Differences in the bioenergetic potential of athletes participating in team sports

Razlike u aerobnom bioenergetskom potencijalu sportista u timskim sportovima

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Abstract

Background/Aim. In modern training technology, assessment of aerobic bioenergetic potential in athletes is commonly performed by standard laboratory procedures to determine basic or specific functional abilities for specific sport activity or discipline. The aim of study was to assess the aerobic bioenergetic potential of athletes participating in basketball, football and handball. Methods. The study included 87 athletes (29 basketball players, 29 football players, and 29 handball players) aged 21–24. Evaluation of the aerobic bioenergetic potential of athletes participating in basketball, football and handball was performed followed by both univariate (ANOVA) and multivariate (MANOVA) statistical methods to determine differences among the athletes in relative (VO2 mL/kg/min) and absolute oxygen consumption (VO2 L/min). Results. Statistically significant differences between absolute and relative oxygen consumption were found in basketball players (Mb), football players (Mf), and handball players (Mh) (MANOVA, p = 0.00). ANOVA also revealed significant differences in relative oxygen consumption (VO2 mL/kg/min) (p = 0.00). The football players (55.32 mL/kg/min) had the highest relative oxygen consumption, followed by the handball players (51.84 mL/kg/min) and basketball players (47.00 mL/kg/min). The highest absolute oxygen consumption was recorded in the basketball players (4.47 L/min), followed by the handball players (4.40 L/min) and footballers (4.16 L/min). Conclusion. Statistically significant differences in the aerobic bioenergetic potential, expressed by the relative oxygen consumption, were found among athletes participating in different team sports. It can be assumed that the player from the sports in which it is necessary to cross greater distance in total during the match have a greater need for aerobic capacity.

Key words: athletes; football; basketball; oxygen consumption.

Apstrakt

Uvod/Cilj. Kod savremenih načina vežbanja vrši se procena aerobnih bioenergetskih mogućnosti sportista obično primenom standardnih laboratorijskih postupaka, sa ciljem da se utvrde ili osnovne ili specifične funkcionalne sposobnosti za određenu sportsku aktivnost ili disciplinu. Cilj istraživanja bio je da se izvrši procena aerobnog bioenergetskog potencijala sportista u košarci, fudbalu i rukometu. Metode. Istraživanje je bilo obuhvaćeno 87 sportista (29 košarkaša, 29 fudbalera i 29 rukometaca), starosti od 21–24 godine. Izvršena je procena aerobnog bioenergetskog potencijala sportista u košarci, fudbalu i rukometu, a zatim je primenom metode multivariantne i univariantne analize varijanse (MANOVA/ANOVA) ispitana značajnost razlika u relativnoj (VO2 mL/kg/min) i apsolutnoj (VO2 L/min) potrošnji kiseonika. Rezultati. Multivariantna statistička značajnost razlika između aritmetičkih sredina apsolutne i relativne potrošnje kiseonika kod košarkaša (Mk), fudbalera (Mf) i rukometaca (Mr) dobijena je na nivou p = 0,00, dok je univariantnom analizom varijanse statistička značajnost razlika postojala samo u varijabli relativne potrošnje kiseonika (VO2 mL/kg/min), takođe, na nivou p = 0,00. Najviše vrednosti relativne potrošnje kiseonika (VO2 mL/kg/min) dobijena je na nivou p = 0,00. Završni pokreti kod košarkaša (4,47 L/min), fudbalera (4,40 L/min) i rukometaca (4,16 L/min) zatim pokazali su da su u timskim sportovima najveće značajnosti u košarkašima (4,47 L/min), a zatim u fudbalera (4,40 L/min) i rukometaca (4,16 L/min). Zaključak. Dobijene su statistički značajne razlike u aerobnim bioenergetskim potencijalima izraženim u relativnoj potrošnji kiseonika kod ćelinske u različitim timskim sportovima. Rezultati sugerišu da sportisti koji tokom utakmice moraju preći ukupno veću razdaljinu imaju veće potrebe za aerobnim kapacitetom.

Key words: sportisti; fudbal; košarka; kiseonik, potrošnja.

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Introduction

In modern training technology, assessment of aerobic bioenergetic potential in athletes is commonly performed by standard laboratory procedures, to determine basic or specific functional abilities for specific sport activity or discipline. For this purpose, one may use protocols with sustained or unchanging workload, progressive workload to exhaustion, as well as submaximal, maximal and supramaximal workloads. In sports of the aerobic and aerobic-anaerobic type, it is essential to express the actual bioenergetic potential with oxygen consumption, which is an indicator of the aerobic bioenergetic potential or capacity. The upper threshold of the body’s ability to consume oxygen is represented by the maximal oxygen consumption, a net sum of physiological functions of the aerobic bioenergetic systems involving the lungs, the heart, blood, and working muscles.

