Anthropometric indicators and aerobic exercise capacity in young basketball players
Indicatorii antropometrici și capacitatea aerobă de efort la jucătorii de baschet tineri

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Abstract

Background. The current tendencies of modern basketball involve multilateral and specific high level physical training, adapted to the peculiarities of age and level of training.

Aims. The anthropometric indicators and exercise capacity in the pre-competition period were studied in junior basketball players with specific training and pupils with general sports training.

Methods. Our research was performed in 6 groups (n=10 subjects/group), group I (15 years), group II (16 years), group III (17 years), controls, and group IV (15 years), group V (16 years), group VI (17 years), athletes. The monitored anthropometric parameters were: weight, height and indirectly, the body mass index. The exercise capacity indicators were: maximal O2 consumption and maximal aerobic power.

Results. Insignificant increases in the weight, height and body mass index were found in the athlete groups compared to the non-athlete groups, except for the 17-year group for height. Significant increases in VO2max and maximal aerobic power were found in athletes compared to non-athletes of the same age.

Conclusions. Specific sports training determines an increase in aerobic exercise capacity and maximal aerobic power in young basketball players.

Key words: basketball players, VO2 max, anthropometric indicators, physical exercise.
Introduction

The extremely high requirements in modern basketball, characterized by the tendency towards exercise intensification, increase in the speed of movement and execution, lead to the fatigue of the central nervous system, manifesting by the decrease of concentration capacity, and to the overstrain of the myoarthrokinetic, acoustic and vestibular analyzers, which ensure the balance function during jumping.

**Primary selection** in basketball takes place at the age of 7-9 years based on the following indicators: very good health; good physical development (tall or very tall children, with a good weight balance).

**Secondary selection** is performed at the age of 12-14 years. A secondary post-selection study for the age of 14-15 years presents the following data: guards have a height of 185-188 cm, forwards 190-196 cm, and centers 200 cm, with an arm span of 195-205 cm and a longitudinal and transverse palmar diameter of 20-21 cm, 24-25 cm, respectively (Dragnea, 1996).

**Final selection** is intended for athletes that have undergone the previous selection stages and refers to evaluation under playing conditions, which is the real selection criterion that evidences talent.

According to Colibaba & Sufariu (2005), the motor structure of play determines three types of functional strain: aerobic, with an alternative or predominantly mixed manifestation; anaerobic alactacid; anaerobic lactacid. The alternation or the combination of strains occurs within the limits of the following relative values: 10-30 sec – anaerobic alactacid + anaerobic lactacid; 30-90 sec – anaerobic lactacid + anaerobic alactacid; 90-120 sec – anaerobic lactacid + aerobic.

Hypothesis

Height, weight, the body mass index and physiological data may significantly contribute to the improvement of selection methods in the case of young basketball players, but they cannot determine in a high proportion individual sports performance.

Material and methods

**Research protocol**

a) **Period of the research**

The research was approved by the Ethics Board of the "Iuliu Hațieganu" University of Medicine and Pharmacy Cluj-Napoca and the informed consent of the subjects’ parents was obtained. The determination period was May 2012 for groups I, II and III, and for groups IV, V and VI, three weeks in May 2013, after training.

**Subjects and groups**

The determinations were performed in 6 groups (n=10 subjects/group):
- 3 control groups; CI (15 years), CII (16 years), CIII (17 years)
- 3 groups of athletes; AIV (15 years), AV (16 years), AVI (17 years)

The groups of young professional athletes were members of the "U Mobitelco" Club Cluj-Napoca and the control groups were pupils of the Informatics High School in Cluj-Napoca.

b) **Tests applied**

**Anthropometric indicators**
- direct - weight (G) in kg, by weighing with a digital scale, and height (H) measured in cm using a stadiometer, for the determination of the body mass index (BMI);
- indirect - BMI, calculated using the formula $G/H^2$ (kg/m$^2$).

**Aerobic exercise capacity (AEC)** was indirectly investigated using the Astrand-Ryhming method (Drăgan 2002); 6 minute submaximal exercise, performed on the Ergoline 900 cycloergometer (commercialized by Tehnomed SRL, Cluj-Napoca), with a 40-80/min rotation and 2.5 W/Kg intensity, maintained constant throughout the duration of the test.

