EVALUATION OF SPIROMETRIC PARAMETERS AND MAXIMUM OXYGEN CONSUMPTION IN ATHLETES AND NON-ATHLETES

ANALIZA RESPIRATORNIH PARAMETARA I MAKSIMALNE POTROŠNJE KISEONIKA KOD SPORTISTA I OSOBA KOJE SE NE BAVE SPORTOM („NESPORTISTA“)

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Summary
Introduction. There is a great interest to identify factors that influence the value of maximum oxygen consumption. The goal of this research was to assess the body composition, pulmonary parameters, and maximum oxygen consumption in different types of sports and in non-athletes. Material and Methods. The research included 149 male participants: aerobic athletes (n = 55), anaerobic athletes (n = 53) and non-athletes (n = 41). The participants were tested at the Department of Physiology, Faculty of Medicine of the University of Novi Sad. Anthropometric parameters and body mass index were measured. Also, the body fat mass was determined by bioelectrical impedance. Pulmonary parameters by spirometry and maximum oxygen consumption on a bicycle ergometer. Results. The body mass index values in non-athletes were the highest and significantly different compared to the aerobic athletes (p < 0.001). Non-athletes had significantly higher values of body fat mass compared to athletes (p < 0.001). The pulmonary parameters were not significantly different between the tested groups (p > 0.05). The values of maximum oxygen consumption were significantly different between all three tested groups (aerobic athletes 53.75 ± 7.82 ml/kg/min; anaerobic athletes 48.04 ± 6.79 ml/kg/min; non-athletes 41.95 ± 8.53 ml/kg/min) (p < 0.001). A low degree of correlation was found between maximum oxygen consumption and pulmonary parameters in the tested groups. Conclusion. Body composition has an impact on the pulmonary parameters. The values of maximum oxygen consumption depend on the type of sport and training. The highest values are in aerobic sports. There is a low degree of correlation between maximum oxygen consumption and pulmonary parameters in the tested groups.

Key words: Spirometry; Oxygen Consumption; Athletes; Body Composition; Body Mass Index; Sports; Anaerobic Threshold; Respiratory Function Tests

Original study
Originalni naučni rad
UDK 612.21:796 i 572.51.087
https://doi.org/10.2298/MPNS1806157R

Sažetak
Uvod. Postoji velika zainteresovanost za identifikovanje faktora koji utiču na vrednost maksimalne potrošnje kiseonika. Cilj rada bio je procena telesnog sastava, respiratornih parametara i maksimalne potrošnje kiseonika kod osoba koji se bave različitim sportovima i osoba koje se ne bave sportom („nesportisti“). Materijal i metode. Istraživanje je obuhvatilo 149 ispitanika muškog pola: aerobni sportovi (n = 55), anaerobni sportovi (n = 53) i „nesportisti“ (n = 41). Testiranje je sprovedeno na Zavodu za fiziologiju Medicinskog fakulteta Univerziteta u Novom Sadu. Izmereni su: antropometrijski parametri i izračunat je indeks telesne mase. Procent masne mase je određen bioelektričnom impedancijom, respiratorni parametri pomoću spirometra, dok je vrednost maksimalne potrošnje kiseonika merena na bicikl-ergometru. Rezultati. Najviše vrednosti indeksa telesne mase imale su osobe u grupi „nesportista“ i u poredanju sa osobama iz grupe aerobnih sportova statistički se značajno razlikuju (p = 0,01). „Nesportisti“ su imali statistički značajno više vrednosti procenta telesnih muskih u odnosu na sportiste (p < 0,001). U sve tri grupe ispitanika nije dobijeno postojanje statistički značajne razlike (p > 0,05) u vrednostima respiratornih parametara. Međutim u pogledu vrednosti maksimalne potrošnje kiseonika između sve tri posmatrane grupe postoji samostalno, (napredna grupa 53,75 ± 7,82 ml/kg/min; anaerobna grupa 48,04 ± 6,79 ml/kg/min; „nesportisti“ 41,95 ± 8,53 ml/kg/min) (p < 0,001). U sve tri grupe zabeležen je nizak stepen koeficijenta korelacije između vrednosti maksimalne potrošnje kiseonika i respiratornih parametara. Zaključak. Telesna konstitucija ima uticaj na parametre plućne funkcije. Vrednost maksimalne potrošnje kiseonika zavisi od vrste sporta i tipa treningu i najviša je kod osoba koje se bave aerobnim sportovima. Postoji nizak stepen koeficijenta korelacije između vrednosti maksimalne potrošnje kiseonika i respiratornih parametara plućne funkcije unutar svih grupa.

