Correlation of maximum oxygen consumption with component composition of the body, body mass of men with different somatotypes aged 25-35

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Authors’ Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection.

Abstract

Purpose: The somatotype determines not only physical development, but also the functional capabilities of the organism. Investigation of the correlation relations between the component of body and VO2 max will reveal the influence of each of the components on the aerobic capacity of men in the first period of mature age. The aim of the work – to detect the peculiarities of manifestation of maximum oxygen consumption of men with different somatotypes and to investigate the relationship with the component composition of the body.

Material: The study involved 150 men aged 25-35 years. The somatotype was determined by the Heath-Carter method. The component composition of the body was determined by the bioelectrical impedance method. The VO2_max indicator was determined, metered loads were performed on a bicycle ergometer. A correlation analysis of the absolute and relative VO2_max values with the fat and muscle components of the body was performed.

Results: A high degree of inverse correlation between the relative VO2_max indicator with body mass in men of mesomorphic somatotype was established and a high degree of inverse correlation between the relative VO2_max indicator with body mass and BMI in men of endomorphic-mesomorphic somatotype.

Conclusions: For representatives of the mesomorphic and endomorphic-mesomorphic somatotype, a larger body mass and a high degree of correlation between body mass and relative VO2_max indicator are characteristic. For representatives of the ectomorphic and balanced somatotype, a smaller body mass and a lower degree of correlation between body mass and relative VO2_max indicator max are characteristic.

Keywords: aerobic capacity, muscular, fat component, men.
component on the VO$_2$\textsubscript{max} in obese individuals is indicated in studies M.Pourhassan and co-authors [14]. Payam Heydari et al found that demographic variables and BMI are factors that influence the determination of maximum oxygen consumption [15]. Daniel Bunout et al found that body mass without fat in men is an important predictor of maximum oxygen consumption [16].

Kaur et al point out that with the age in urban women of Punjab of age 50-80 years, the endomorphic and mesomorphic components decreases [17]. The variability of the component body composition in the process of human ontogenesis is shown by Sallnikova’s study. The author argues that in the period of ontogenesis from 30 to 40 years in women, the fat component increases, and the muscle component decreases [18]. In view of the variability of the body components in the process of human ontogenesis, it is important to obtain data on all age groups.

**Hypothesis:** The study of maximum oxygen consumption and the body components of men in the first period of mature age will allow to determine the peculiarities of their manifestation, depending on the somatotype. Investigation of the correlation relations between the components of the body and VO$_2$\textsubscript{max} will reveal the influence of each of the components on the aerobic capacity of men aged 25-35 years.

**Purpose:** to detect the peculiarities of manifestation of maximum oxygen consumption of men with different somatotypes and to investigate the relationship with the component composition of the body.

**Material and Methods**

**Participants.**

The study involved 150 men aged 25-35 years. In all subjects identified somatotype, VO2 max, component body composition. All subjects gave written consent to participate in the experiment.

**Procedure.**

The somatotype was determined by the Heath-Carter method [19]. For this purpose, the following anthropometric studies were performed: they determined height, body mass, girth dimensions, transverse diameters and thickness of skin-fat foods. Each component was expressed in numerical value. The membership of the somatotype was determined by the advantage of the component at 2.5 points. In the absence of such an advantage, the somatotype of the person was defined as balanced. Participants were conventionally divided into groups by belonging to the somatotype.

Component composition of the body was determined by the method of bioelectric impedance using the OMRON BF-511. The device determined the percentage of fatty tissue in the body (subcutaneous fat), the percentage of skeletal muscle in the body, the percentage of visceral fat, body mass index (BMI), and body mass.

The indicator of maximum oxygen consumption (VO$_2$\textsubscript{max}) was determined by the method of Carpman et al [20]. The men performed two loads on an ergometer for 5 minutes each (interval of rest – 3 minutes). The pedaling speed was 60 turnovers per min$^{-1}$. The power of the first load was 1 W per 1 kg of body mass. The power of the second load was 2 W per 1 kg of body mass. At the end of each load, the heart rate was recorded. The mathematical calculations were used to determine the value of the indicator VO$_2$\textsubscript{max}. VO$_2$\textsubscript{max} was displayed in ml min$^{-1}$.

