,5]. Training loads that approach the anaerobic threshold are considered to be the optimal ones [6]. Some authors consider that anaerobic threshold measures are very sensitive to training stimulus [7,3,8]. Alternatively, according to Rotstein et al. [9], anaerobic threshold measures are less sensitive to the training regimen than $\dot{V}O_2$max and that the 1200-m running performance is strongly associated with both aerobic and anaerobic capacities and less with AT, which in preadolescent boys seems to be higher than in adults. Study Cottin et al. [10] has shown that AT could be assessed during an incremental running test performed on a track using a simple beat-to-beat heart rate monitor, which is less expensive and complex than the classical respiratory measurement devices. Roseguini et al. [11] suggest the determination of pulse deficit (PD) provides an accurate noninvasive estimate of the LT (lactate treshold). Hebestreit et al. [12] plotted gas exchange data over $\dot{V}O_2$ which is likely to be the method of choice for determining VT (ventilatory threshold). Although minorities of children have uninterpretable X-VO, plots, VT can be reliably interpreted in the remainder. Furthermore, VT is a valid marker of aerobic capacity. Thus, VT is a useful measure of aerobic fitness in children.

Satisfactory training effects depend, in the first place, on the appropriate workload control and careful planning of how to develop a given biological characteristic of an individual in the respective period of his or her biological development. Positive effects produced by intensive physical activity are particularly easily noticed in children and youth.

Respiratory exchange ratio (RER) – ratio of carbon dioxide expired to oxygen consumed at the level of the lungs.

The first, foundational stage in the training process is of vital importance to the child's development as the level of skills and aerobic performance obtained by a child will largely affect his or her sports results in the future. Therefore, when preparing training plans one should take into account both current and anticipated states of morphologic and motor development as well as define the physical capacity markers that are most desirable in athletes in their full maturity.

The aim of this study was to determine the aerobic capacity of young judokas, soccer players, swimmers and gymnasts on the basis of anaerobic threshold (AT) specified as RER=1 and of maximal oxygen uptake ($\dot{V}O_2$max). Importantly, these sports differ in their type of work. Swimming is a cyclic sport, soccer is acyclic, and the superiority of the static work characterizes gymnastics (i.e., isometric muscle contraction). Judo training is specifically designed to improve technical abilities, strength, and speed of the movements.

Material and Methods

Subjects

The subjects of this study were both untrained individuals as well as athletes training regularly in the following sports: swimming, judo, soccer and gymnastics (see Table 1 for the subjects' characteristics). The Local Ethics Committee approved the study protocol.

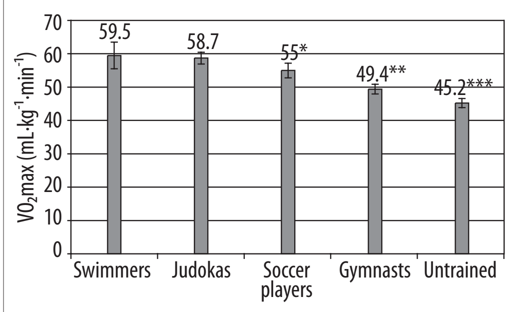

Figure 1. Maximal oxygen uptake ($\dot{V}O_2$max) in young athletes and untrained ($p<0.05$*, $p<0.01$**, $p<0.001$).

Measurement aerobic performance

The subjects performed the test until exhaustion in the Laboratory of Physical Effort and Restitution in the Department of Physiology at the Academy of Physical Education and Sports in Gdansk. Gas analyzer EOS Sprint (Jaeger) and the cycloergometer (Jaeger) were used in the study. The continuous progressive intensity protocol started at 1.5 W·kg^{-1} for 6 min (v=55 rpm) and increased 25 W every 1 minute until exhaustion. The anaerobic threshold (AT) was established with a noninvasive method [5,13] on the basis of the load measure (%$\dot{V}O_2$max) with **respiratory exchange ratio** (RER=1) in the test effort as well as maximal oxygen uptake ($\dot{V}O_2$max). An electrocardiograph was used to monitor the heart rate (HR 1·min^{-1}) during rest, submaximal and maximal work.

Statistics

All reported values are expressed as means ± standard deviations (*SD*). The one-way analysis of variance (ANOVA) was used to analyze the data (*STATISTICA 6.0* software StatSoft Inc. USA). The level of $p<0.05$ was considered to infer statistical significance of the findings.

Results

The highest values of $\dot{V}O_2$max (3.2 L·min^{-1}; 59.5 mL·kg^{-1}·min^{-1}) were obtained by the swimmers, whereas the lowest (2.5 L·min^{-1}; 49.4 mL·kg^{-1}·min^{-1}) were obtained by the gymnasts and untrained subjects (45.2 mL·kg^{-1}·min^{-1}) (Figure 1). The differences were statistically significant ($p<0.001$). Second, while the swimmers obtained AT 70% of $\dot{V}O_2$max, the gymnasts' AT was obtained at 59%, and for the untrained group at 58% of $\dot{V}O_2$max (Figure 2). The differences were statistically significant ($p<0.01$).