Ključne reči: spirometrija; potrošnja kiseonika; sportisti; telesna kompozicija; indeks telesne mase; sport; anaerobni prag; testovi respiratorne funkcije
**Introduction**

Morphological characteristics and functional abilities change due to physical activity, as a result of adaptation of the body to different training and competition requirements, and depend on the type of sports activity [1]. Aerobic capacity is an integral indicator of functional capacities of all systems involved in supplying, transportation and energetic oxygen transformation (cardio-respiratory and functional ability of muscles to create adenosine triphosphate (ATP) in the presence of oxygen) [2]. Maximum oxygen consumption (VO\(_2\)max) is the best indicator of aerobic capacity of an organism [3, 4]. Considering the usage of VO\(_2\)max in diagnostic and therapeutic purposes there is a great interest to identify factors that affect the degree of physical competence [5, 6]. Physiological factors that could limit the VO\(_2\)max are respiratory diffusion capacity, maximal minute heart volume, oxygen transport capacity of the blood, and skeletal muscles properties [7, 8].

The goal of this study was to evaluate the body composition, respiratory parameters and values of VO\(_2\)max in athletes and non-athletes, in various types of sports, as well as to evaluate the degree of correlation between values of VO\(_2\) max and parameters of respiratory function.

**Material and Methods**

This research included 149 male subjects who were divided into three groups: aerobic sports group (n = 55), anaerobic sports group (n = 53) and non-athletes (n = 41). The tests were conducted at the Department of Physiology, Faculty of Medicine of the University of Novi Sad. All participants were informed about the procedures, the purpose of the examination and the confidentiality of personal data and signed a written consent to participate in the research. The approval of the Ethics Committee of the Faculty of Medicine University of Novi Sad was obtained for conducting this research.

A clinical examination was performed and anthropometric parameters, body fat percentage, respiratory parameters, and VO\(_2\)max were measured. Body weight (BW) was measured with a medical balance decimal beam scale (accuracy 0.1 kg), body height (BH) using anthropometer according to Martin’s technique with a precision of 0.5 cm, and body mass index (BMI) was calculated. Bioelectrical impedance, (OMRON BF300) was used for body composition analysis.

Parameters of the respiratory function: forced expiratory volume in the first second (FEV\(_1\)), forced vital capacity (FVC) and percentage of the forced vital capacity – Tiffeneau index (FEV\(_1\)%), were measured by spirometry (MIR SpiroLab Enraf Nonius Holland).

Measurement of the VO\(_2\)max (ml/kg/min) was carried out by FITmate Pro device. In the first 2 minutes, respondents were pedaling a bike ergometer (Ergoselect 100 Cosmed, Ergoline GmbH, Germany) without any resistance, which was progressively increased by 25 W per minute thereafter. During the whole test subjects were supposed to maintain the cadence of 60 revolutions per minute (RPM). The heart rate was continuously monitored during the whole test by pulse meter.

The results were processed using the Jeffrey’s Amazing Statistical Program (JASP) 0.8.0.1. The arithmetic mean (X), standard deviation (SD), single-factor analysis of variance (ANOVA) and Pearson correlation coefficient (r) were used in this study.

**Results**

Average values of BW, BH, BMI, age, and sport experience of all participants are presented in Table 1. We noticed that there was a significant difference in terms of BW and BH between the groups of aerobic and anaerobic athletes (p = 0.03) and in terms of BW between non-athletes and aerobic athletes (p = 0.001). Values of BMI significantly differed between non-athletes and aerobic athletes (p = 0.01). A significant difference was observed comparing the percentage of body fat mass in aerobic and anaerobic athletes with the group of non-athletes (p < 0.001). Average values of spirometric parameters are shown in Table 2. The values of FVC, FEV\(_1\) and FEV\(_1\)% in all three groups were not significantly different (p > 0.05).