*The aerobic exercise indicators were:*
- maximal $O_2$ consumption in ml (VO$_{2\text{max}}$);
- maximal aerobic power in ml/kg (MAP= VO$_{2\text{max}}$/G);

c) **Statistical processing**

Statistical processing was performed using the Excel application (Microsoft Office 2007) and the StatsDirect v.2.7.2 software. The results were graphically represented using the Excel application (Microsoft Office 2007).

Results

a) **Comparative statistical analysis of anthropometric indicators in the studied groups**

**Body mass** (Table I)

The statistical analysis of body mass values, considering all groups, showed very statistically significant differences between at least two of the groups (p=0.001).

The statistical analysis of body mass values, considering all control groups, revealed statistically significant differences between at least two of the groups (p=0.0322).

The statistical analysis of the body mass values, considering all athlete groups, indicated highly statistically significant differences between at least two of the groups (p=9.64x10$^{-4}$).

The statistical analysis of body mass values for unpaired samples showed:
- highly statistically significant differences between groups A15-A16 and A15-A17 (p<0.001)
- statistically significant differences between groups C15-C16 and C15-C17 (p=0.05).

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean</th>
<th>SE</th>
<th>Median</th>
<th>SD</th>
<th>Min.</th>
<th>Max.</th>
<th>Statistical significance (p)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C15</td>
<td>59.3</td>
<td>3.7861</td>
<td>56</td>
<td>11.9727</td>
<td>45</td>
<td>80</td>
<td>C15-C16: 0.0218 C15-A15: 0.1004</td>
</tr>
<tr>
<td>A15</td>
<td>52.2</td>
<td>3.2755</td>
<td>50.5</td>
<td>10.3580</td>
<td>40</td>
<td>76</td>
<td>C15-C17: 0.0243 C16-A16: 0.9717</td>
</tr>
<tr>
<td>C16</td>
<td>72.5</td>
<td>4.3621</td>
<td>71.5</td>
<td>13.7944</td>
<td>55</td>
<td>95</td>
<td>C16-C17: 0.8541 C17-A17: 0.7598</td>
</tr>
<tr>
<td>A16</td>
<td>72.3</td>
<td>3.4417</td>
<td>72</td>
<td>10.8837</td>
<td>50</td>
<td>89</td>
<td>A15-A16: 0.0005</td>
</tr>
<tr>
<td>C17</td>
<td>73.7</td>
<td>4.7259</td>
<td>72.5</td>
<td>14.9447</td>
<td>55</td>
<td>105</td>
<td>A15-A17: 0.0002</td>
</tr>
<tr>
<td>A17</td>
<td>72</td>
<td>2.7203</td>
<td>72.5</td>
<td>8.6023</td>
<td>59</td>
<td>89</td>
<td>A16-A17: 0.9463</td>
</tr>
</tbody>
</table>

Comparative analysis of body mass values (measured in kg) in the studied groups and statistical significance.
Anthropometric indicators and aerobic exercise capacity in young basketball players

**Height (Table II)**
The statistical analysis of height values, considering all groups, evidenced highly statistically significant differences between at least two of the groups ($p=3.42\times10^{-4}$).

The statistical analysis of height values, considering all control groups, showed very statistically significant differences between at least two of the groups ($p=0.00345$).

The statistical analysis of height values, considering all athlete groups, revealed highly statistically significant differences between at least two of the groups ($p=3.31\times10^{-4}$).

The statistical analysis of height values for unpaired samples evidenced:
- highly statistically significant differences between groups A15-A16 and A15-A17 ($p=0.001$)
- very statistically significant differences between groups C15-C16 and C17-A17 ($p<0.05$).

**Body mass index (Table III)**
The statistical analysis of body mass index (BMI) values, considering all groups, showed no statistically significant differences between the groups ($p=0.3281$).

The statistical analysis of BMI values, considering all control groups, revealed no statistically significant differences between the groups ($p=0.2829$).

