Antropomotoryka. Journal of Kinesiology and Exercise Sciences

Description and profile of the journal

Antropomotoryka. Journal of Kinesiology and Exercise Sciences (JKES) is the official, reviewed, quarterly academic publication of the International Association of Sport Kinesiology (IASK), issued by the University of Physical Education in Krakow since 1989, and from 2010, in cooperation with the University School of Physical Education in Wroclaw. The journal has received academic patronage from the Rehabilitation, Physical Education and Social Integration Committee of the Polish Academy of Sciences and can be found in the IC Journal Master List international indexing database. Since 2014, the journal is published in the original electronic version in English. On subscribers’ request, the journal may be issued in English and Polish in book format.

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Aim

In Antropomotoryka. Journal of Kinesiology and Exercise Sciences (JKES) the results of innovative experiments and observations on human locomotive activities conducted under natural and laboratory conditions by researchers of human motor skills (anthropomotorics) or related fields and disciplines, such as: physiology, psychology, physical anthropology, biomechanics, medicine, computer sciences, economics, genetics, pedagogy, sports education are presented. This allows to acquaint oneself with the essence of human physical activities, their structure, skills, motor functions and aptitudes, learning of these motor functions, their monitoring and control, and the health and sports effects of the broadly understood human notion of physical activity.

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II. Scientific basis of motor function training in sports and recreation (Sport Sciences).
III. Teaching, controlling and monitoring motor functions. Scientific basis, formation and evaluation of activity and physical fitness (Exercise Sciences).
IV. Reviews, debates and discussions, historical elaborations, conference announcements, reports from conferences and congresses of the IASK and brief summaries of papers printed in foreign journals, book reviews on the theory of human motor skills and also, assessment of the current state and prospects for the development in anthropomotoric research achievements (Varià).

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Example:
Table 1., Fig. 1., Commentary, Boys

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The main body of the text should include the following parts:
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Conclusions. Presenting cognitive and applicative findings, the posed hypotheses should be considered and vague statements not supported by the results of the research should be avoided.

Acknowledgements. A list of persons or institution(s) contributing to the preparation of the article, financially or technically supporting the research process or article publication may be given. It is particularly desirable to provide the study grant number.

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Table 1. Differences (d) in body height and mass as well as BMI between student group A and B

<table>
<thead>
<tr>
<th>Group Variable</th>
<th>Variable</th>
<th>A</th>
<th>B</th>
<th>d</th>
<th>Significance level p</th>
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</thead>
<tbody>
<tr>
<td>Age [years]</td>
<td></td>
<td>21.5</td>
<td>3.2</td>
<td>22.0</td>
<td>1.5</td>
</tr>
<tr>
<td>Body height [cm]</td>
<td></td>
<td>176.2</td>
<td>3.3</td>
<td>178.0</td>
<td>4.1</td>
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<tr>
<td>Body mass [kg]</td>
<td></td>
<td>68.3</td>
<td>2.7</td>
<td>79.4</td>
<td>3.5</td>
</tr>
<tr>
<td>BMI [kg/m²]</td>
<td></td>
<td>22.3</td>
<td>2.2</td>
<td>25.7</td>
<td>2.8</td>
</tr>
</tbody>
</table>

NS – statistically non-significant difference
* – p<0.05; ** p<0.01; ***p<0.001

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Concluding remarks
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- Abstracts and full texts in English and Polish are posted on the following websites: http://www.antropomotoryka.pl/ and http://970.indexcopernicus.com/
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We are just on time to go on a holiday with Anropomotoryka – Journal of Kinesiology and Exercise Sciences (JKES). In this issue, we have included some very interesting and important reports on the measurement methods and determinants of physical activity undertaken not only by children and youth.

This next issue, No. 67 of our Wroclaw-Krakow journal opens with the article titled New formula of conversion the results in Olympic weightlifting created in the circle of the Wroclaw ‘antropomotoricians’, under the direction of the most loyal and faithful collaborators of Antropomotoryka published in Krakow. This time, the always lively, active and tireless retired promoter of researching the scientific basis of sports motor abilities directs its reader’s attention to an issue very close to heart - the problem of evaluating Olympic weightlifting results. The first part of the discussion on that subject was included in this year’s first issue of Antropomotoryka. The study results presented in this report are a supplement to the information provided several months earlier.

Their cognitive and applicative value may be indicated by usage of the earlier developed formulas, the doyen of contemporary research issues on human motor skills, in sports federations during the most important worldwide competitions. Congratulations, and we hope that the equalization of results in terms of the women’s category up to 75 kg+ and men’s up to 105 kg+ proposed on the pages of today’s Antropomotoryka will be used to judge sports competitions of the highest rank. In the work, the point of applying equalization of results is given on the example by Cleather. Discussed are the currently used formulas in sports - Wilks and Sinclair and the very interesting, but unfortunately complicated Siff formula, which so far has not found universal application. There is no doubt that the development of the new principle, which was supplemented by two-variable formulas, is an important step in equalizing the results of the Olympic weightlifting, allowing to objectively choose the best player as well reliably determine the team’s position.

In the current issue of our journal, the place of scientific basis of motor training in sport and recreation (Sports Sciences) is taken by the article entitled, Identifying and establishing the factorial structure of anaerobic capacity in eleven nineteen-year-old badminton players submitted by the Krakow Academy of Physical Education. The aim of the study was an attempt to apply multivariate statistical methods to determine the factorial structure of anaerobic motor ability potential in young badminton players.

In two reports (Reactions of the circulatory system of fourth-grade pupils in physical education lessons and The level of physical activity of Spanish boys) the authors point to the possibility of using various methods to control the physical activity of children and youth. It is interesting that with one of them (Physical activity level of boys in Spain) the subject of study, using the IPAQ questionnaire, was the Spanish youth aged 12-16.

The very important issue of the impact of varying amounts of activating actions on the quality of life was highlighted in the article: The Relation between the quality of life of elderly women and the standards in their places of residence. The study participants included 124 female residents of social welfare homes, age 60-89.

The issue ends with the considerations of the article titled The mobility of the thoracolumbar spine and its relationship with ranges of movement of the lower limbs in the hip joint in female students regarding the impact of mobility of the spine on the range of movement of the lower limbs in the hip joint, called – agility - in human motor skill theory.

I hope that the presented issues may be of interest to the loyal readers of Antropomotoryka. Wishing all a good holiday, I announce the release of this year’s final issue of the journal which includes very interesting articles.

As usual, I remain yours faithfully and respectfully and send kind regards from the royal-capital Cracow.

Edward Mleczko

Editor-in-Chief
Antropomotoryka
NEW FORMULA OF CONVERSION THE RESULTS IN OLYMPIC WEIGHTLIFTING

Adam Haleczko

Wrocław, Kotsisa Street 21/4

Key words: olympic weightlifting, relationships result – body mass, Sinclair formula, the formula of the three variables

ABSTRACT

Introduction. The article is a complement to the preliminary report published in No 65 of Antropomotoryka in which the rules of conversion of results in women weight categories up to 75 kg and in men categories up to 105 kg were presented. Now it is the turn to do the same for categories +75 and +105 kg. Using the example given by Cleather the need of result conversion of the weightlifter’s results from these categories was presented. Currently used formulas of conversion like these by Wilks and Sinclair as well as very interesting but complicated Siff’s procedure were discussed. The last however has not found widespread use.

Aim. Description of formula of conversion the Olympic weightlifting results in women categories +75 kg and men categories +105 kg.

Material and methods. The material comprise the body weight data and the results of 199 women and 272 men participating in 2006-2013 in weightlifting competitions of the highest level. Due to the low relationship between body weight and result in these groups of lifters the formulas with three variables could not be used. In this situation, formulas were developed on the basis of rank lists and tables which cover the collected material. Because it does not allow the use of formulas closely describing the relationship between body weight and the achievements of lifters, particular attention was paid to the results of outstanding competitors to make that they have been properly evaluated.

Results. The effectiveness of the conversion by the new formula was evaluated with use of previously adopted criterion – the variability coefficient. Of course, its value was much higher than that obtained in the lighter categories. Comparisons with conversion formula by Sinclair were made based on the classification of lifters according to both methods of conversion and establishing the differences between extreme results. Such comparison showed the similarity of the evaluation by these two methods, like in categories up to 75 kg and 105 kg, however AT the same time proved that the new formula occurred to be more accurate. Major difficulties of interpretation provided the thirteen weightlifters closing the rank list, who get high results, but the body weight of the lightest of them had exceeded 157 kg. Such relationships are difficult to explain and raise doubts in the literature in the field of competitive sports. Steady progress in the methods of evaluation of the body composition can bring in the future, in such cases, the solution purifying lifter with suspicion (of use some illegal agents).

Conclusions. The new three-variable formula described in the preliminary reference, supplemented in this publication by formulas with two variables, is a qualitative leap in leveling the Olympic weightlifting results and allows an objective selection of the best lifter and reliable determination of the place of the team.
cause Iranian weighed 162.95 kg, but 4 years later at the Olympic Games in Athens, while in Sydney his body weight was 147.48 kg, and Mutlu's exactly 55.62 kg). In this situation, the issue is which the world record is better?

A common way to judge in such cases is the use of the quotient method, i.e., dividing the weight lifter by the body weight of a lifter. In the case of athletes comparison is made by expressing their sports results as a multiple of their body weight. Regarding Mutlu it gives 5.5, while in Reza Zadeh only 3.2. The basis of the quotient method is the assumption that between these variables there is a linear relationship. The actual relationship between body weight and weightlifter result suggests that it is, however, non-linear. The use of dimensional analysis shows that the result of weightlifter is proportional to his/her body weight raised to the power of 2/3. In the natural sciences so-called allometric scaling is applied. In weightlifting, it leads to dividing the result of the lifter by his body mass raised to the power of 2/3. In the example given by Cleather [1] such recalculated result of Mutlu is 20.9 kg, while the result of Reza Zadeh only 16.9 kg. According to Cleather it proves the superiority of the allometric method compared to quotient method. However, the allometric method is characterized by some mistake – it favors lifters with an average body mass and lowers the results in extreme categories. A similar phenomenon is observed by majority of authors working on this theme. They point out that this is a consequence of starting in the mid weight categories significantly more players, which is associated with normal body weight distribution in populations [2–7]. Specialists in sports dietetics regard this as being caused by, regardless of discipline, the most advantageous ratio of the active to passive tissue in the body weight [9–12].