The amount of oxygen that can be distributed to the working muscle and be utilized there is limited, and it can be estimated by a special equipment measuring the volume of the inhaled vs exhaled oxygen. The difference between the two volumes represents the amount of oxygen that has been used by the muscle, in the literature called maximal oxygen consumption (VO2 L/min). It is normally expressed in liters per minute (absolute) as opposed to relative oxygen consumption (VO2 mL/kg/min) calculated as absolute oxygen consumption in one minute per unit of body mass. This greatest volume of oxygen utilized by the body in a single minute, is essentially an indicator of the greatest amount of energy generated for physical work by all the aerobic metabolic processes.

The values of maximal oxygen consumption was expressed in absolute and relative units is critical for successful performance in all sustained activities lasting over 2–3 minutes.

Team sport complexity is reflected in their structural, energy and neuro-muscular components. More specifically, a football player must be able to sprint, jump, change direction, be involved in physical contacts, and accurately passes the ball to a teammate or kicks it into the net. A basketball player must play aggressive defence, rebound, run a fast-break and shoot in the basket. A handball player, often in physically demanding, even rough playing conditions, has to be able to penetrate with the ball, shoot at the net from various out-of-balance positions, and eventually return to defence as quickly as possible. These kinds of motor structures would not be so demanding for an athlete, were they not performed in long-lasting, sustained fashion for at least an hour or more (during a whole game) and in mostly aerobic conditions. Accordingly, team sports consist of a number of high-intensity motion structures which, except during brief periods of rest, should be performed at a high level during a game, from its first to the last minute. If an athlete, participating in a team sport, wants to be successful, he/she must possess optimal aerobic and aerobic-anaerobic bioenergetic potentials, allowing for dealing with extreme demands of training and elite competition, delaying the onset of fatigue, and accelerating recovery processes.

The purpose of this study was to evaluate and assess aerobic bioenergetic potentials of athletes participating in basketball, football and handball. Following this, differences in absolute and relative values of oxygen consumption among athletes in the three sport disciplines were subjected to both multivariate and univariate statistical analyses of mean differences. Obtained informations can then be used for managing, modeling, diagnostics, planning, programming, and monitoring of training and competition cycles.

Methods

There were 87 male athletes (29 basketball players, 29 football players and 29 handball players), aged 21–24, 181–191 cm tall, weighing 76–90 kg, members of the first league clubs. Tests were conducted before the start of the preparatory period. Subjects were tested voluntarily (Table 1).

Two variables were used for the assessment of the aerobic bioenergetic potential of each athlete: maximal oxygen consumption (VO2 L/min), estimating the absolute amount of oxygen used by the body, and relative oxygen consumption (VO2 mL/kg/min), representing absolute oxygen consumption per unit of body mass (kg).

Ergometric testing was run on a treadmill (Cosmed T150, Italy), with the use of a gas analyser (Cosmed Quark b2, Italy), through progressively increasing workloads. Testing protocol included 3 min of warm-up (at 3 km/h, without inclination), at the speed of 7 km/h that was increased by 1 km/h each minute, at the steady 1.5% incline. This was followed by an increase of 0.5 km/h every 30 sec, with the incline remaining at 1.5%.

For each applied variable, the following statistical central and dispersion parameters were calculated: mean (M), minimal value (min), maximal value (max), and standard deviation (S). The normalcy of distribution was expressed by skewness (Sk) and kurtosis (Ku).

Both multivariate and univariate analyses of variance (MANOVA/ANOVA) were run to test the differences between mean values of the applied variables for basketball, football and handball players. Multivariate testing of the null hypothesis that group centroids are equal to the common centroid (GENERAL MANOVA) was performed with the γ-Wilks’ lambda test; F-ratio, and statistical significance set at $p < 0.05$. Univariate statistical significance of mean differences was calculated with the F-test at $p < 0.05$. All the data were analysed with the Statistica 8 computer software application.

Table 1

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Mb (n = 29)</th>
<th>Mf (n = 29)</th>
<th>Mh (n = 29)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>21.6 ± 1.05</td>
<td>23.04 ± 2.48</td>
<td>24.09 ± 1.58</td>
</tr>
<tr>
<td>BH (cm)</td>
<td>190.46 ± 8.73</td>
<td>181.66 ± 5.01</td>
<td>189.51 ± 4.96</td>
</tr>
<tr>
<td>BM (kg)</td>
<td>83.56 ± 9.12</td>
<td>76.72 ± 7.49</td>
<td>89.11 ± 9.72</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>23.04 ± 0.41</td>
<td>23.25 ± 0.99</td>
<td>24.81 ± 1.41</td>
</tr>
</tbody>
</table>

Mb – basketball players; Mf – football players; Mh – handball players; BH – body height (cm); BM – body mass (kg); BMI – body mass index (kg/m²).

Results

Analysing data given in Table 2, it is clear that both relative (VO$_2$ mL/kg/min) and absolute (VO$_2$ L/min) oxygen consumption values do not skew significantly from normal distribution (Sk), demonstrating quality measuring techniques. The results showed that football players had the greatest relative oxygen consumption (55.32 mL/kg/min), followed by handball players (51.84 mL/kg/min) and basketball players (47.00 mL/kg/min). Conversely, the highest absolute oxygen consumption was recorded in basketball players (4.47 L/min), followed by handball players (4.40 L/min) and footballers (4.16 L/min) (Table 2).