The statistical analysis of BMI values, considering all athlete groups, evidenced no statistically significant differences between the groups ($p>0.05$).

The statistical analysis of BMI values for unpaired samples showed no statistically significant differences between the groups ($p>0.05$).

**Comparative analysis of height values (measured in m) in the studied groups and statistical significance.**

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean</th>
<th>SE</th>
<th>Median</th>
<th>SD</th>
<th>Min.</th>
<th>Max.</th>
<th>Statistical significance ($p$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C15</td>
<td>1.68</td>
<td>0.0294</td>
<td>1.70</td>
<td>0.0931</td>
<td>1.47</td>
<td>1.80</td>
<td>C15-C16: 0.0138, C15-A15: 0.183</td>
</tr>
<tr>
<td>A15</td>
<td>1.61</td>
<td>0.0408</td>
<td>1.61</td>
<td>0.1289</td>
<td>1.39</td>
<td>1.85</td>
<td>C15-C17: 0.0045, C16-A16: 0.2739</td>
</tr>
<tr>
<td>C16</td>
<td>1.78</td>
<td>0.0210</td>
<td>1.76</td>
<td>0.0665</td>
<td>1.68</td>
<td>1.87</td>
<td>C16-C17: 0.5285, C17-A17: 0.0113</td>
</tr>
<tr>
<td>A16</td>
<td>1.82</td>
<td>0.0284</td>
<td>1.81</td>
<td>0.0899</td>
<td>1.68</td>
<td>1.96</td>
<td>A15-A16: 0.0006</td>
</tr>
<tr>
<td>C17</td>
<td>1.80</td>
<td>0.0208</td>
<td>1.78</td>
<td>0.0657</td>
<td>1.73</td>
<td>1.92</td>
<td>A15-A17: 3.75 X 10^{-5}</td>
</tr>
<tr>
<td>A17</td>
<td>1.88</td>
<td>0.0223</td>
<td>1.88</td>
<td>0.0705</td>
<td>1.75</td>
<td>1.96</td>
<td>A16-A17: 0.0899</td>
</tr>
</tbody>
</table>

**Comparative analysis of BMI values (measured in kg/m^2) in the studied groups and statistical significance.**

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean</th>
<th>SE</th>
<th>Median</th>
<th>SD</th>
<th>Min.</th>
<th>Max.</th>
<th>Statistical significance ($p$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C15</td>
<td>20.94</td>
<td>0.8746</td>
<td>20.45</td>
<td>2.7659</td>
<td>18.29</td>
<td>26.73</td>
<td>C15-C16: 0.2176, C15-A15: 0.7245</td>
</tr>
<tr>
<td>A15</td>
<td>20.60</td>
<td>1.6898</td>
<td>19.87</td>
<td>5.3437</td>
<td>13.15</td>
<td>29.50</td>
<td>C15-C17: 0.1655, C16-A16: 0.59</td>
</tr>
<tr>
<td>C16</td>
<td>22.82</td>
<td>1.0243</td>
<td>23.14</td>
<td>3.2392</td>
<td>18.62</td>
<td>28.06</td>
<td>C16-C17: 0.9061, C17-A17: 0.0577</td>
</tr>
<tr>
<td>A16</td>
<td>21.97</td>
<td>1.1706</td>
<td>21.47</td>
<td>3.7018</td>
<td>17.10</td>
<td>30.12</td>
<td>A15-A16: 0.516</td>
</tr>
<tr>
<td>C17</td>
<td>22.65</td>
<td>0.9464</td>
<td>22.62</td>
<td>2.9928</td>
<td>18.38</td>
<td>28.48</td>
<td>A15-A17: 0.8764</td>
</tr>
<tr>
<td>A17</td>
<td>20.31</td>
<td>0.6431</td>
<td>19.95</td>
<td>2.0335</td>
<td>17.24</td>
<td>23.55</td>
<td>A16-A17: 0.2363</td>
</tr>
</tbody>
</table>

**Maximal oxygen consumption - VO\textsubscript{2} max (Table IV)**
The statistical analysis of VO\textsubscript{2} max values, considering all groups, evidenced highly statistically significant differences between at least two of the groups ($p=1.07\times10^{-4}$).

