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THE INFLUENCE OF THE TYPE OF TRAINING ON ANTHROPOMETRIC AND FUNCTIONAL CHARACTERISTICS IN THE POPULATION OF COMPETITIVE ATHLETES

Abstract: Introduction: The basic measurement of aerobic capability of an organism is the quantity of oxygen uptake (VO_2 ml/min/kg). Aerobic power or the maximum aerobic capacity is determined by the maximum value of oxygen uptake (VO_2 max).

Aim: The aim of this study was to compare the maximal oxygen uptake between two groups of athletes involved with different training regimes. .

Materials and Methods: There were 204 top male athletes from a variety of disciplines participating in our research, aged between 18 and 35. The participants were divided into two groups corresponding to the characteristics of their training: skill sports group (n = 86) and endurance sports group (n = 118).

Results: Subjects in the group of skills sports were significantly older than those in the endurance sport group (25 ± 5, 23 ± 4, respectively; $p < 0.05$). The body height values were significantly higher in the endurance sports group compared to skills sports (185.54 ± 7.24, 183.41 ± 7.79, respectively; $p < 0.05$). Body weight values did not significantly differ among groups. The body mass index was statistically significantly lower in the endurance sports group when compared to the skill sports group (23,32 ± 1,88 kg/m^2 and 24,80 ± 3,37 kg/$m^{2,}$ respectively; $p < 0,001$). Testing showed that the body fat percentage statistically significantly higher for the skill sports group when compared to the endurance sports group (13,52 ± 6,45% and 8,39 ± 3,62%, respectively; $p < 0,001$). The participants part of the skill sports group had a statistically significantly lower oxygen consumption at rest when compare to the endurance sports group (5,87 ± 1,20 ml/min/kg and 6,54 ± 1,26 ml/min/kg, respectively; $p < 0.05$). Within the endurance sports group a statistically significantly higher maximum oxygen consumption when compared to the skill sports group (55,35 ± 8,44 ml/min and 45,50 ± 7,49 ml/min respectively; $p < 0,001$).

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Conclusion: The results of our study pointed to the existence of a significant difference in the anthropometric and functional characteristics between the two examined groups of athletes who are in different training regimes. Higher values of maximum oxygen consumption in a group of athletes involved in endurance sport points to a better physical fitness in comparison with the group of skills sports.

Key words: maximum oxygen uptake, endurance sports, skill sports, anthropometry

Introduction

Each type of exercise is different and has its own specific requirements. What is common to all of them is that every physical activity leads to an increase in energy demands, which are manifested by increased oxygen consumption. (1) The best and generally accepted indicator of physical fitness is aerobic ability of the body. The basic measure of the aerobic ability is the amount of oxygen consumed (VO_2 ml / min / kg). Aerobic power or maximum aerobic capacity is determined by the maximum value of oxygen consumption (VO_2 max). (2) The maximal oxygen consumption is generally accepted as the best measure of the functional ability of the cardiovascular system and is most often interpreted as an index of maximal capacity of the cardiorespiratory system, since with the further increase in the intensity of physical effort, the consumption of oxygen cannot be increased. (3)

For many years, maximal oxygen consumption has been studied as the main physiological parameter for athletes engaged in endurance sports. (4-7) Athletes engaged in endurance sports have higher VO_2 max values primarily due to higher cardiac output, as the consequence of higher volume of cardiac chambers and thus achieve higher minute cardiac output. (1, 5, 7)

It is important that athletes dealing with endurance sports have the appropriate anthropometric and physiological characteristics needed to achieve top results. (8) Certain studies have proven that anthropometric characteristics are directly related to better competitive success. The results of these studies have shown that marathons have low body weight and fat percentage, which as a specific anthropometric characteristic contributes to better results. (9, 10)

In addition to the specific anthropometric characteristics for achieving good competitive results, the functional characteristics of athletes that are determined by the type of training are also important. For the purpose of evaluating and describing the different training characteristics, for many years the classification of sports by Michel was used, according to which the sports are classified into 9 groups, based on different representation of the static and dynamic components of sports. (11) In recent years, the classification of Casseli has become more and more popular in the professional public. According to this classification, sports are divided into four groups: skills sports, power sports, mixed sports and endurance sports, depending on the prevailing type of training (primary technical activities, primary isometric activity, combination of isometric and isotonic activities and primary isotonic activity). (12)

The aim of our study was to examine and compare the anthropometric and functional physiological characteristics between a group of athletes engaged in enduarne sports and a group of athletes engaged in skills sports.

Material and Methods

The research involved 204 competitive athletes engaged in various sports disciplines, male, aged between 18 and 35 years. All subjects were classified into 2 groups, in accordance with the prevailing training characteristics (classification of sports by Casselli) (11):

1. Skill sports – primary technical activities (n = 86) – artistic gymnastics, karate, taekwondo, sailing, golf, table tennis;
2. Endurance sports – primary isotonic activities (n = 118) – rowing, kayaking, long distance running and marathon, swimming, biking, triathlon.