Regardless of these opinions, some researchers sought other formula adjusting the weightlifting results to the body weight of lifters through the use of various forms of equations describing this relationship. Inter alia in 1985, Sinclair [13] analyzed the relationship between the logarithm of these two features and presented them as quadratic equations. This method was known earlier as the Sinclair formula, because since 1979, has been recognized by the IWF (International Weightlifting Federation) and in the form of tables of coefficients for establishing the actual performance of lifters is used till now in competitions subject to the Federation. Sinclair examining the Olympic weightlifting results found that above 82.5 kg the increase of results in relation to the increase in the body weight is substantially smaller and from approx. 100 kg becomes negligible or even completely disappears. Hence, in his model of results conversion he devoted especially much attention to this question. The aim of his study was to search for an answer to the question, what the result in Olympic weightlifting should be achieved by X kg weighting weightlifter who had competed in the category of +110 kg (the heaviest category) at the same level of sports ability? [13, p. 94]. Sinclair in January of each year, calculated the ratios of the Olympic world records in each weight category in relation to the record in the 52 kg category at December 31 in each of the previous four years, then taking their average value. Body weight in the highest category with no upper limit he computed statistically using the least squares method. In 2001-2004, this value for men was 157.0 kg, and 112.7 kg for women, four years later – 168.1 and 107.7 kg, and now is 174.4 and 148.0 kg resp. [14]. The mentioned above two values of body mass correspond to a weight ratio of 1.0 in the tables. Gradually, the higher is the body mass, the lower is the correction of the result under conversion. In persons exceeding these limit values the coefficients do not change, they are fixed in accordance with the assumptions adopted by Sinclair [13].

Another of the commonly used methods of the results conversion is Wilk’s formula [5]. Used in IPC (International Paralympic Committee) competitions up to 2003, when it was replaced by the formula AH (current name AH (Haleczko Formula [15])). Wilk's scoring is currently used only for powerlifting competitions organized by the IPF (International Powerlifting Federation). This formula leads to the use of fifth degree polynomial in the description of the relationship between result and body weight [5].

An alternative method was proposed by MC Siff [16]. In his opinion, this method is correct from a mathematical and biological points of view. The essence of this method is using the Gompertz function, being better than the previously adopted functions for determining the relationship: strength – body weight. According to Cleather [1] this method was the best for modeling the relationship between the best results and body weight of lifters at the World Championships in powerlifting in 1995–2004. According to Siff the Gompertz function proved to be superior to all new and previously used formulas for both the Olympic weightlifting and the powerlifting, in terms of accuracy and compliance with the growth models used in biology. Its advantage is that the variability of results, with different body weights, does not depend on whether the force is released rapidly as in Olympic weightlifting or slower as in powerlifting.

Also Finnish researchers Kauhanen et al. [17] point out that in the comparison of the results obtained in the Olympic weightlifting the relationships result vs body weight are non-linear. In their opinion, the formula with exponent 2/3 may prove to be false, because not only the strength themself, but also the ability to release the high power is a factor influencing the result in weightlifting.
Moreover, although a linear relationship between muscle strength and muscle cross-section has been documented, a similar relationship between the cross-sectional area of muscle and released power (which except the cross-sectional area depends on the characteristics of muscle fibers and nerve and mechanical factors) not yet been determined, and perhaps does not exist. Assumption that muscle mass is directly proportional to the mass of the body can be justified only in closed weight categories (i.e. with the upper limit) but a considerable variation in body weight that occurs in superheavy categories not may reflect only the variation in muscle mass. It was noticed also by Lietzke [18], which for this reason excluded from his analysis this weight class. The Finnish researchers in their work evaluated both Siff and Sinclair formulas and on the basis of the collected material, exceeded of 1500 data, proposed nonparametric and complex method of conversion called Lowess. However, it has not found widespread use. Unambiguous on this issue is the statement of Hunter et al. [19] who believe that, while accurate and truthful relationship between strength and weight will not be known, all attempts to transform the results in weightlifting are only approximations.

**Aim**

Description of formula of conversion results in women categories +75 kg and men categories +105 kg.

**Material and methods**

The exact way to create a formula of the three variables for conversion the results in lighter weight categories was presented in preliminary report [20]. The high degree of effectiveness of the equalization of results in lower weight classes was achieved by addition in calculations of the third feature (the difference between the result and the body weight), which was possible thanks to a very high correlation (close to 1.00) between result and body mass. In heaviest weight categories this correlation reached the value r-0.44 in men and r-0.36 in women (tab. 1). At low correlations only the tendency to obtain better results with greater body mass can be observed in the rank lists. The lack of a clear trend and at the same time an uneven configuration of high results almost in the whole range of the rank lists created on a basis of the body mass of weightlifters can be observed especially in women. This phenomenon is illustrated by the rank list attached in the preliminary report and Tables 2 and 3, where the randomness to obtain good results by lifters regardless of their body weight is shown. This type of distributions exclude the application of a formula with three variables. The collected material precludes the creation of formulae closely describing the relation between the body weight and the result. However, they must at least reflect the existing trends. An adequate valuation, especially particularly in outstanding lifters, is very important.

Formulated by Kauhanena et al. [17] assumption that in the allometric model a muscle mass is a certain fixed proportion of the body weight in the whole sample, couldn’t be true in the case of heavier categories. Unfortunately, the lack of data on the composition of the body doesn’t allow to confirmate this hypothesis. However it seems be confirmed by findings of Hester et al. [21] who reported that a dependence of the strength on the body weight retains the linear only to the value of 180–200 pounds (81.7 kg–90.7 kg), as well as by previously submitted Sinclair’s comments on this topic [13] and the statement of Batterham and George [4] that the uniformity of the samples of athletes weighing from 90 kg to over 150 kg is dubious due to the shape of the body, its structure and composition. Also cannot be ignored the note of Milicier, cited in the preliminary report, about the occurence of higher amount of fat in persons with high

<table>
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<tr>
<th>N</th>
<th>Women</th>
<th></th>
<th>Men</th>
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<td>54</td>
<td>76–97</td>
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<td>132–157</td>
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<td>.36</td>
<td>198</td>
<td>105–157</td>
</tr>
</tbody>
</table>

Table 1. The results of analysis of the correlation between body mass and results of weightlifting in +75 kg category (women) and +105 category (men).
### Table 2. Numbers of athletes and results of Olympic weightlifting of women in category +75 kg on the basis of rank lists of the results and the body mass

<table>
<thead>
<tr>
<th>Body mass [kg]</th>
<th>N</th>
<th>$\overline{Y}$</th>
<th>$Y_{\text{max}}$</th>
<th>Body mass [kg]</th>
<th>N</th>
<th>$\overline{Y}$</th>
<th>$Y_{\text{max}}$</th>
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<td>267</td>
<td>76–81</td>
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<td>224</td>
<td>234</td>
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<tr>
<td>86–89</td>
<td>9</td>
<td>261</td>
<td>294</td>
<td>82–87</td>
<td>11</td>
<td>243</td>
<td>283</td>
</tr>
<tr>
<td>90–91</td>
<td>9</td>
<td>239</td>
<td>303</td>
<td>88–93</td>
<td>19</td>
<td>241</td>
<td>303</td>
</tr>
<tr>
<td>91–94</td>
<td>9</td>
<td>242</td>
<td>297</td>
<td>94–99</td>
<td>30</td>
<td>241</td>
<td>315</td>
</tr>
<tr>
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<td>9</td>
<td>246</td>
<td>274</td>
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<td>253</td>
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<td>154–159</td>
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</table>

$\overline{Y}_{\text{tot}} = 105,0 \quad \Sigma = 145 \quad \overline{Y} = 249,0 \quad \overline{Y}_{\text{tot}} = 105,0 \quad \Sigma = 145 \quad \overline{Y} = 258,3 \quad \overline{Y} = 294,4$

### Table 3. Numbers of athletes and results of Olympic weightlifting of men in category +105 kg on the basis of rank lists of the results and the body mass

<table>
<thead>
<tr>
<th>Body mass [kg]</th>
<th>N</th>
<th>$\overline{Y}$</th>
<th>$Y_{\text{max}}$</th>
<th>Body mass [kg]</th>
<th>N</th>
<th>$\overline{Y}$</th>
<th>$Y_{\text{max}}$</th>
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<tbody>
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<td>116–120</td>
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<td>377</td>
<td>407</td>
<td>123–131</td>
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<td>11</td>
<td>374</td>
<td>415</td>
<td>132–140</td>
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<td>458</td>
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<td>123–126</td>
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<td>396</td>
<td>460</td>
<td>141–149</td>
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<td>407</td>
<td>461</td>
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<tr>
<td>127–129</td>
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<td>430</td>
<td>150–158</td>
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<td>464</td>
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<td>394</td>
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<td>150–152</td>
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<td>464</td>
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<tr>
<td>158–169</td>
<td>11</td>
<td>443</td>
<td>464</td>
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<tr>
<td>170–184</td>
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<td>441</td>
<td>451</td>
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</tr>
</tbody>
</table>

$\overline{Y}_{\text{tot}} = 135,5 \quad \Sigma = 211 \quad \overline{Y} = 391,6 \quad \overline{Y} = 435,8 \quad \overline{Y}_{\text{tot}} = 135,5 \quad \Sigma = 211 \quad \overline{Y} = 401,6 \quad \overline{Y} = 443,6$
body weight and results of Forbes [23] that the increase of body weight to the limits of 110–120 kg in men and to 70–80 kg in women is mostly due to the increase of the fat tissue, provided that athletes do not use illegal agents. For these reasons, some authors do not take into account the results of these weight categories in their studies.

Following the remarks of Finns [17] and findings of Lietzky [18] as well as own findings [7, 8, 24] the material was divided into two parts: the results of weightlifter of both sexes in categories up to 75 kg and 105 kg resp. and the results in the heavier categories. s of In the first part the upper limit of a category was taken as the body mass data, while in the second the actual lifter’s body weight for both sexes was taken into account.