Analyzing the values of VO\(_2\) max significant difference (p < 0.01) between tested groups was found (Graph 1).

Examining the relation between VO\(_2\) max and FVC, FEV\(_1\) and FEV\(_1\)% in tested groups a low degree of correlation was determined.

**Discussion**

This research shows that the values of BW and BH in the anaerobic compared to aerobic athletes are statistically significantly high. Aerobic sports are characterized by activities where the endurance is dominant, while in anaerobic sports development of explosive strength is emphasized. This can explain the observed difference [9]. In non-athletes with a sedentary lifestyle, changes in body composition are unavoidable. In our study, non-athletes were statistically significantly heavier with higher values of BMI compared to the aerobic athletes. When it comes to body fat mass, non-athletes had significantly higher values of body fat mass than athletes, while the difference between aerobic and anaerobic athletes was not observed. Previous studies have shown that physical activity contributes to a reduction of body fat.

**Abbreviations**

- ATP – adenosine triphosphate
- VO\(_2\)max – maximum oxygen consumption
- BW – body weight
- BH – body height
- BMI – body mass index
- FEV\(_1\) – forced expiratory volume in the first second
- FVC – forced vital capacity
- FEV\(_1\)% – percentage of the forced vital capacity
mass. The lowest values of body fat mass were recorded in aerobic sports (triathlon, marathon, cross-country skiing, cycling) [10–12].

It is known that parameters of the respiratory function vary depending on the age, height, weight, gender and ethnicity [13]. The parameters of the respiratory system were not significantly different in physically active individuals compared to the sedentary population as it was reported in earlier study [14]. However, according to recent literature, the respiratory volumes can vary considerably depending on the type, intensity, duration and frequency of sports activities [15, 16]. Durmić et al, showed that the type of sport has a significant impact on the adaptation of the respiratory system [17]. Athletes who are engaged in sports where the endurance is dominant (rowing and canoeing, swimming, long-distance running and marathon, cycling, triathlon) have higher values of respiratory functions compared to athletes who train sports where the development of explosive strength is most important [18]. Our results did not show a statistically significant difference in the values of respiratory parameters between athletes and non-athletes, as well as between different types of sports, compared to previous studies. These results can be explained by the difference in body composition of the participants.

Regular physical activity increases the values of VO\textsubscript{2}max which is the main indicator of the fitness level [19, 20]. According to the literature data, the value of VO\textsubscript{2}max can be increased by 20–30% during 8–10 weeks of training and even by 40–50% during the

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**Table 1. Anthropometric parameters and percentage of body fat mass**

<table>
<thead>
<tr>
<th>Parameters/Parametri</th>
<th>Body weight/(kg)/Telesna težina (kg)</th>
<th>Body height/(cm)/Telesna visina (cm)</th>
<th>Body mass index/(kg/m\textsuperscript{2})/Indeks tel-esne mase (kg/m\textsuperscript{2})</th>
<th>Body fat/ (%)/Telesna mast (%)</th>
<th>Age (years)/Starost (godine)</th>
<th>Sport experience/(years)/Sportsko iskustvo (god)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aerobic sports/Aerobni sportovi X±SD</td>
<td>74.77±8.89</td>
<td>178±0.06</td>
<td>23.40±2.39</td>
<td>11.11±4.66</td>
<td>21.98±5.65</td>
<td>8.09±4.84</td>
</tr>
<tr>
<td>Anaerobic sports/Anaerobni sportovi X±SD</td>
<td>79.80±11.87†</td>
<td>182±0.06†</td>
<td>24.14±2.96</td>
<td>11.08±3.93</td>
<td>20.94±2.53</td>
<td>7.25±4.02</td>
</tr>
<tr>
<td>Non-athletes/Nesportisti X±SD</td>
<td>82.6±10.78*</td>
<td>181±0.06</td>
<td>25.05±2.69*</td>
<td>14.78±5.39†‡</td>
<td>21.19±1.72</td>
<td>/</td>
</tr>
</tbody>
</table>

Legend:† p < 0.05 between aerobic and anaerobic sports;* p < 0.05 between non-athletes and aerobic sports; ‡ p < 0.05 between non-athletes and anaerobic sports