It can be observed, that there were statistically significant differences in both variables among basketball (Mb), football (Mf) and handball players (Mh) ($p = 0.00$) (MANOVA), whereas ANOVA demonstrated significant differences only in the relative oxygen consumption ($p = 0.00$), but not in the absolute one ($p = 0.07$) (Table 3).

Discussion

Assessment of the aerobic bioenergetic potential of athletes represents an integral marker of functional ability of all the systems participating in delivery, transport and energy transformation of oxygen. High aerobic bioenergetic potential is essential for successful performance in many sports, including handball, basketball and football.

Football is a game requiring both anaerobic, a mix of anaerobic-aerobic, and aerobic work. Besides aerobic endurance, which is the most important in terms of the average distance covered (8–12 km), there is the need for anaerobic work as well, such as in sprints, accelerations, contact game, etc. In football, body’s bioenergetic needs vary, and depend a great deal on the level of competition, game model, team position, training cycle stage, as well as the area of running covered during a game. The average relative oxygen consumption in football is about 58.2 mL/kg/min, specifically about 51 mL/kg/min for keepers, 59 mL/kg/min for defenders, 63 mL/kg/min for midfielders, and 60 mL/kg/min for attackers. Keepers are normally characterized by explosiveness, flexibility and quick reactions, defenders by endurance and coordination, while attackers typically possess extraordinary speed and explosiveness.

The greatest positive influence on the level of skill and performance in football players is typically due to a well-developed aerobic and anaerobic/glycolytic mechanism of energy generation, necessary for performing various technical-tactical tasks in situational competitive conditions.

It is possible to apply a similar model to handball and basketball, that essentially have comparable, but not identical physical demands. Recent rule changes in handball have significantly altered the way the game had been played up until ten years ago. The rules on passive play, a quick pivot, letting keepers quickly introduce the ball into play, are only some of the changes which have rather increased the speed of the game, as well as shortened the intervals between sprints. In modern handball, motion structures are characterized by frequent, short sprints separated by brief pauses.

Players run over between 4,500 and 5,500 meters on the match in a variety of movements (37% walking, running 31%, 25% fast running and 7% in different sprint dynamic). Relative oxygen consumption of trained senior basketball players is somewhere between 45–65 mL/kg/min. The values for younger players are slightly lower (37–55 mL/kg/min). In the present study, no differences were found in relative oxygen consumption with respect to the

<table>
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<tr>
<th>Statistic parameters and their discrimination</th>
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<tbody>
<tr>
<td>Sport</td>
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</tr>
<tr>
<td>Basketball</td>
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<td>Football</td>
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<td>Handball</td>
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<td>Basketball</td>
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<td>Football</td>
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<td>Handball</td>
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$M$ – mean; $S$ – standard deviation, min - minimal value; max – maximal value; Sk - skewness; Ku - kurtosis; *normalcy of distribution; VO$_2$ (L/kg/min) – relative oxygen consumption; VO$_2$ (L/min) – absolute oxygen consumption.

<table>
<thead>
<tr>
<th>Statistical parameters of univariate (ANOVA) and multivariate (MANOVA) analysis of variance</th>
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<tbody>
<tr>
<td>Variable</td>
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<tr>
<td>VO$_2$ (mL/kg/min)</td>
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<td>VO$_2$ (L/min)</td>
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$k = .44$ F = 20.46 $p = .00*$

Mb – basketball players; Mf – football players; Mh – handball players; VO$_2$ (mL/kg/min) – relative oxygen consumption; VO$_2$ (L/min) – absolute oxygen consumption; * – statistically significant difference.

position of play. It is generally accepted that anaerobic functioning is crucial for high performance in basketball. Nevertheless, the role of aerobic mechanisms is important, especially during recovery time rather than having a direct influence on the game.

Since there are limits in utilizing aerobic mechanisms in recovery, it is reasonable to say that high-level aerobic ability is necessary for playing basketball, but further improvements of this ability will not have more significant benefits. For this reason, aerobic metabolism is thought to have a moderate effect on basketball performance.

In American college basketball, there was even a negative correlation between aerobic power and the amount of time spent in the game.

According to our results, it can be assumed that the differences found in the aerobic bioenergetic potential, as expressed by the relative oxygen consumption, may be due to differences in morphological characteristics (body height and mass), situational motion structures (technical and tactical elements), training routines and characteristics (training methods), intensity, duration and ways of motion (specific and situational conditions), as well as the workload in metabolic zones at the aerobic threshold (compensated acidosis).

**Conclusion**

This study confirmed significant differences among football, handball and basketball players in aerobic bioenergetic potential, as demonstrated by their relative oxygen consumption. It can be assumed that the players from the sports in which it is necessary to cross greater length (distance) in total during the match have a greater need for aerobic capacity due to different loads in metabolic zones at the aerobic threshold level (compensated acidosis).

**REFERENCES**