In the preliminary report [20] only the concept of conversion of the results of women in weight categories up to 75 kg and 105 kg of man was considered, and only the formulas of calculations for women were presented. So now the formulas for all weight categories for men and women are given below.

**Formulas defining the coefficients of result conversion in Olympic weightlifting**

\[ WW - \text{result conversion coefficient} \]
\[ X: \text{body mass} \]
\[ Y: \text{result (weight lifted)} \]
\[ X - Y: \text{the difference between the result and body mass (third variable)} \]

**Women**

Categories up to 75 kg

1. \[ WW = \left( \frac{Y - X}{Y^{0.53}} \right)^{195} \]

Category +75 kg

2. \[ WW = \left( \frac{Y}{\log X} \right)^{-5 \cdot 19.5} \]

**Men**

Categories up to 105 kg

3. \[ WW = \left( \frac{Y - X}{Y^{0.63}} \right)^{302} \]

**Results**

For all categories the computer programs have been developer, first of all being necessary in the lower categories because of the difficulties in the development of conversion tables when using the formula of the three variables. It significantly speeds up and simplifies conversion of the results and gives the final results in kilograms.

In relation to the Cleather question [1] which one from the two world record holders is better, we now may answer, using this new method of conversion, that converted result of Mutlu would be equal 442.73 kg, while one of Reza Zadeh would be 438.29 kg. In the scoring by Sinclair the difference between them would be very small (2.13 kg), while in our formula it amounts 4.44 kg, which clearly indicates Mutlu’s result as being better.

The adoption of only two features (variables) greatly reduces the effectiveness of the computations. The coefficient of variation which is the evaluation criterion [19], increases for women to the value of 7.6%, and to 4.6% in men, while in lower categories it gains the values of 0.9% in women and 0.7% in men.

In order to highlight the differences between the two scores in Tables 4–6 the world records in Olympic weightlifting (established on 31.12.2014) are provided.

Table 4. The women’s world records for the day 31.12.2014 converted and rated by “Haleczko formula” and the comparison with computations with use of Sinclair tables

<table>
<thead>
<tr>
<th>Category</th>
<th>Body mass [kg]</th>
<th>Result [kg]</th>
<th>Sinclair formula</th>
<th>Place</th>
<th>3 variables formula</th>
<th>Place</th>
<th>Haleczko formula</th>
<th>Place</th>
</tr>
</thead>
<tbody>
<tr>
<td>48</td>
<td>47.80</td>
<td>217</td>
<td>357.02</td>
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<td></td>
<td></td>
<td>243.58</td>
<td>4</td>
</tr>
<tr>
<td>53</td>
<td>52.64</td>
<td>230</td>
<td>349.06</td>
<td>6</td>
<td></td>
<td></td>
<td>243.08</td>
<td>5</td>
</tr>
<tr>
<td>58</td>
<td>57.76</td>
<td>251</td>
<td>354.27</td>
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<td>63</td>
<td>62.60</td>
<td>257</td>
<td>342.99</td>
<td>7</td>
<td></td>
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<td>242.37</td>
<td>7</td>
</tr>
<tr>
<td>69</td>
<td>68.87</td>
<td>286</td>
<td>358.89</td>
<td>2</td>
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<td></td>
<td>244.56</td>
<td>2</td>
</tr>
<tr>
<td>75</td>
<td>75.00</td>
<td>296</td>
<td>354.42</td>
<td>4</td>
<td></td>
<td></td>
<td>242.94</td>
<td>6</td>
</tr>
<tr>
<td>+75</td>
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<td>363.46</td>
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<td>236.42</td>
<td>7</td>
<td>251.88</td>
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</tr>
</tbody>
</table>

The maximum difference between the results of the weightlifters from places 1 and 7 according to “Haleczko formula” – 9.51 kg, according to Sinclair – 20.47 kg
and the results of the nineteenth W. Malak Memorial which illustrate the differences in the taken places of athletes in the competitions significantly different from the point of view sports level of the competitors. In these tables the reshufflings occurring in places taken by competitors are interesting and provide information about the effectiveness of the used model. Much greater differences between the positions occupied by the weightlifters when the classification is made on the basis of Sinclair method [13] prove the higher efficiency of the new formula. Trial use of the three variables formula in heavy categories (Tab. 4–6) resulted in a solution significantly different from the others, which in these categories fully confirmed an application of the commonly used formulas containing only two basic variables. Formulas applied in analyzed categories give final solutions similar to those obtained with use of the Sinclair coefficients, about what inform the world record tables (Tab. 4 and 5). This can best be assessed taking into account not the absolute values of the results expressed in kilograms, but the order of the lifters determined on the basis of the places taken by them. Greater consistency in the hierarchy of the taken positions is seen in women and mainly it relates to extreme places. Kashirin (category 75 kg, the result of 348 kg) with the exceptional quotations in the most heavy categories, in terms of evaluation differs from the other women. Paradoxically, in contrast to her, Reza Zadeh (category 105, the result of 472 kg) takes

<table>
<thead>
<tr>
<th>Category</th>
<th>Body mass [kg]</th>
<th>Result [kg]</th>
<th>Sinclair formula</th>
<th>Place</th>
<th>3 variables formula</th>
<th>Place</th>
<th>Haleczko formula</th>
<th>Place</th>
</tr>
</thead>
<tbody>
<tr>
<td>56</td>
<td>55,62</td>
<td>305</td>
<td>478,72</td>
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<td>442,77</td>
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<td></td>
</tr>
<tr>
<td>62</td>
<td>61,77</td>
<td>327</td>
<td>474,01</td>
<td>7</td>
<td>443,49</td>
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<td></td>
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<tr>
<td>69</td>
<td>68,68</td>
<td>359</td>
<td>484,30</td>
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<td>445,59</td>
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<tr>
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<td>84,69</td>
<td>394</td>
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<td>442,74</td>
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<td></td>
</tr>
<tr>
<td>94</td>
<td>93,52</td>
<td>418</td>
<td>477,96</td>
<td>4</td>
<td>442,29</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>105</td>
<td>104,76</td>
<td>436</td>
<td>476,81</td>
<td>5</td>
<td>438,73</td>
<td>7</td>
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</tr>
<tr>
<td>+ 105</td>
<td>147,48</td>
<td>472</td>
<td>476,59</td>
<td>6</td>
<td>418,42</td>
<td>8</td>
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</tr>
</tbody>
</table>

The maximum difference between the results of the weightlifters from places 1 and 8 according to “Haleczko formula” – 8.15 kg, according to Sinclair – 12.63 kg

<table>
<thead>
<tr>
<th>Initials</th>
<th>Body mass [kg]</th>
<th>Result [kg]</th>
<th>Sinclair formula</th>
<th>Place</th>
<th>3 variables formula</th>
<th>Place</th>
<th>Haleczko formula</th>
<th>Place</th>
</tr>
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<td></td>
<td>433,55</td>
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<td>420,67</td>
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<td>417,36</td>
<td>4</td>
<td>413,77</td>
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<td>407,97</td>
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<td>423,79</td>
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<tr>
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<td>382</td>
<td>362,18</td>
<td>4</td>
<td>363,31</td>
<td>15</td>
<td>389,87</td>
<td>11</td>
</tr>
<tr>
<td>P.B.</td>
<td>105,0</td>
<td>339</td>
<td>370,48</td>
<td>5</td>
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<td>407,56</td>
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</tr>
<tr>
<td>D.S.</td>
<td>77,5</td>
<td>295</td>
<td>370,15</td>
<td>6</td>
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<td>417,39</td>
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</tr>
<tr>
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<td>338</td>
<td>363,69</td>
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<td>374,48</td>
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<tr>
<td>P.S.</td>
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<td>292</td>
<td>362,52</td>
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<td>414,61</td>
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<tr>
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<td>360,37</td>
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<td>411,59</td>
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<tr>
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<td>10</td>
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<td></td>
<td>410,96</td>
<td>7</td>
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<td>310</td>
<td>327,13</td>
<td>11</td>
<td>381,85</td>
<td>12</td>
<td>363,35</td>
<td>14</td>
</tr>
<tr>
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<td>275</td>
<td>327,12</td>
<td>12</td>
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<td></td>
<td>399,58</td>
<td>9</td>
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<td>270</td>
<td>324,38</td>
<td>13</td>
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<td>399,11</td>
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<td>350,28</td>
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</tbody>
</table>

The maximum difference between the results of the weightlifters from places 1 and 15 according to “Haleczko formula” – 83.27 kg, according to Sinclair – 136.92 kg
among the world record holders one of the last places. The score of Russian lifter is 52 kg higher than the result of a lifter from the lower category while the result of the Iranian lifter is only of 36 kg better than those of competitor in category 105 kg. By such comparisons, it is important to take into account the gender differences in the results which are gained in the higher categories of women (58 to 75 kg) and men (77 to 105 kg), giving an average ratio of 1: 1.5. Thus it increases considerably the actual advantage of Kashirin.

Great difficulties arise when trying to adequately assess the results of weightlifters with the highest body mass, namely the last thirteen closing rank list. This group received an average result of 443.1 kg with an average body weight of 164.1 kg what it is difficult to accept in view of the opinion of Forbes [23] about the ratio of muscle tissue to fat. By this author the active tissue, understood as the upper limit of lean body mass, is about 100 kg in men and 60 kg in women. The similar conclusion may be drawn from the previously cited results of Batterham and George [4], Kauhanen et al. [17] and also follow from own findings concerning the relation of the body weight and the results in shot put [24]. Also significant is Sinclair’s opinion [13] about predispositions of weightlifter with the highest body mass in whom the movement of a very large mass of the body and at the same time raising the weight of the barbell cause that the increase in the performance decreases to 0 or even its regression is observed. It is therefore difficult to understand why, in recent years, Sinclair took 148 kg of the body weight as a upper limit by conversion the results in women and 174.4 kg in men, while in the years 2001–2004 this limit value in women he determined as 112.7 kg and 157.0 kg respectively [14].