All subjects were informed in detail about the protocol of our research and have signed the written consent to participate in it.

The criteria for participation in the research were: male sex, ages 18 to 35 years, professionally engaged in sport for at least 5 years, and at least 10 hours of training per week and participation during the current season in competitions of national or international importance.

The criteria for excluding subjects from the study were: diagnosed with cardiovascular disease, smoking and inability to perform the cardiopulmonary exercise test.

Testing procedure began by filling out a standardized sports medicine questionnaire that maintains questions related to personal, family and system medical history.

All subjects proceed to anthropometric testing, a physical examination during which an electrocardiogram (ECG) was performed. Body height (BH), expressed in centimeters, was determined using a standard laboratory height meter (*Seca 214 Portable Stadiometer, Cardinal Health, USA*). Body mass (BM), expressed in kilograms, as well as the percentage of body fat (BF%), were measured using the body composition analyzer by the bioimpedance method (*InBody 230 Body Composition Analyzer*, *Seoul, Korea*). Using the measured values of TV and TM, a body mass index (BMI) is determined using the formula: $BMI=TM(kg)/(TV(m)^2)$.

After physical examination, all subjects started performing the maximal cardiopulmonary exercise test (ergo spirometry). Testing was performed the same morning in controlled, laboratory conditions: comfort temperature (18-22 °C) and relative humidity of 30-60%. These parameters are continuously monitored during entire testing.

The maximal cardiopulmonary exercise test consisted of 3 phases: the resting phase (the subjects stand still for 3 minutes), the testing phase and the recovery phase (at first, the active phase during which the subjects walk at a speed of 4 km/h for 1 minute and then continues with the passive phase recovery in sitting position for 2 minutes). The gas exchange analysis was performed using the breath by breath method (*The Oxycon Mobile OM, Jäger, Würzburg, Germany*), with continuous monitoring of twelve-channel ECG. Heart rate was determined using ECG records.

The maximal cardiopulmonary exercise test was completed by reaching at least 2 of the 4 criteria:

1. Making a plateau in maximal oxygen consumption (VO_2 max) despite the increase in load (oxygen consumption did not increase despite the increase in load)
2. Attaining the respiratory exchange ratio (RER) ≥ 1.10;
3. Reaching the heart rate within 10 beats less than the predicted maximal heart rate (HRmax), determined according to the formula HRmax = 220 – the number of years of subjects;
4. Occurrence of psychophysical fatigue or subjective interruption of the testing phase by subject himself.

All data are presented using standard descriptive statistics and presented as an arithmetic mean ± standard deviation. To evaluate the significance of the difference between measured variables Student's T test was used. All statistical analyzes were performed using Statistic package for social sciences 22 (SPSS22) program.

Results

Table 1 shows the basic anthropometric and demographic characteristics of the subjects by groups. Subjects engaged in skill sports were significantly older compared to a group of endurance sports (25 ± 5 years and 23 ± 4 years respectively, $p < 0.05$). Athletes involved in endurance sports had a significantly higher body height compared to a group of skill sports (185.54 ± 7.24 cm and 183.41 ± 7.49 cm respectively; $p < 0.05$). Body weight values did not significantly differ between groups of subjects. The body mass index was significantly lower in the endurance sport group compared to a group of skill sports (23.32 ± 1.88 kg/m^2 and 24.80 ± 3.37 kg/m^2 respectively, $p < 0.001$). Testing showed that the percentage of body fat was significantly higher in the sports skills category compared to a group of endurance sports (13.52 ± 6.45% and 8.39 ± 3.62% respectively; $p < 0.001$). A group of endurance sports had a high statistically significantly higher percentage of muscle mass compared to a group of sports skills (53.11 ± 2.05% and 49.48 ± 3.88% respectively; $p < 0.001$).

Table 2 shows the functional characteristics of the examinees by groups. Heart rate in peacetime was highly statistically significantly higher in the sporting skill group compared to a group of endurance sports (64 ± 9 min-1 and 58 ± 12 min-1, respectively; $p < 0.001$). Members of the Sports Skills Team had statistically significantly lower oxygen consumption in peace compared to a group of endurance sports (5.87 ± 1.20 ml / min / kg and 6.54 ± 1.26 ml / min / kg, respectively; $p < 0.05$). There was no statistically significant difference in the maximum heart rate values between the test groups. Within a group of endurance sports, a statistically significant increase in the maximum oxygen consumption in relation to the group of sports skills was determined (55.35 ± 8.44 ml / min / kg and 45.50 ± 7.49 ml / min / kg respectively, $p < 0.001$). Heart rate recovery in the first minute after the load test was statistically significantly higher in the sporting endurance group compared to a group of sports skills (31 ± 14 min-1 and 25 ± 11min-1 respectively; $p < 0.001$).