Compared the average group values of the indicators among representatives of different somatotype groups and group of men, which included all participants.

A correlation analysis of the absolute and relative VO$_2$\textsubscript{max} values with the fat and muscle components of the body was performed.

**Statistical analysis.**

The statistical analysis of the data was using the Excel 2010 program. The independent samples were compared for the analysis of the studied measures. Ranks of distribution displayed indicators features according to men’s somatotypes. Statistical processing was performed applying Student’s t-criterion. It was defined as an average mean (X), Student’s t-criterion (t), standard error of the mean (±m), number of degrees of freedom (f), significance value (p). The difference was considered significant at p < 0.05.

The correlation analysis was performed to determine the interrelation between the studied measures. The correlation coefficient (r) was defined. The number of degrees of freedom (k) was calculated. The $a = r$ is the tabular coefficient of correlation which corresponds to the certain level of significance and calculated by means of tabular data. The significance of correlation coefficient was checked in comparison the obtained data with tabular. The connection considered significant at p < 0.05. The gradation proposed by Cheddok was applied for the determination of constraint force. According to this technique the constraint force was estimated as follows: 0.1 ≤ r < 0.3 – weak; 0.3 ≤ r < 0.5 – moderate; 0.5 ≤ r < 0.7 – average; 0.7 ≤ r < 0.9 – high; 0.9 ≤ r ≤ 0.99 – very high.

Experimental studies are in accordance with the directive of the Helsinki Declaration of the World Medical Association on ethical principles of medical research with human participation as the object of study (Protocol of the Commission on Bioethics at Vinnnytsia State Pedagogical University No. 10 of 21.11.2018)

**Results.**

The absolute indicator of VO$_2$\textsubscript{max} in men of the mesomorphic somatotype is higher value relative to the representatives of the ectomorphic somatotype. According to the relative indicator of VO2 max, the representatives of ectomorphic and balanced somatotypes have higher values, while the lowest ones are representatives of the endomorphic-mesomorphic somatotype (Table 1).

In men with endomorphic-mesomorphic somatotype revealed significantly bigger of the body mass, a significantly highest percentage of fat component and visceral fat, among men of different somatotypes. Representatives of mesomorphic somatotype have the highest percentage of muscle component (Table 2).
Generalize the data in Table 1 and Table 2, we notice the following trends. The lowest value of the relative $\text{VO}_2\text{max}$ indicator was found in men with endomorphic-mesomorphic somatotype, who have the highest percentage of subcutaneous fat in the body, the highest percentage of visceral fat and the largest body mass.

Men who belong to the ectomorphic somatotype have higher values of relative $\text{VO}_2\text{max}$ indicator, lower percentage of subcutaneous fat in the body, lower percentage of visceral fat, less body mass and body mass index.

The revealed trends have led us to put forward the hypothesis that for men of certain somatotypes, the lower values of the relative $\text{VO}_2\text{max}$ indicator are due to high values of the percentage of fat component, visceral fat, body mass, and body mass index. To test the hypothesis, we conducted a correlation analysis between $\text{VO}_2\text{max}$ and body mass, body mass index, components of body composition in men with different somatotypes (Table 3).

The correlation analysis revealed a high degree of inverse relationship of the relative $\text{VO}_2\text{max}$ indicator with body mass in men with a mesomorphic somatotype; a high degree of inverse relationship of relative $\text{VO}_2\text{max}$ indicator with a body mass and BMI in men with endomorphic-mesomorphic somatotype; a high degree of inverse correlation of the relative $\text{VO}_2\text{max}$ indicator with a body mass in the male group, which brings together representatives of all somatotypes.

### Discussion

Thus, it can be argued that in men with mesomorphic and endomorphic-mesomorphic somatotype a greater body mass causes lower relative $\text{VO}_2\text{max}$ indicator. In addition, in men with endomorphic-mesomorphic somatotype, the low values of the relative $\text{VO}_2\text{max}$ indicator are associated with high BMI values. Representatives of somatotypes that are characterized by a smaller body mass (ectomorphic and balanced) have a lower degree of inverse relationship of body mass with a relative $\text{VO}_2\text{max}$ indicator. The influence of muscle and fat components, BMI on the level of $\text{VO}_2\text{max}$ in representatives of balanced and endomorphic somatotypes smaller, because the strength of the correlation between these indicators is characterized as noticeable, moderate, or correlation is absent.