According to the statements of aforementioned authors the achievements of the heaviest weightlifters may raise problematic reflections. The solution would be to perform the precise study of the body composition of all the lifters using a modern equipment, especially in categories +75 kg and +105 kg. In this issue are also important the results of author’s own research regarding the shot put [24]. Out of 67 the world’s leading shot putters the two groups were selected: one consisting of 31 athletes weighing 83–114 kg and the second consisting of 36 shot putters weighing from 115 to 145 kg. In the lighter group correlation the body mass with the result was negative (r = –.23), while in the heavier one was positive (r = .40). In the comparison group of decathletes the relationships show progression up to 97 kg and above this body mass present the picture of regression similar to one mentioned above in lighter group of shot putters. Opposite signs of correlation coefficients in shot putters groups with different body weight and regression of results in group of the decathletes with the body mass above 95 kg may suggest that some persons in the heavier group uses illegal agents. Figure 1 shows three groups of athletes with different sign and value of the correlation between result and the body weight. The correlation in the shot put group suggests to carry out the similar analysis in weightlifters. An assess-
ment of the relationship between body weight and the result was made on the complete material of women but in men the group of 13 the most heavy lifters should be excluded in order to avoid misleading picture of dependence. These two groups were additionally divided into 2 and 3 subgroups, taking into account first of all the body weight of athletes. Results presented in Table 1 have provided the similar information as one previously obtained when used visual assessment i.e. the value of relations that precludes the application of a formula of three variables, but also confirmed the possibility the creation of meaningful formulas. At the same time the obtained relationships do not suggest the situation like in the shot put – the use of illegal agents in group of heavy lifters. Fully explaining and cleansing with suspicion of the most heavy weightlifters could be done when we use the modern equipment for testing of body composition, ensuring reliable measurement, taking into account except of the two diagnostic features -weight and result, a third variable informing about proportions between muscle mass and fat.

Summary

The presented work is a continuation of a study concerning the problem of aligning the Olympic weightlifting results, discussed in the preliminary report printed in No 65 of Anthropomotyka [20]. In it the basic assumptions regarding the choice of the best player were presented as well as the computational procedures that were necessary to create the conversion formulas for weight categories up to 75 kg in women and up to 105 kg in men. The obtained coefficients according to the adopted criterion - the coefficient of variation, proved to be effective reaching levels below 1%, while the conversion using the Sinclair tables gave significantly worse results. Such a positive effect of the new formula should be attributed to inclusion in the models except two features – lifter’s result and body weight of a lifter, a third variable – the difference between the two mentioned.

This paper presents the difficulties in searching of formulas describing, as closely as possible, the relationship between performance and body weight in categories + 75 kg and + 105 kg. The main obstacle to the adoption of the formula of the three variables were very low and random relationships between result (lifter’s weight) and this somatic feature. Formulas with two variables were created on the basis of rank lists and distribution tables (tab.1 and 2) which of course clearly reduced the effectiveness of the conversion, nevertheless maintaining the trend of influence of body weight on the achievements of weightlifters.

Comparisons with the formula by Sinclair was based on the differences between places achieved in competitions and those resulting after conversion with use of the two formulas. It was found a great similarity in the results of conversions by both models. However, the differences in the order of the extreme places are greater after conversion by Sinclair method, what indicate lower quality of conversion by this method. Additional advantage of the new model is connected with the possibility to adjust the value of the results simply by changing only the numbers in the formulas of conversions to kilograms.

Conclusions

The new three variable formula which was described in the preliminary report, supplemented in this publication with the formulas of two variables, is a qualitative leap in leveling the Olympic weightlifting results and makes possible an objective and fair selection of the best weightlifter and reliable determination of the place of the team. In this situation, it appears appropriate to replace the 36 year old Sinclair tables by this new model of conversion and brought it into use in the competitions subordinate to the Federation.

References

New Formula of Conversion the Results in Olympic Weightlifting

IDENTIFYING AND ESTABLISHING THE FACTORIAL STRUCTURE OF ANAEROBIC CAPACITY IN ELEVEN NINETEEN-YEAR-OLD BADMINTON PLAYERS

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Keywords: badminton, anaerobic capacity, factorial structure

Summary

Aim of the study. To establish the factorial structure of anaerobic capacity in young badminton players as functional traits of their organisms, expressing their ability to activate energy reserves (anaerobic, both lactic and alactic).

Material and methods. The study was conducted on a group of 96 badminton players (in four age groups). Factorial analysis of twelve variables (i.e. the results of motor ability tests) was used to calculate the results. A variant of Hotelling’s principal components, modified by Tucker was used, as well as Varimax rotation, proposed by Kaiser. In order to better recognize the structure of relations introduced into the analysis of variables, the results of Word’s taxonomic method were used in the description of the studied phenomena.

Results and conclusions. The conducted analysis allowed a reduction of variables to three independent factors that explain over 68 percent of shared (total) variance. It would seem that they are especially helpful in training young badminton players. The factors could be called maximal anaerobic power of the upper limbs, maximal anaerobic power of the lower limbs and universal anaerobic power.

Introduction

Sport has gained a reputation as highly qualified and has become a social phenomenon. Today, it is hard to imagine that this positive outcome of human activity was accidental. The problem of achievement optimization in this regard must be considered in the context of various feedback, functioning on a common plane of practice and sport as a science in the broader sense.

Exploration and detailed scientific penetration are mainly focused on phenomena related to sports competitions. The complex structure of training cycles and the diversity of forms applied in practice require us to organize the means and methods as well as to establish efficient and economical training programs. This naturally applies to all levels of training, because sports mastery can only be attained when the chain of educational and training activities is well-organized. This undoubtedly means that the training stages included in this chain are mutually dependent and arranged in a logical manner. Therefore, all the activities carried out in the successive phases of an athlete’s development should be procedurally specified and constitute a closed training cycle aimed at achieving sports mastery in the future \cite{1–3}.

Sports training of children and teenagers has to be subordinated to the processes of individual development and to support this development. It should be marked by versatility which gradually and systematically transforms
into specialization. Such versatility should be based on the selective stimulation of the skills which, at a particular period of the child’s development, are the most easily shaped by physical exercises – sensitive periods [4, 5] and the development of various motor skills. Hence, the effectiveness of training children and adolescents cannot be judged merely on the basis of short-term (stage-related) achievements, but only in the context of the planned prospective targets. The operational objectives therefore need to be subordinated to stage-related objectives as well as clarified and put into a logical whole. The work of a coach is rational and effective only if he is aware of the partial meaning of the operational objectives. This logical chain of tasks in badminton should be implemented while factoring in at least the following six training stages: preparation for selection; initial sports training; targeted training; initial specialization, involving the training of technical elements compatible with the athlete’s special predisposition; specialized training, and mastery. Each new training period should trigger specific adaptation changes in such content so that it is possible to further hone the athlete’s skills at the next level of sports training. What is crucial at this point is the exploration to assess the competence of sports novices and athletes in terms of their health, motor predisposition, psychological predisposition to work in a team and carry out joint activities (team games), abilities, motor skills, and developmental age.

One of the most important elements of this broad evaluation seems to be an individual diagnosis of the anaerobic motor potential of the athlete. It is determined by the nature of the badminton game, which requires significant motor involvement, particularly including maximum anaerobic power. Naturally, each sequence of movements observed in the game proper requires an appropriate set of predisposition and therefore the use of a specific quantum of power, speed, endurance, and coordination. When observing the game, however, it is clear that the nature of a badminton player’s efforts is the combination of speed and endurance. Hence, alongside with aerobic efforts (due to the duration of one game and the number of different repeated movement sequences), these are mainly anaerobic efforts, which is what we wish to analyze in this study. They include using the following movements during the game: starts, changes in the direction of movement, quick shuttlecock smash, jump ups, lunges with simultaneous shoulder involvement, etc. [6, 7].

Undoubtedly, the dynamics of a badminton game is a related issue. It requires muscle work which changes muscle length and tension. During a badminton game, the player uses 80% of the total muscle mass (overall effort), mainly the lower limbs, shoulder girdle, shoulders, and forearms. When returning the shuttlecock, chest, abdomen, and back muscles are equally important. When trying to determine the type and nature of a badminton player’s efforts in the game proper, badminton as a sports discipline is widely regarded as having high intensity stress loads, which are anaerobic and aerobic. In addition, a very important role during the game is played by all the speed components [6, 7].

Despite such complexity of badminton motor acts and sometimes extreme stress loads, not many scientific studies have been conducted on this relatively new Olympic discipline so far. - not many. The seemingly large number of such studies is expressed by the heuristics mostly concerning minor contributory studies on adult players. Fewer observations have been made on the development of players and their aptitude in the early stages of training. For these reasons, the objective of this work is to define the factor structure of the anaerobic motor potential of young badminton players who train in three youth groups (categories: sub juniors, younger juniors, and juniors).

Material and methodology

The research material consisted of data collected in 2009. The players were tested in the final stage of preparation for major tournaments in their age categories. The observations included badminton players from leading clubs in Poland, located in the following cities: Niepołomice (MCS “Spartakus”), Straszecin (UKS “Orbitek”), Głubczyce (LKS “Technik”), Ropczyce (UKS “Sokół”), Tarnobrzeg (UKS “Trójka”), Gorlice (UKS “Badmin”), Białystok (UKS “Hubal”), and Suchedniów (MKS “Orlicz”). The analysis entailed the results of 96 young badminton players who had complete medical test results. The participants included 40 boys in the sub junior category (age 11–13, average training experience of 3.07 years); 32 subjects in the younger junior category (age 14–16, average training experience 5.87 years); and 24 junior players aged 17–19 (average training experience 8.25 years). The data was collected during interviews with coaches and badminton players.