Discussion

In the population of young athletes competing we can count all adult athletes aged up to 35 years (13). Our study included competitive athletes dealing with sports skills and endurance sports. Different characteristics of the training that the respondents exercise (sports skills – primary technical characteristics with low dynamic and low static component and endurance sports – high dynamic component) condition the emergence of significant differences in anthropometric and functional characteristics indicated by the results of various scientific studies. (12, 14, 15)

With this study we found that there are differences in the values of maximum oxygen consumption, as well as differences in heart rate values as well as differences in anthropometric characteristics between two groups of athletes. It has been shown that members of the endurance sports group have significantly higher maximum oxygen consumption compared to the group of examinees who deal with sports skills. In support of our results are the results obtained in their study by Montero et al. pointing to the existence of high values of maximum oxygen consumption in the population of athletes who are dealing with durability sports, primarily due to the adaptation of the hematopoietic system to the continuous participation in endurance sports. (5) In addition to our results, the fact is that the athletes who deal with endurance sports have a larger volume of the left ventricle, and therefore both the stroke and the minute cardiac volume, which leads to better vascularization of muscle tissue and its oxygen supply, to what also indicate the results of the Hoffman study. (16) The results can be explained by the fact that sporting endurance features a very high dynamic exercise component as well as engagement of large groups of muscles, which together leads to high oxygen consumption during a physical activity session. (11)

Similar to our study, Ersan et al. she examined the values of maximum oxygen consumption within a group of athletes who deal with endurance sports (triathlon and cycling). (17) The results of this study confirmed the values of the maximum oxygen consumption that we received during our research.

The results of our study have shown that athletes dealing with sports skills have a statistically negligible increase in maximum oxygen consumption compared to the average untreated healthy male population, which is in line with the results present in educational literature. (18) The results obtained can be explained by the fact that sports skills characterized by a low dynamic component of training, and therefore, there is no development of adaptation mechanisms that would result in increased oxygen consumption. (11, 12)

In contrast to maximum oxygen consumption, anthropometric characteristics such as body mass index (BMI) and body fat percentage (% BF) were statistically significantly lower within a group of athletes who deal with endurance sports. The obtained results can be explained by the low representation of the static and high representation of the dynamic component of the training. (11) Dynamic type of exercise causes changes in the length of muscles due to prolonged, repeated rhythmic contractions that develop very low force and do not lead to a significant increase in muscle mass that would also result in an increase in the body mass index. On the other hand, a dynamic type of training conditions a large metabolic consumption, which can explain the low value of the percentage of fat. (11, 17)

When looking at the values of heart failure recovery, we can notice the existence of a significant difference in the recovery of heart rate between the observed groups. The results of our study are confirmed by the results of numerous experimental studies, pointing to the emergence of the high component of the parasympathetic tonus conditioned by long-term training with a high dynamic component, characterized by endurance sports (19, 20, 21, 22)

Conclusion

The results of our study have indicated that there are significant differences in anthropometric and functional characteristics between a group of athletes participating in skills sports and a group of athletes dealing with endurance sports. Higher values of maximum oxygen consumption in a group of athletes dealing with endurance sports unquestionably indicate better physical fitness and fitness compared to respondents who deal with sports skills, although both groups can be included in the competitive athletes population.

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APPENDIX 1

Table 1. Demographic and anthropometric characteristics of the examined competitive athletes

Variables	**Skill sports (n = 86)**	**Endurance sports (n = 118)**	**p**
Age	25 ± 5	23 ± 4	**0.005***
BH (cm)	183.41 ± 7.49	185.54 ± 7.24	**0.042***
BW (kg)	83.53 ± 14.28	80.35 ± 9.52	0.075
BMI (kg/m^2)	24.80 ± 3.37	23.32 ± 1.88	**<0.001****
%BF	13.52 ± 6.45	8.39 ± 3.62	<0.001**
% Muscles	49.48 ± 3.88	53.11 ± 2.05	<0.001**

The variables are represented as X ± SD; BH – body height; BM – body mass; BMI – Body Mass Index; % BF – percentage of body fat; Student T test * $p < 0.05$; ** $p < 0.001$

APPENDIX 2

Table 2. Functional parameters in the examined population of competitive athletes

Variables	Skill sports (n = 86)	Endurance sports (n = 118)	p
HRRest (min^{-1})	64 ± 9	58 ± 12	**<0,001****
VO_2 rest (ml/min)	5,87 ± 1,20	6,54 ± 1,26	**0,004***
HR max (min^{-1})	185 ± 10	186 ± 10	0,622
VO_2 max (ml/min)	45,50 ± 7,49	55,35 ± 8,44	**<0,001****
HRR1 (min^{-1})	25 ± 11	31 ± 14	**<0,001****

The variables are represented as X ± SD; HR rest – heart rate at rest; VO2 rest – consumption of oxygen in idle state; HR max – maximal heart rate; VO2 max – maximum oxygen consumption; HRR1 – recovery of heart rate in the first minute after the load test; Student T test * $p < 0.05$; ** $p < 0.001$