The statistical analysis of VO\textsubscript{2} max values, considering all control groups, showed statistically significant differences between at least two of the groups ($p=0.0332$).

The statistical analysis of VO\textsubscript{2} max values, considering all athlete groups, revealed highly statistically significant differences between at least two of the groups ($p=0.0003$).

The statistical analysis of VO\textsubscript{2} max values for unpaired samples showed:
- highly statistically significant differences between groups A15-A17 and C17-A17 ($p=0.001$)
- very statistically significant differences between groups A15-A16 and C16-A16 ($p<0.01$)
- statistically significant differences between groups C15-C16, C15-C17 and C15-A15 ($p<0.05$).

Maximal aerobic power (Table V)
The statistical analysis of maximal aerobic power (MAP), considering all groups, showed highly statistically significant differences between at least two of the groups ($p<0.0001$).

The statistical analysis of MAP values, considering all control groups, evidenced no statistically significant differences between the groups ($p=0.4033$).

The statistical analysis of MAP values, considering all athlete groups, indicated statistically significant differences between at least two of the groups ($p=0.0206$).

The statistical analysis of MAP values for unpaired
samples revealed:
- highly statistically significant differences between groups C15-A15, C16-A16 and C17-A17 (p<0.001); 
- very statistically significant differences between groups A15-A16 (p<0.01).

a) Statistical analysis of correlation between the studied indicators (Table VI)

Discussion

In the literature, the majority of the authors have studied the exercise capacity of adult and young basketball players aged over 18 years, at various levels (middle level – national teams).

Physiological anthropometric indicators may significantly contribute to the improvement of selection procedures in the case of adolescent basketball players.

Our data are in accordance with the literature data regarding height, for groups A16 and A17 (Gurău, 2002), and body mass, for groups A15, A16 and A17 (Cordun, 2009).

Studies carried out by Jelícic et al. (2002) using anthropometric measurements in young basketball players show that players in the center position are characterized by a prominent size of the skeleton in longitudinal and transverse plane, as well as of the circumference, but they present no significant differences compared to players in the forward position. Center players are predominantly endomorphic compared to the other players, while players in the guard position are predominantly mesomorphic.

In a study performed by Torres-Unda et al. (2013), following anthropometric determinations, it was found that weight, height and muscle percentage were higher in the guard position compared to the other players, while players in the guard position were predominantly mesomorphic.

Faludi et al. (1999), in a study on aerobic exercise capacity in mini-basketball players (7-9 years) show that this is determined by a number of factors such as: the genetic factor, physical development, and exercise tolerance. The results of the study demonstrated that the study group had a better exercise tolerance and cardiorespiratory capacity than the control group. The performance of the first group was not due to the degree of physical development.

Training exercise, particularly in junior players, is below the level of exercise during the game and should be raised to higher physiological rates, according to the specificity of the basketball play. This attitude of continuous correction, adjustment to the "physical reality" in the field will be a determining factor for constant progress (Feflea, 2009).

A study on the recovery period after maximal exercise in male basketball players carried out by Gocentas & Andziulis (2004) shows that total recovery time was long, 1200s, but certain processes were completed earlier: accumulation of lactic acid at 95s, oxygen uptake at 620s, normalization of heart rate at 730s.

A meta-analysis conducted by Ziv & Lidor (2009) regarding sports performance in basketball players found that maximal aerobic capacity values ranged between 44-54 and 50-60 ml O2/kg/min. Play leaders performed higher intensity exercise than forwards and centers during a game.

Castagna et al. (2009) examined VO2 max in basketball players. Values during training were 60.88±6.26 and 50.33±3.98 for juniors and seniors, respectively. The results show that a value of 50 ml x kg x min is sufficient to practice middle level basketball.