The scope of research

In line with the research objectives and the nature of badminton, the scope of the research included the following motor skill tests:

- standing long jump according to the “Eurofit” test instructions [8];
- medicine ball throw (2 kg) with both hands in a straddle position from behind the head while front— and rear—facing the throw direction; measured by distance with an accuracy of 10 cm;
- medicine ball throw (1 kg) from behind the head in a kneeling position according to the test by Spieszny.
et al. [9]; measured by distance with an accuracy of 10 cm;

– medicine ball tapping (2 kg) – 10 cycles of taps with a ball held in both hands over the head against the wall as well as against the floor between the spread lower limbs; measured by test time with an accuracy of 0.1 s [9];

– “envelope” run with direction change, measured by the total time of three full repetitions with an accuracy of 0.1 s;

– shuttle run 10 × 3 m – total test time measured with an accuracy of 0.1 s [9];

– shuttle run 10 × 5 m – total test time measured with an accuracy of 0.1 s [9];

– abdominal muscle dynamic strength test according to the instructions of the International Physical Fitness Test [10];

– handgrip strength test, measured with a handgrip dynamometer with an accuracy of 1 kG according to the “Eurofit” test instructions [8].

All tests were carried out in the same research team, at the same time of day, and using the same equipment.

The methods of statistical analysis

1. Statistical parameters were calculated for all tested parameters in three age categories (sub juniors, younger juniors, juniors).

2. MMA (maximum anaerobic power) was calculated according to the formulas [11]:

\[
MMA = \frac{36000 \cdot m}{t^3}
\]

where:

\( m \) – body weight [kg],

\( t \) – test time [s].

– from the medical ball tapping (2 kg) results:

\[
MMA = \frac{20 \cdot (2 + 0.1 \cdot n) \cdot g \cdot h_s}{t}
\]

where:

\( m \) – body weight [kg],

\( g \) – gravitational acceleration [9.81 m/s²],

\( h_s \) – sitting height [m],

\( t \) – test time [s].

3. The most important factors of the high level of the game were selected. For this purpose, a factor analysis was applied. The entire collected material (results of 96 players) was used for calculations. The variables introduced to the analysis were standardized to the arithmetic means and standard deviations of results of individual sports groups. The variant of analysis that was used was based on the method of Hotteling’s principal components modified by Tucker and supplemented by Varimax rotation proposed by Kaiser [12]. Since the method of factor analysis is very “sensitive” to the set of characteristics introduced in calculations, a preliminary selection based on fundamental characteristics (not calculated) was conducted. From among the parameters which were a compilation of several measurements or other mathematical calculations, only the following variables remained: MMA of lower limbs and MMA of upper limbs, because the adopted formula resulted in values which had already been tested and verified in relevant literature and which hypothetically determine the strength indicators typical of badminton.

4. The taxonomic method by Word was used in order to better understand the structure of connections introduced to the variable analysis.

Calculations were performed using STATISTICA 10.0 PL for Windows.

Results

The adopted variables were clustered in three separate factors, explaining 68.1% of common variance (Table 1). The table also shows the values for factor loadings of individual variables as well as percentages of common variance accounted for by particular factors. The biggest common variance (40.9%) is explained by the factor associated with the following tests: medicine ball throw backward, forward, and kneeling, static strength, and MMA of upper limbs. The method of conducting the tests as well as their great similarity allow us to consider the components of the factor as logical and refer to the factor as “anaerobic power of the upper limbs.” It is difficult to determine the leading variable here, since most of the factor loadings approaches or exceeds 0.8. The only thing worth reflecting upon is the presence of the static strength parameter. However, it has to be remembered that this parameter was measured with a handgrip, and this element seems equally important when performing other tests integrated with the discussed factor.

The factor significantly associated with the results of “envelope” run and standing long jump has a much smaller contribution to explaining common variation (15.8%). Based on the relevant literature [5], it can be called “MMA of lower limbs”. The “envelope” run test is a leading variable here, with the factor loading above 0.8.

What seems problematic is the third factor, being the combination of variables which are also the components of the MMA of lower and upper limbs formula (leading parameters) and of the results of the 10 × 5 shuttle run...
and the abdominal strength test. In this formula, it explains 11.5% of common variance. Due to the fact that the results of these tests are determined by the work of most of the major muscle groups commonly used in badminton, it is possible, with certain caution, to define this factor as "comprehensive anaerobic power".

In order to better understand the structure of connections adopted for the variable analysis, the cluster complexity of relations between the tested abilities is additionally presented (Fig. 1). The structure of the hierarchy of clusters of observed variables, illustrated using the taxonomic method by Word, provides a similar picture as

<table>
<thead>
<tr>
<th>Variable</th>
<th>Factor 1</th>
<th>Factor 2</th>
<th>Factor 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standing long jump</td>
<td>0.3007</td>
<td>0.6644</td>
<td>0.3906</td>
</tr>
<tr>
<td>10 × 5 m run</td>
<td>−0.0272</td>
<td>0.3852</td>
<td>0.5926</td>
</tr>
<tr>
<td>„envelope“ run</td>
<td>0.1891</td>
<td>0.8502</td>
<td>0.4213</td>
</tr>
<tr>
<td>10 × 3 m run</td>
<td>0.0408</td>
<td>0.3871</td>
<td>0.8325</td>
</tr>
<tr>
<td>MMA of lower limbs</td>
<td>0.3536</td>
<td>0.3110</td>
<td>0.8235</td>
</tr>
<tr>
<td>medicine ball tapping</td>
<td>0.3139</td>
<td>−0.1925</td>
<td>0.7459</td>
</tr>
<tr>
<td>MMA of upper limbs</td>
<td>0.7233</td>
<td>−0.2703</td>
<td>0.5592</td>
</tr>
<tr>
<td>abdominal strength</td>
<td>0.0314</td>
<td>0.4863</td>
<td>0.5752</td>
</tr>
<tr>
<td>medicine ball throw forward</td>
<td>0.8790</td>
<td>0.2358</td>
<td>0.1087</td>
</tr>
<tr>
<td>medicine ball throw backward</td>
<td>0.8619</td>
<td>0.1387</td>
<td>0.0621</td>
</tr>
<tr>
<td>medicine ball throw kneeling</td>
<td>0.8615</td>
<td>0.3310</td>
<td>0.3201</td>
</tr>
<tr>
<td>static strength</td>
<td>0.7999</td>
<td>−0.1402</td>
<td>0.1546</td>
</tr>
<tr>
<td>% total common variance</td>
<td>40.88</td>
<td>15.76</td>
<td>11.47</td>
</tr>
<tr>
<td>cumulative % variance</td>
<td>40.88</td>
<td>56.64</td>
<td>68.12</td>
</tr>
</tbody>
</table>

Factor loadings above 0.5000 are in bold

Fig. 1. Tree diagram – the cluster structure of connections between anaerobic-related skills
in the case of factor analysis. It coincides with the results of the factor analysis to such an extent that it requires no special description or additional comments.

Summing up the factor analysis of the energy skills, it should be noted with certainty that, in addition to reducing the variables, it allowed us to indicate the general basic as well as more detailed parameters typical of badminton players. There is no doubt that the anaerobic motor capacity of a skilful badminton player should encompass a high level of maximal anaerobic power of upper and lower limbs. Another key parameter is the comprehensive anaerobic power which primarily involves the use of large muscle groups.

**Discussion**

The scientific analyses of this study aimed at formulating the unique and possibly end-to-end paradigm paradigm in terms of motor skills based on anaerobic potential which significantly determine the sports level of young badminton players in the processes of player development. Most importantly, the applied multidimensional statistical procedures (factor analysis and Word’s taxonomic analysis) allowed us to determine the factor structure of these skills, with an indication of their modes (leading factors). Therefore, the variables we focused on are the variables which should be inherently paid special attention to during sports training. It seems that the obtained information may be useful both in the recruitment phase and during further selection on the path to sports mastery. In a simplified way, the hierarchy of variables is expressed by their factor loadings, especially including the leading parameters representing specific clusters of anaerobic-based skills.

It should be however remembered that the factor analysis used in the study yields results which largely depend on the type of variables entered into the correlation matrix. Hence the importance of their proper and logical selection, taking into account knowledge and the nature of the problems being solved. Only this methodological approach protects against artefacts such as clustering of included variables with indicators being their derivatives or accumulating of different results describing the same characteristics [5]. In our own explorations, such indicators were left only for MMA of lower limbs and MMA of upper limbs, since the adopted formulas provided us with figures which hypothetically seemed to accurately define the indicators of anaerobic efforts characteristic of badminton [13]. The role of such efforts in badminton was already discussed by Liddane [14] as well as Ooi et al. [15]. Their research, however, concerned elite players who were already developed. More advanced heuristics of these phenomena affirmed the great importance of maximal anaerobic power among all the activities performed during the game by mature badminton players.

The detailed factor and taxonomic analyses in our own research led to the emergence of three independent factors determining the anaerobic potential of young badminton players. These include: anaerobic power of upper and lower limbs and the so-called comprehensive anaerobic power.

While interpreting the results, it is worth noting other researchers’ views on the manifestations of anaerobic motor potential in different motor activities. Undoubtedly, the research done by “the Cracow school of motor activity” is the closest to our deliberations [16-18]. It shows that the division of muscle strength into static, dynamic, and explosive (also known as the “speed strength”) cannot withstand the modern scientific criticism. According to Szopa [16], there are only two genuine factors: static strength and “explosive strength – MMA”. They are present in such tests as jumping, dynamic strength of abdominal muscles, running speed, “agility”, etc. It is worth remembering, too, that during puberty the results of as many as 11 tests are identified in the last factor, including the movement speed test (foot and hand tapping). Given that MMA is a relatively homogeneous (at least in terms of measurement) functional feature of the body, with the ability to rapidly launch anaerobic energy reserves (non-lactic-acid-related and lactic-acid-related), the authors cited above accepted that it is a primary feature of this factor. On the other hand, the factor corresponds to “speed skills” [17]. A recommended method of measurement includes determining the maximum anaerobic work obtained in vertical jump or long standing jump as well as the speed of movements (due to the complex nature of such skills). The distinctive nature of this factor is also indicated by genetic studies [19-21], which show different levels of genetic control in factors “static strength and explosive strength – MMA”. In the context of these views, it can be concluded that the factors identified during the research share common energy-related elements (anaerobic sources) and elements related to muscle contraction speed (time of achieving maximum speed). Typical motor-related results of these efforts are manifested in e.g. motor activities observed for badminton [22]. They include starts, quick changes in the direction of movement, jump ups, various shuttlecock smashes with the racket, etc. – based on non-lactic-acid and lactic-acid MMA [22].