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**Graph 1. Maximum oxygen consumption in all three groups**

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**Table 2. Average values and standard deviation of spirometric parameters in investigated groups**

<table>
<thead>
<tr>
<th>Parameters/Parametri</th>
<th>Aerobic sports/Aerobni sportovi</th>
<th>Anaerobic sports/Anaerobni sportovi</th>
<th>Non-athletes/Nesportisti</th>
</tr>
</thead>
<tbody>
<tr>
<td>FVC (L)/X±SD</td>
<td>5.10±0.64</td>
<td>5.16±0.76</td>
<td>5.39±0.71</td>
</tr>
<tr>
<td>FEV1 (L)/X±SD</td>
<td>4.76±0.54</td>
<td>4.83±0.56</td>
<td>5.03±0.64</td>
</tr>
<tr>
<td>FEV1% /X±SD</td>
<td>93.41±5.33</td>
<td>94.19±6.12</td>
<td>93.54±6.17</td>
</tr>
</tbody>
</table>

Legend: FVC - forced vital capacity. FEV1% - percentage of the forced vital capacity (Tiffeneau index)

**Legenda: FEV1 - forsirani eksspiratorni volumen u prvoj sekundi, FVC - forsirani vitalni kapacitet i FEV1% - Tifnoov indeks**
period of 1–4 years of intense physical activity [21–23]. Our results showed significantly lower values of VO_{2,max} in non-athletes compared to athletes engaged in different types of sports. Intensive physical activity causes expansion of the heart chambers and muscle hypertrophy and increases the density of the capillary network and the number of mitochondria which leads to an increase of VO_{2,max} [24]. Numerous studies showed that values of VO_{2,max} are significantly lower in the group of non-athletes compared to the aerobic and anaerobic athletes, which is in agreement with our results [25–31].

Analyzing the values of VO_{2,max} in this study, we found that participants from the aerobic sports group have significantly higher values compared to the anaerobic group. Ranković et al. also proved that the values of VO_{2,max} were significantly higher in aerobic sports (football players 51.70 ml/kg/min) compared to the anaerobic sports (volleyball players 45.40 ml/kg/min) [25]. Other authors reported that rowers achieved the best results of VO_{2,max} (55.8 ml/kg/min) compared to football players (53.6 ml/kg/min) and judo athletes (47.2 ml/kg/min), because it is a sport that requires high aerobic capacity. The lowest values of VO_{2,max} were found in judo athletes, which can be attributed to the anaerobic character of this sport [26]. Lazović-Popović et al., showed that football players have significantly higher VO_{2,max} values (57.1 ml/kg/min) compared to karate players (48.98 ml/kg/min) [27]. Other researchers showed that handball players (51.90 ml/kg/min) achieved significantly higher values of VO_{2,max} compared to volleyball players (45.50 ml/kg/min) [28].

In this research, there is also a very low degree of correlation between the value of VO_{2,max} and the parameters of the respiratory function in all tested groups. The same results were presented in previously conducted researches [27, 32]. MacAuley reported that there was a significant correlation between the respiratory function and physical activity, however, the relation between respiratory parameters and physical fitness has not been established. Our study included testing in the maximum load area, unlike other researches, which included testing in the mid-load zone. Previously, it was considered that there was a possibility that the degree of load may affect the respiratory function, and that the mid-load zone was not sufficient to push the respiratory function to the limits where it was a limiting factor in assessing physical capacity. However, our results showed that the degree of load was not a limiting factor. A low degree of correlation between VO_{2,max} and respiratory parameters can be explained by the fact that the cardiovascular system actually limits VO_{2,max} much more than the respiratory system [33, 34].

**Conclusion**

Considering values of the respiratory parameters, there was no significant difference between the tested groups. The value of maximum oxygen consumption in non-athletes was significantly lower compared to both groups of athletes. Subjects in the aerobic group had significantly higher values of maximum oxygen consumption compared to the anaerobic group. A low correlation between maximum oxygen consumption and respiratory parameters was observed in the tested groups.

**Literatura**


Rad je primljen 5. II 2018.
Recenziran 22. II 2018.
Prihvaćen za štampu 2. III 2018.