In a study on aerobic exercise capacity based on the Astrand-Ryhming test applied before and after training for 21 days, Boroș-Balint (2012) evidenced an increase in post-training VO2, which indicates a good adaptation of

<table>
<thead>
<tr>
<th>Comparative analysis of MAP values (measured in ml/kg) in the studied groups and statistical significance.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td>C15</td>
</tr>
<tr>
<td>A15</td>
</tr>
<tr>
<td>C16</td>
</tr>
<tr>
<td>A16</td>
</tr>
<tr>
<td>C17</td>
</tr>
<tr>
<td>A17</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Statistical analysis of correlation between the values of the studied indicators.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indicator</td>
</tr>
<tr>
<td>----------</td>
</tr>
<tr>
<td>Age – body mass</td>
</tr>
<tr>
<td>Age – height</td>
</tr>
<tr>
<td>Age – BMI</td>
</tr>
<tr>
<td>Age – HR</td>
</tr>
<tr>
<td>Age – VO2 max</td>
</tr>
<tr>
<td>Body mass – height</td>
</tr>
<tr>
<td>Body mass – BMI</td>
</tr>
<tr>
<td>Body mass – HR</td>
</tr>
<tr>
<td>Body mass – VO2 max</td>
</tr>
<tr>
<td>Height – BMI</td>
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<tr>
<td>Height – HR</td>
</tr>
<tr>
<td>Height – VO2 max</td>
</tr>
<tr>
<td>BMI – HR</td>
</tr>
<tr>
<td>BMI – VO2 max</td>
</tr>
<tr>
<td>HR – VO2 max</td>
</tr>
</tbody>
</table>

Correlation: **** very good, ** good, * acceptable, * weak.
the body regarding maximal \( O_2 \) uptake, \( O_2 \) transport and consumption systems for exercise.

The research performed by Vanvakoudis et al. (2007) was aimed at determining the effects of basketball training on maximal aerobic power, isokinetic strength, mobility and body fat index. On the initial test, basketball players had a lower heart rate and a higher \( \text{VO}_2 \) compared to the control group. After 18 months, there were no significant differences in isokinetic strength and mobility between the two groups, but basketball players had a lower body fat index.

Sallet et al. (2005) evaluated the physiological characteristics and physical capacities of basketball players competing in the first and second basketball divisions and their correlation with the position of each player and the level of play: centers had a lower maximal speed than play coordinators and forwards; the \( \text{VO}_2 \) max level of first league players was significantly lower than that of lower division players, and the fatigue index was higher in first division players; the general aerobic capacity was similar between players competing in different positions, despite certain differences between athletes, determined by individual physiological capacities.

Castagna et al. (2008) examined the effects of maximal aerobic power on the repeated sprint ability (calculated as the decrease of performance and total sprint time) in young basketball players. The results of this study indicate that \( \text{VO}_2 \) max is not a predictive factor for the repeated sprint ability in young basketball players. The high blood lactate concentrations found at the end of the repeated sprint ability protocol suggest its use for the development of lactate tolerance in trained basketball players.

Hoffman et al. (1999) studied the effect of aerobic capacity on performance, fatigability and heart rate recovery after high intensity anaerobic exercise in national level basketball players. A weak or no correlation was evidenced between aerobic capacity and recovery indicators after high intensity exercise in basketball players.

Tavino et al. (1995) monitored the effects of basketball training in the pre-season period and during a season on the aerobic capacity, anaerobic capacity and body composition in basketball players aged between 18 and 22 years. The tested parameters included body fat percentage, a functional capacity test, and an anaerobic capacity test. The study included three testing phases (during the pre-season, 5 weeks after pre-season training, at the end of the season). The results suggest that the players had significant body fat decreases. Aerobic capacity did not improve during the pre-season period. The players also lost their aerobic capacity during the season.

Conclusions

The following changes were found in the athlete groups:
1. Insignificant increases in body mass, height and body mass index in the athlete groups compared to the non-athlete groups, except for the 17-year groups for height.
2. Significant increases in \( \text{VO}_2 \)max and maximal aerobic power in athletes, compared to non-athletes of the same age.

Conflicts of interests

Nothing to declare.

Acknowledgments

The paper is based on the results of the first author’s doctoral thesis, which is in progress at the “Iuliu Hațieganu” University of Medicine and Pharmacy Cluj-Napoca.

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