At this point, it is worth mentioning several literary positions presenting the project of stimulation for body balance shaping exercises at various racket smashes in the attack – which require the maximum use of muscle strength in the shortest time possible [23]. Although only contributory in nature, such positions are very important. Moreover, the study by Mooney and Mu-
trie [24] also seems coherent with the subject matter of this paper. They tested the impact of speed-strength exercises on the effectiveness of acquiring badminton skills, confirming their significant efficacy for easy and medium-hard tasks. Other interesting explorations include those by Sekurai and Ohtsuki [25], who proved beyond all doubt that the efficiency of muscle work has a significant impact on accuracy, power, and speed of technical elements during the game. Our findings may be affirmed by the analyses conducted by Amuse et al. [13]. These studies (contributory), conducted on the best African juniors, proved the significant impact of the multifaceted factors of shoulders, back, and lower limbs muscle strength as well as power in these areas on game effectiveness. Many authors have noticed that playing badminton requires high intensity efforts, and that applies not only to oxidative stress but also energy requirements as expressed in anaerobic processes taking place in the player’s body [6, 26]. Furthermore, the dominant role of anaerobic work during the game was also described in the observations of Ślawska and Jagodzińska [27]. A great importance of the MMA factor during extreme racket shuttlecock smashes performed by highly-skilled players was elaborated on by Waddell and In Hong [28]. In the area of motor capabilities needed to conduct an effective game of badminton, Nawara [29] and Steler [30-32] paid attention primarily to the development of power, muscle strength, speed, and endurance as well as selected knowledge. The issue of developing power, mainly in order to improve the elements associated with the technique of racket smashing, was solved by Waddell and In Hong [28], Wolkow [33], and Laffaye and Papelier [34].

To sum up the discussion, it is again worth emphasizing that the three independent factors of anaerobic motor potential identified in our own research are highly logical, since – as is also apparent from the literature review – they involve nearly 80% of the total muscle mass of the player. Some motor activities mainly require the use of lower limb muscles; other activities use the muscles of the shoulder girdle, arms, and forearms; finally, there are activities which require the simultaneous involvement of most of the muscles, chest, abdomen, and spine muscles [22]. This would indicate to the fact that, on the one hand, comprehensive physical fitness is essential for effective badminton play, and, on the other hand, that the game of badminton itself contributes to the development of such fitness. Therefore, while nearing the end of the discussion, the developmental and recreational aspect of badminton should also be emphasized. With the phenomenon of hypokinesis observed more and more frequently in our society, not only in adults but also among children and adolescents, it is worth paying attention to exercises with badminton elements as a very attractive and utilitarian form of physical activity. Research has shown that playing badminton activates the entire human locomotor system and does not require complex and expensive sports equipment. It can be played outside and with many participants. Finally, it has to be stressed that almost all the utilitarian values resulting from physical activity are present in the structure of exercises and all forms of recreation associated with this particular sports discipline.

Conclusions

1. The factor structure of the analysed anaerobic potential is composed of 3 independent factors which explain more than 68% of common variance.

2. Based on the factor analysis results, it is possible to reduce the number of variables to the following hypothetical factors: maximal anaerobic power of the upper limbs, maximal anaerobic power of the lower limbs, and comprehensive anaerobic power.

3. There should be initiatives to promote badminton among children and teenagers. Due to the utilitarian nature of badminton exercises, it can be postulated to include this sports discipline in the universal physical education curricula.

References

Identifying and Establishing the Factorial Structure of Anaerobic Capacity in Eleven...
REATIONS OF THE CIRCULATORY SYSTEM OF FOURTH-GRADE PUPILS IN PHYSICAL EDUCATION LESSONS

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Key words: heart rate, student, primary school, sports lessons, physical education, basketball, Polar Team 2 System.

SUMMARY

Aim. To compare heart rate of fourth-grade pupils during selected basketball lessons.

Material and methods. Study involved 77 fourth-grade pupils (36 girls and 46 boys) from primary schools in Wołów and Wrocław. Heart rate was recorded using Polar Team 2 System during basketball lessons.

Results. The heart rate of fourth-grade students from the 1st Primary School in Wołów (SP1) and the 45th Primary School in Wrocław (SP45) showed big differences in the exercise intensity during basketball lessons. The students of the fourth grade from the 1st Primary School in Wołów were exercising with heart rate $\geq 70\%$ HR max during 18 minutes and 42 seconds $\pm$ 7 minutes and 18 seconds. Meanwhile, the time in which the students from the 45th Primary School in Wrocław were making exercises with heart rate $\geq 70\%$ HR max was 24 minutes and 19 seconds $\pm$ 6 minutes in 34 seconds. There were no significant statistical differences in the average value of HR (p < 0,05) between girls and boys from the study group.

Conclusions. Based on the research, systematic monitoring of the exercise intensity during physical activity lessons should be considered purposeful. This knowledge allows to select optimal exercise load (plays, games, exercises), which will have positive influence on physical development of students.

Introduction

Contemporary civilizational development has had adverse impact on physical fitness of children and adolescents, as well as adults. One of the reasons for occurrence of civilizational diseases is the lowered levels of physical activity [1, 2]. Lack of physical activity undertaken undoubtedly contributed to an alarming increase in obesity in children and adolescents [2, 3, 4, 5]. The problem of obesity already affects about 20% of youth [6], which means that students who go to schools have increasingly higher BMI (Body Mass Index). This worrying phenomenon undoubtedly involves mass leaves from physical education lessons [7], which are often the only form of organized physical activity for 60–70% of students [8]. Only 36% of high school students meet the level of physical activity recommended for proper biological development [9]. Participation in extra-curricular sport activities is not systematically undertaken either [3], despite significant benefits of improving physical fitness and overall health [10]. Passive recreation in form of watching TV or spending time in front of the computer is becoming the dominant form of spending free time [11]. Demographic, personal, social and environmental factors are all responsible for this state of affairs [12].

Among various factors, it is physical education teachers who have significant impact on students engaging in physical activity during both physical education lessons and extracurricular physical activities. Shaping young people through sport and physical education is a very
complex process. To a large extent, it depends on the teacher’s help, his educational methods and forms of work, and a climate of student’s trust [13]. Every physical education teacher’s task is to equip the student with knowledge and skills, and care for the body and health [14]. Physical education teacher should not be limited only to the knowledge of the methodology of their own subject, or for sporting activities. They should have a broad knowledge of both biological as well as psychological, social, humanistic and cultural components of the person, their development and health. Größing [15] sees doubt as to the healthiness of physical education. Sports promoting pro-health education are also treated harshly [13]. It is recommended that physical education teachers prefer endurance activities, which have great, measurable impact on health. But in order to efficiently and effectively interact with the student’s health using team sports, gymnastics or athletics lessons, one must reflect on their intensity. Research shows that physical education classes are conducted in schools with too little intensity. Baquet et al. [16] assessing the intensity of a traditional physical education class in France among 9–12 year-old children, diagnosed the average value of heart rate at 134 beats per minute. An even lower value of 128 beats per minute was diagnosed by Gavarry et al. [17]: the classes were attended by students aged 11-15 years. Bronikowski et al. [18] suggest that the intensity of exercise during lessons should be maintained (for a minimum of 50% of the duration of the lesson) at over 140 HR. Of course, this is not the main objective of the lessons, but by using various intensity of exercise in physical education lessons, it is possible to stimulate the cardio-respiratory system and increase maximal oxygen uptake of the body. Raising these parameters has a positive effect on exercise capacity widely regarded as one of the most important positive markers of health and human development.

**Aim**

The aim of the study was to compare heart rate among pupils of the fourth grade of primary school during a selected basketball lesson. It was decided that following research questions should be answered:

1. What was the reaction of the cardiovascular system of pupils from primary schools in Wolow and Wroclaw to the exercises and games applied during the selected physical education lesson (basketball)?
2. How long did the pupils maintain a heart rate of ≥ 70% HR max during the physical education lesson?
3. Does heart rate depend on pupil’s gender?
4. Is monitoring the intensity of physical education classes justifiable?

**Material and methods**

The study included pupils of two fourth-grade classes from 1<sup>st</sup> Elementary School in Wolowa and two fourth-grade classes from 45<sup>th</sup> Elementary School in Wroclaw, both implementing a research project called “Integrated education using EDUBAL educational balls.” The frequency of heart contractions was diagnosed in 77 elementary school pupils – 36 girls and 41 boys, all in the standard program of physical education. 27 children attended extracurricular physical activities. Body height of boys was 149.5 ± 9.5 cm, and of girls 148.8 ± 11.1 cm. Body weight of boys was 40.3 ± 10.5 kg, and of girls 39.9 ± 11.5 kg. The studied physical education classes were conducted in both schools as the first two hours at school. The study was performed in a sports hall with dimensions 9 x 18 m. The scenario for a 45-minute lesson was conducted by physical education teachers teaching the children. Lesson plan has been prepared in advance by experts on methodology of school physical education and basketball from among the staff of the University School of Physical Education in Wroclaw. The subject of classes was: “Improving passes and holds during pair interaction in basketball.” When starting the lesson, pupils had straps with transmitters put on their chests (thus, observation of the heart was possible). HR max value was determined individually for each pupil using the Polar Team 2 System, based on age, weight and gender.

Statistica 10.0 was used to prepare statistical data. Arithmetic means and standard deviations were calculated. To compare the mean values of heart rate, ANOVA variance analysis was used. Specific differences were tested with Fisher’s NIR test. The total time of heart work in particular intensity intervals was determined.

Heart rate was recorded with Polar Team 2 System, which is certified as a research tool in the Laboratory of ball games (PN-EN ISO 9001: 2009), the Department of Team Sports at the University School of Physical Education in Wroclaw.