The data we received about lower relative $\text{VO}_2\text{max}$ indicator men 25-35 years of mesomorphic and endomorphic-mesomorphic somatotype is new. In the scientific literature, there is evidence of the significant role of somatotype components in influencing to exhibit aerobic productivity. Rupasinghe et al found that endomorphism-dominated medical students were found to have low $\text{VO}_2\text{max}$ levels [7]. Marangoz İrfan et al established a high degree of negative correlation between $\text{VO}_2\text{max}$ and endomorphism in handball players of 18-30 years; a marked degree of positive correlation between $\text{VO}_2\text{max}$ and ectomorphism [21]. Himel Mondal & Snigdha Prava Mishra showed of negative influence of Increasing waist size and Waist-to-height index on $\text{VO}_2\text{max}$ of men 17-25 years [22].

Studies performed by Mamnohan Sharma et al found in men of 25-35 years old a very high degree of inverse relationship between the percentage of subcutaneous fat and the relative $\text{VO}_2\text{max}$ indicator. These authors also found a high degree of inverse relationship between BMI and relative $\text{VO}_2\text{max}$ indicator [9]. The data obtained by us indicate a noticeable degree of the inverse relationship of the relative $\text{VO}_2\text{max}$ indicator with a percentage of subcutaneous fat and a moderate inverse correlation with BMI. According to the established trends, the results of our research coincide with the data of the above-mentioned authors. The only difference is the degree of

### Table 1. Maximum oxygen consumption of men with different somatotypes aged 25-35

<table>
<thead>
<tr>
<th>Indicators</th>
<th>Representatives of the mesomorphic somatotype</th>
<th>n = 39</th>
<th>Representatives of the ectomorphic somatotype</th>
<th>n = 32</th>
<th>Representatives of the endomorphic-mesomorphic somatotype</th>
<th>n = 37</th>
<th>Representatives of balanced somatotype</th>
<th>n = 42</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\text{VO}_2\text{max}$ (ml·min⁻¹)</td>
<td>$\bar{X}$</td>
<td>m</td>
<td>$\bar{X}$</td>
<td>m</td>
<td>$\bar{X}$</td>
<td>m</td>
<td>$\bar{X}$</td>
<td>m</td>
</tr>
<tr>
<td></td>
<td>2809.7</td>
<td>26.02</td>
<td>2680.7</td>
<td>44.19</td>
<td>2776.8</td>
<td>22.04</td>
<td>2792.1</td>
<td>47.06</td>
</tr>
<tr>
<td>$\text{VO}_2\text{max}$ (ml·min·kg⁻¹)</td>
<td>●●●</td>
<td>○○○</td>
<td>●●</td>
<td>○○○</td>
<td>○○</td>
<td>○○○</td>
<td>○○</td>
<td>○○○</td>
</tr>
</tbody>
</table>

Notes: The statistically significant difference: * – in relation to the ectomorphic somatotype; ○ – in relation to the mesomorphic somatotype; ● – in relation to the endomorphic-mesomorphic somatotype; □ – in relation to the all participants. The number of marks (○,*,●,□) corresponds: 1 mark – (p < 0,05), 2 marks - (p < 0,01), 3 marks - (p < 0,001).
correlation. This difference may be due to the fact that the authors used the step-method to determine VO$_{2\text{ max}}$ and in our research the method of bicycle ergometry was used. Also, the difference in results may be due to the region’s characteristics of the residence of the participants. Consideration should also data obtained by Christina Grüne et al who found that obesity affects the growth of error in determining VO$_{2\text{ max}}$ by not a direct method [23].