Finally, statistically significant differences occurred between the group of swimmers and the rest of the sub-

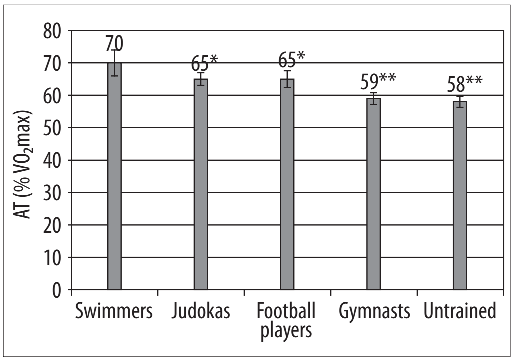

Figure 2. Anaerobic threshold (AT) in the young athletes and untrained ($p<0.05$*, $p<0.01$**).

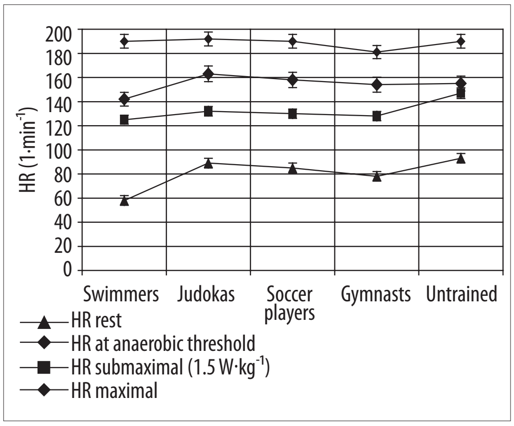

Figure 3. Heart rate (HR) in exercise tests until exhaustion of the young athletes and untrained. ($p<0.05$*).

Table 1. Characteristics of subject's (mean ±SD, n – number of subject).

Groups	n	Age (years)	Body mass (kg)	Training (years)
Untrained	12	15.0±0.5	60.1±12.9	0
Swimmers	12	14.2±1.0	55.5±12.0	6
Judokas	15	14.1±1.0	56.2±10.0	3
Soccer players	12	13.8±0.5	59.8±6.0	3
Gymnasts	10	13.7±0.5	50.6±3.0	6

jects with HR ($1·min^{-1}$) in the steady state ($p<0.05$) (Figure 3).

Discussion

Effective adaptation to specific physical work loads for athletes representing different sports is largely predetermined by characteristics of ontogenesis.

In ontogenesis, significant changes in an individual's metabolic energy processes take place. Sports training may have both positive and negative influence on the biological development of a young athlete.

In this project, we reported the values of aerobic capacity obtained from trained boys from several sports. Research by Metaxas et al. [14] and Chamari et al. [15] demonstrated greater highest values $\dot{V}O_2max$ (63.5 $mL·kg^{-1}·min^{-1}$) and $\dot{V}O_2max$ (65.3 $mL·kg^{-1}·min^{-1}$) as compared with our sample of young male soccer players (55 $mL·kg^{-1}·min^{-1}$). It has gotten similar values for our at young gymnasts $\dot{V}O_2max$. Research by Jemni et al. [16] demonstrated greater highest values $\dot{V}O_2max$ (48.6 $mL·kg^{-1}·min^{-1}$) of national male gymnasts, but highest values AT (76–82% $\dot{V}O_2max$).

The values obtained in our research are similar to the results describing metabolic efficiency of judokas as reported by Little [17] and swimmers as reported by Perini et al. [18]. It is important to note that there are differences in the accumulated amount of practice among different sports. Specifically, athletes in swimming and gymnastics start their careers earlier, often at the age of 7.

Some authors seek methods to define physical work capacity on the basis of a comparison of the anaerobic threshold (AT) of young people training regularly with those untrained [6,19,20]. Opinions concerning the best methods of measuring AT differ [21]. According to our investigation the AT measure based on workload with RER =1 (noninvasive method) works well with children as described in our sample [5,13].

According to Kemper et al. [20], at the stage of pubertal growth spurt in boys a slowdown in the development of their aerobic performance may happen. Consequently, swimmers' high level of AT and aerobic capacity may be attributed to the specific character of their sports training. Swimming (excluding the 50 m races) is a sport in which aerobic processes are the main source of energy for muscles. The lowest AT results in the group of young gymnasts are undoubtedly connected with their specific metabolic processes and adaptations involved in training. In gymnastics, the static efforts with isometric contractions predominate which does not facilitate the development of aerobic performance. Higher values obtained by soccer players reflect their proper development and adequate management of training loads that reflect well the biological characteristics of this age group. The young judokas obtained surprisingly high AT values, which might result from the fact that they were not required to make excessively intense efforts; thus, more specific to the competitive demands in this sport. Sport-specific intensities in judo require high anaerobic energy potential in releasing energy for muscles' work [22]. Taking into account the maximal oxygen uptake and AT, it might be said that young judokas show good base for the increased specialized training loads in their full maturity.

Conclusions

Respiratory exchange ratio enables to differentiate young male athletes with respect to aerobic performance. The significant group differences probably resulted from the character of completed training in the respective sports.

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