**Results**

The reactions of the cardio-respiratory system for boys and girls in the 4<sup>th</sup> grade from the 1<sup>st</sup> Primary School in Wolow (SP1) and the 45<sup>th</sup> Primary School in Wroclaw (SP45) during PE lessons were significantly different (Tab. 1). The boys from class 4a in the 1<sup>st</sup> Primary School in Wolow achieved significantly higher mean values of heart rate from their peers in class 4a of the 45<sup>th</sup> Primary School in Wroclaw. Also, girls from class 4b (SP1) and 4b (SP45) achieved significantly higher average values of heart rate from the boys from class 4a (SP45 in Wroclaw) (Tab. 2).
Reactions of the Circulatory System of Fourth-Grade Pupils in Physical Education Lessons

Statistically significant differences in mean heart rate values were found in SP1 in Wrocław between girls from class 4a and their peers from 4b (Tab. 2). There were no statistically significant differences in the average value of heart rate (p < 0.05) between girls and boys in the studied 4th-grade classes (Fig. 1). During basketball physical education lessons, the average value of heart rate was slightly higher in girls than in boys with the exception of the final part of the lesson. The curve indicated that the intensity of effort in the game “Tag in pairs,” both girls and boys achieved the highest values of heart rate, 152 and 148 beats per minute respectively.

Heart rate among both girls and boys was definitely higher in the final part of the lesson than at the beginning (Fig. 1).

Although there were no statistically significant differences (p < 0.05) in the mean values of heart rate of pupils in each class, the reaction of the cardiovascular system at different stages of the lesson underwent fairly rapid changes in both primary schools (Fig. 2). The highest momentary value of heart rate (165 contractions/min) of all classes was achieved by class 4b of the 45th Primary School in Wrocław. The lowest intensity among all the studied lessons in the fourth grade characterized the lesson of class 4a of 1st Primary School in Wrocław. The largest differences in average heart rate values among pupils in the fourth grade were observed in the initial (38 contr./min) and final part of the lesson (35 contr./min) (Fig. 2).

Table 1. Heart rate (contraction/min) of girls and boys from 4th grade in 1st Primary School in Wołów and 45th Primary School in Wrocław during physical education lesson

<table>
<thead>
<tr>
<th>Variable</th>
<th>HR mean</th>
<th>HR min.</th>
<th>HR max.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>X</td>
<td>SD</td>
<td>X</td>
</tr>
<tr>
<td>SP 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4a</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bs</td>
<td>140.18</td>
<td>8.70</td>
<td>74.45</td>
</tr>
<tr>
<td>Gs</td>
<td>132.00</td>
<td>11.87</td>
<td>73</td>
</tr>
<tr>
<td>4b</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bs</td>
<td>133.82</td>
<td>11.38</td>
<td>81.27</td>
</tr>
<tr>
<td>Gs</td>
<td>142.40</td>
<td>8.60</td>
<td>83.10</td>
</tr>
<tr>
<td>SP45</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4a</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bs</td>
<td>130.17</td>
<td>8.43</td>
<td>74.50</td>
</tr>
<tr>
<td>Gs</td>
<td>136.27</td>
<td>10.13</td>
<td>74.27</td>
</tr>
<tr>
<td>4b</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bs</td>
<td>137.71</td>
<td>8.94</td>
<td>77.14</td>
</tr>
<tr>
<td>Gs</td>
<td>140.57</td>
<td>14.80</td>
<td>84.43</td>
</tr>
</tbody>
</table>

X – mean value, SD – standard deviation, Bs – boys, Gs – girls.

Table 2. Statistical differences (p < 0.05) of mean heart rate for boys and girls of 1st Primary School in Wołów and 45th Primary School in Wrocław during physical education lesson

<table>
<thead>
<tr>
<th>SP1</th>
<th>SP45</th>
</tr>
</thead>
<tbody>
<tr>
<td>4a</td>
<td>4b</td>
</tr>
<tr>
<td>Bs</td>
<td>Gs</td>
</tr>
<tr>
<td>4a</td>
<td></td>
</tr>
<tr>
<td>Bs</td>
<td>0.1039</td>
</tr>
<tr>
<td>Gs</td>
<td>0.1039</td>
</tr>
<tr>
<td>4b</td>
<td>0.1506</td>
</tr>
<tr>
<td>Bs</td>
<td>0.6225</td>
</tr>
<tr>
<td>Gs</td>
<td>0.0224*</td>
</tr>
<tr>
<td>4a</td>
<td>0.3750</td>
</tr>
<tr>
<td>Bs</td>
<td>0.6207</td>
</tr>
<tr>
<td>Gs</td>
<td>0.9377</td>
</tr>
</tbody>
</table>

* statistically significant differences p < 0.05
heart rate. Of all examined classes, the children from class 4a of the 45th Primary School in Wrocław practiced with the intensity of 80–89% for longest periods of time (9 minutes and 46 seconds ± 3 minutes and 1 second) and 90–100% HR max (5 minutes and 21 seconds ± 2 minutes and 27 seconds) (Tab. 4).

The mean time during which the intensity of the lessons of basketball was ≥ 70% HR max differed significantly (p < 0.01) between schools, classes, and gender of the pupils. Pupils from SP45 in Wrocław performed exercise at a level of intensity above or equal to 70% of the maximum heart rate for 24 minutes and...
Reactions of the Circulatory System of Fourth-Grade Pupils in Physical Education Lessons

Among the four tested classes, statistically significant (p <0.01) longer time of exercises at an intensity ≥70% HR max was observed in class 4a of the 45th Primary School in Wrocław (Fig. 3). The pupils from this class practised for 27 minutes and 12 seconds ± 5 minutes and 52 seconds at intensity of ≥70% HR max, while the class 4a from the 1st Primary School in Wolów for just 18 minutes and 31 seconds ± 8 minutes and 6 seconds (Fig. 3).

Among girls and boys from all fourth-grade classes from the 1st Primary School in Wolów and the 45th Primary School in Wrocław, there are also found statistically significant differences (p <0.05) in the length of time of exercises with intensity greater than or equal to 70% HR max. The boys from the class 4a from the 45th Primary School in Wrocław performed the exercises for the longest period of time (28 minutes and 11 seconds ± 4 minutes and 54 seconds) at intensity of ≥70% of maximum heart rate. Girls in class 4a from the 1st Primary School in Wolów exercised the least at this intensity level, with 13 minutes and 35 seconds ± 8 minutes and 40 seconds. (Tab. 5)

Table 3. Time of exercises (min: sec) in particular intensity intervals as performer by fourth-grade pupils from the 1st Primary School in Wolów and the 45th Primary School in Wrocław

<table>
<thead>
<tr>
<th>Interval</th>
<th>SP1</th>
<th>SP45</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>50–59 % HR max</td>
<td>13:03 ± 7:14</td>
<td>9:56 ± 4:36</td>
<td>0.01</td>
</tr>
<tr>
<td>60–69% HR max</td>
<td>13:15 ± 2:49</td>
<td>10:45 ± 3:21</td>
<td>0.00</td>
</tr>
<tr>
<td>70–79% HR max</td>
<td>12:22 ± 4:02</td>
<td>11:44 ± 3:21</td>
<td>0.43</td>
</tr>
<tr>
<td>80–89% HR max</td>
<td>5:59 ± 4:11</td>
<td>8:41 ± 3:12</td>
<td>0.00</td>
</tr>
<tr>
<td>90–100% HR max</td>
<td>0:22 ± 0:41</td>
<td>3:53 ± 3:00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Table 4. Time of exercises (min: sec) in particular intensity intervals as performer by fourth-grade pupils from the 1st Primary School in Wolów and the 45th Primary School in Wrocław during a basketball lesson

<table>
<thead>
<tr>
<th>Intervals</th>
<th>50–59 % HR max</th>
<th>60–69% HR max</th>
<th>70–79% HR max</th>
<th>80–89% HR max</th>
<th>90–100% HR max</th>
</tr>
</thead>
<tbody>
<tr>
<td>SP 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4b</td>
<td>12:34 ± 7:03</td>
<td>13:35 ± 2:51</td>
<td>13:02 ± 3:30</td>
<td>5:32 ± 4:05</td>
<td>0:17 ± 0:41</td>
</tr>
<tr>
<td>SP 45</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 3. Mean time of heart contractions among fourth-grade children from the 1st Primary School in Wolów and the 45th Primary School in Wrocław (≥70% HR max).
Table 5. The time of exercises (min: sek) at the intensity level of ≥ 70 % HR max for fourth-grade boys and girls from the 1st Primary School in Wołów and the 45th Primary School in Wrocław

<table>
<thead>
<tr>
<th></th>
<th>SP1 4a</th>
<th>SP1 4b</th>
<th>SP45 4a</th>
<th>SP45 4b</th>
</tr>
</thead>
</table>

Discussion

Providing stimulating biological development of the student through the use of appropriate amount of movement under compulsory school education is one of the most important tasks of school physical education. Physical activity undertaken in physical education classes should be for a very important arbitrary value for young people, also realized later in adulthood [19]. Through mandatory physical education in schools, it is possible to provide a lasting functional change in cardiopulmonary respiratory system, changes in metabolic control and muscle work [20]. For that to happen, according to World Health Organization, children should do exercises at least five times a week for 20 minutes, with intensity of over 140 beats per minute, as well as make maximum exertions or ones close to the maximum, in which the frequency of heart contractions will amount to more than 200 beats per minute [21]. The intensity of physical effort undertaken during physical education classes varies widely. These differences arise from the venue of the course, the type of lessons [22], the level of physical fitness of students [23, 24] and their involvement. The optimal intensity of exercise, is one of many indicators of the efficiency and quality of physical education lessons. However, the intensity of physical education classes is too low to properly stimulate development of cardiopulmonary respiratory system, about which Bronikowski [20] and Stratton [25] speak.

In this study, which examined the intensity of exercise loads of pupils in a basketball lesson in 1st Primary School in Wołów and 45th Primary School in Wrocław, the most efficient classes in terms of intensity were deployed in both classes 4b. Average intensity of lessons in these classes was 138 ± 1 beats per minute. In classes 4a, the average value for the two schools was 134 ± 2 contractions per minute. In all the surveyed fourth grade classes, the average frequency of heart contractions for boys and girls was lower than the average value of the intensity of the basketball lesson in the study by Bronikowski [20] where it amounted to 148 beats per minute for girls and over 146 beats per minute for boys. Research by Bronikowski shows that basketball lessons, apart from field athletics, are some of the most intense physical education classes. This raises a question: What is the intensity of the remaining physical education lessons, since such lessons as table tennis or gymnastics are characterized by a generally low intensity of activities [20]?