Studies performed by Mondal & Mishra found in men of 18-25 years moderate degree of negative correlation BMI with relative VO$_{2\text{ max}}$ indicator and a high degree of negative correlation between the percentage of subcutaneous fat and the relative value of VO$_{2\text{ max}}$ indicator [24]. Marcin Maciejczyk et al found a moderate degree of negative correlation in men of 18-30 years between the relative VO$_{2\text{ max}}$ indicator and body mass, BMI, fat component, and the lack of correlation with the muscle component. In addition, they found a moderate degree of positive correlation between the absolute value of VO$_{2\text{ max}}$ and the muscular component. The authors argue that
Table 3. Correlation ratio of maximum oxygen consumption indicators with component composition of the body, body mass of men aged 25-35

<table>
<thead>
<tr>
<th>Indicators</th>
<th>Fat component</th>
<th>Muscle component</th>
<th>Visceral fat</th>
<th>Body mass</th>
<th>Body mass index</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>r</td>
<td>p</td>
<td>r</td>
<td>p</td>
<td>r</td>
</tr>
<tr>
<td>mesomorphic somatotype, n = 39</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VO$_2$ max, abs.</td>
<td>-0.035</td>
<td>p&gt; 0.05</td>
<td>-0.033</td>
<td>p&gt; 0.05</td>
<td>0.346</td>
</tr>
<tr>
<td>VO$_2$ max, rel.</td>
<td>-0.241</td>
<td>p&gt; 0.05</td>
<td>0.241</td>
<td>p&gt; 0.05</td>
<td>-0.132</td>
</tr>
<tr>
<td>ectomorphic somatotype, n = 32</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VO$_2$ max, abs.</td>
<td>-0.149</td>
<td>p&gt; 0.05</td>
<td>0.326</td>
<td>p&gt; 0.05</td>
<td>-0.123</td>
</tr>
<tr>
<td>VO$_2$ max, rel.</td>
<td>-0.109</td>
<td>p&gt; 0.05</td>
<td>0.338</td>
<td>p&gt; 0.05</td>
<td>-0.431</td>
</tr>
<tr>
<td>endomorphic- mesomorphic somatotype, n = 37</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VO$_2$ max, abs.</td>
<td>0.086</td>
<td>p&gt; 0.05</td>
<td>-0.125</td>
<td>p&gt; 0.05</td>
<td>0.161</td>
</tr>
<tr>
<td>VO$_2$ max, rel.</td>
<td>-0.430</td>
<td>p&lt; 0.05</td>
<td>0.222</td>
<td>p&gt; 0.05</td>
<td>-0.520</td>
</tr>
<tr>
<td>balanced somatotype, n = 42</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VO$_2$ max, abs.</td>
<td>-0.080</td>
<td>p&gt; 0.05</td>
<td>0.168</td>
<td>p&gt; 0.05</td>
<td>0.035</td>
</tr>
<tr>
<td>VO$_2$ max, rel.</td>
<td>-0.521</td>
<td>p&lt; 0.05</td>
<td>0.292</td>
<td>p&gt; 0.05</td>
<td>-0.580</td>
</tr>
<tr>
<td>all participants (representatives of all somatotypes), n = 150</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VO$_2$ max, abs.</td>
<td>0.061</td>
<td>p&gt; 0.05</td>
<td>0.125</td>
<td>p&gt; 0.05</td>
<td>0.151</td>
</tr>
<tr>
<td>VO$_2$ max, rel.</td>
<td>-0.596</td>
<td>p&lt; 0.05</td>
<td>0.183</td>
<td>p&lt; 0.05</td>
<td>-0.621</td>
</tr>
</tbody>
</table>

Notes: VO$_2$ max, abs. – absolute indicator of maximum oxygen consumption; VO$_2$ max, rel. – relative indicator of maximum oxygen consumption; r – coefficient of correlation; p – statistical significance for correlation.

Low values of relative VO$_2$ max indicator are due to high body mass values, regardless of whether the fat or muscle component has an advantage [25]. The results of our research agree with this statement. Thus, it can be argued that there is a negative correlation between body mass, BMI, percentage of subcutaneous fat with relative VO$_2$ max indicator in men without somatotype consideration. However, according to various data, the degree of these correlation ranges from moderate to very high.

Conclusions
We have established the features of the manifestation of maximum oxygen consumption in men 25-35 years with different somatotypes. For representatives of the mesomorphic and endomorphic-mesomorphic somatotype, a larger body mass and a high degree of correlation between body mass and relative VO$_2$ max indicator are characteristic. For representatives of the ectomorphic and balanced somatotype, a smaller body mass and a lower degree of correlation between body mass and relative VO$_2$ max indicator max are characteristic.

Conflict of interest
The authors state that there is no conflict of interest.
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