The mean value of the minimum pulse rate among the pupils in the fourth grade was lower in classes 4a in both schools examined, and equalled 74 ± 1 beats per minute. In parallel classes 4b, the minimum average heart rate was approximately 80 ± 4 beats per minute. It should be borne in mind, however, that the pupils from class 4a of the 45th Primary School, in comparison with their peers from other classes, were characterized by higher body weight, which could have an impact on the higher value of the minimum pulse rate [26]. In turn, the mean value of the maximum heart rate in both schools exceeded 180 beats per minute. It is therefore suggested to use such exercises for physical education classes that will activate students for efforts of high and very high intensity.

The intensity of basketball lessons in the tested classes showed very high variability during various stages of the lesson, as evidenced by changes of the heart rate. Similar conclusions were proposed by Chmura et al [27] during deployment of the running play among first grade pupils. However, attention should be paid to pupils’ commitment and motivation during exercises performed [28]. There are students who are more engaged during physical education classes than other students. The teacher should make sure that each of the students becomes involved in the lesson. By monitoring the heart rate, it is possible to observe objective exercise loads during physical education lessons.

Analysis of the time spent on efforts with the intensity of ≥ 70% HR max in fourth grade classes confirmed that among the four tested classes, students from the 45th Primary School in Wrocław performed exercises of this intensity longer than their peer in the 1st Primary School in Wołów. Students of fourth grade classes from the 45th Primary School in Wrocław were practicing with the intensity of ≥ 70% HR max for 54% of the lesson time, while their peers from the 1st Primary School in Wołów performed exercises of such intensity for less than 42% of the lesson time. A worrying phenomenon is the amount of time spent on exercises that cause no increase in the heart rate to the level of 70% HR max.
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This translates into a low average value of the heart rate and low stimulation of the cardiopulmonary respiratory system [29, 30].

Conclusions

1 Analysis of heart rate of the pupils in fourth grade of 1st Primary School in Wolów and 45th Primary School in Wrocław showed considerable variation in intensity of the exercises and games deployed during the basketball lessons, as evidenced by the curve of intensity of effort in each class.

2 Pupils in fourth grade of the 1st Primary School in Wolów practiced with the intensity of ≥ 70% HR max for 18 minutes and 42 seconds ± 7 minutes and 18 seconds. However, in the 45th Primary School in Wrocław, the time in which students performed exercises with the intensity of ≥ 70% HR max was 24 minutes and 19 seconds ± 6 minutes and 34 seconds.

3 Heart rate does not depend on the gender of the respondents in the analysed age of 10–11 years. A few relations between heart rate and the way physical education lessons are conducted were found, and the teacher and his involvement in motivating student, for that matter.

4 Given the dynamic development of children aged 10–11 years, it is reasonable to monitor the intensity of physical education classes in school. The optimal intensity of exercise, being one of the many indicators of efficiency and quality of physical education lessons has a positive effect on physiological development. Therefore, more research is needed on monitoring the intensity of lessons that will provide further information about the capabilities of students, especially during accelerated development.

References


THE LEVEL OF PHYSICAL ACTIVITY OF SPANISH BOYS

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¹ Institute of Tourism and Recreation, Opole University of Technology

SUMMARY

Aim. To evaluate the level of physical activity of boys, 12 to 16 years old, in the light of selected standards.

Material and methods. The study material is comprised of data collected after research conducted among high school boys from Puerto de Mogan (Spain). A total of 235 boys were examined. Two main study methods were used: observation method and diagnostic poll method. Within the observation method framework, participation observation was employed to measure body mass, for which medical scales were used. Survey methodology was used in the diagnostic poll method framework; the Spanish version of the International Physical Education Questionnaire (IPAQ) served as the tool. On the basis of the acquired results, basic parameters of descriptive statistics were calculated: arithmetic means, standard deviations and extremes (minimums and maximums); also, structure analysis was performed by calculating the number and frequency of study subjects meeting the standards recommended by IPAQ and Paffenbarger.

Results. The total weekly physical activity rate in the study group was established at 3363.58 MET minutes per week. Average total weekly caloric cost of the physical exertions engaged in by the study group amounts to 3091.33 kcal per week. Amongst the pollees, most popular were high-intensity exertions, whereas the least popular were moderate-intensity exertions. It was shown that 77.02% of the pollees meet the IPAQ criteria for physical activity, with 61.70% of the pollees meeting the recommendations formulated by Paffenbarger.

Conclusions. It would seem extremely important to continue research in the field of physical activity amongst people of different age groups, both genders and of different nationalities.

Introduction

Physical activity is now considered the primary carrier of health, and the level of physical activity as one of the best of its measures [1]. Numerous scientific studies point to physical activity as an element necessary for proper functioning of the human body at every age [2, 3, 4, 5]. Appropriately programmed and implemented physical exertions have positive impact on almost every system of the human body. As a result of changes of adaptive nature, there follows an improvement of the overall efficiency of the system, metabolism and biochemical parameters. The positive effects of physical activity on the cardiovascular system include increasing stroke volume and cardiac output at rest and during exercise, changes in the size of the heart chambers, wall thickness and strength of heart contractions, lowering the arterial blood pressure, peripheral vascular resistance and heart rate, as well as improving the vascularisation of the heart. Improvement of coronary circulation contributes to a better supply with oxygen and energy substrates to the heart. As a result of physical exertions there follow also positive changes to metabolism, i.e. reduction in triglycerides and total cholesterol, and improvement of its structure (increased HDL and reduced LDL). Regular physical activity also leads to the improvement of some respiratory parameters. Vital capacity of lungs, respiratory muscle strength, expiratory volume and oxygen limit all increase. Within the musculoskeletal system, positive changes occur in both its passive and active part. The most important are those relating to skeletal muscles, and are manifested in increasing muscle strength and endurance. This translates into the ability
to maintain correct posture, prevent pain in the lower spine and prevent falls in old age. As to the passive apparatus, advantageous changes occur in tendons, ligaments and bones. Physical activity is a very effective means of preventing and treating obesity and diabetes, and present significant advantages for the human psyche. Physical activity helps to improve mood, increase optimism and resistance to stress, reduce rest time, alleviate depressive symptoms and improve the quality of sleep and self-image [1, 3, 6, 7, 8, 9, 10, 11, 12].

Physical activity plays a special role in the case of children and young people, because it has positive effect not only on health, but also on the development processes of biological, psychological and social nature. Some studies also point to a relationship between the level of physical activity during childhood and adolescence, and the tendency to make physical exertions and overall health status (particularly in relation to the skeletal system) in adulthood [9, 13, 14]. The level of physical activity of children and youth is strongly individualised and depends on several factors of psychological, physiological, environmental and socio-cultural nature. Epidemiological data also show a tendency of physical activity to decrease during the period of human ontogenetic development described in this study [9, 15, 16, 17].

In the context of the introductory remarks, the study subject of this paper is the issue of physical activity among young males between 12 and 16 years of age, coming from Spain. The aim of the study is to evaluate weekly physical activity undertaken by the subjects in the light of selected standards. Through empirical research, it was decided to solve the following specific research problems:

1. What is the volume and caloric cost of physical activity among surveyed boys?
2. Which intensity level of physical activity is favoured by the respondents?
3. What percentage of respondents met the criteria of the minimum recommended physical activity in the context of selected standards?

**Material and methods**

The material for the work is comprised of the data obtained from studies conducted in January 2013 among young males attending high school in Puerto de Mogan, in the southern part of the Gran Canaria island (Spain). A total of 235 boys aged 12 to 16 years were studied. All participants were informed about the purpose of the study and its course, and all of them consented to it.

The study used two main research methods: observation method and diagnostic poll method. As a part of the observation method, direct participation observation was used for measuring body weight. Medical scales served as the tool.

As a part of the diagnostic poll method questionnaire was used – the International Physical Activity Questionnaire (IPAQ). In our study, the short version of the Spanish IPAQ referred to as the “average week” was used. It contained seven questions concerning physical activity of respondents in a typical week from their life. In the analysis, answers about own assessment of physical activity were used, examined at three levels of intensity: low, moderate and high.

For the presentation of the final results, the authors of IPAQ adopted appropriate MET conversion values for each level of intensity of physical activity, shown in Table 1.

<table>
<thead>
<tr>
<th>Level of intensity of the exertion</th>
<th>Value of the MET coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>3.3</td>
</tr>
<tr>
<td>Moderate</td>
<td>4.0</td>
</tr>
<tr>
<td>High</td>
<td>8.0</td>
</tr>
</tbody>
</table>

Full presentation of the final results of the IPAQ self-assessment of physical activity questionnaire consists in determining its total weekly extent – the total volume of physical activity on every level of intensity expressed in METmin × week–1. For this purpose, the value of the MET factor attributed to the given level of-intensity of physical activity must be multiplied by the number of days of exertion in the week and its duration in minutes per day.

Based on the results of self-evaluation of the volume of weekly physical activity, the subjects can be classified in terms of the declared level of physical activity as [18]:

1. Highly physically active – those which meet at least one of the two criteria:
   a. three or more days of high-intensity exertions – a total of at least 1500 METmin × week–1,
   b. seven or more days of any combination of physical exertions (low, medium and high intensity), exceeding 3000 METmin × week–1.
2. Sufficiently physically active – those who meet one of the three criteria:
   a. three or more days of intensive exertions, lasting no less than 20 minutes per day (480–1500 METmin × week–1),
b. five or more days of moderate or low-intensity exertions, not less than 30 minutes per day (495–3000 MET min × week⁻¹),

c. five or more days of any combination of physical exertions (low, medium and high intensity) – 600–3000 MET min × week⁻¹.

3. Insufficiently physically active – people who did not engage in any physical activity, or do not meet the conditions for levels sufficient or high.

The results of the study of physical activity with IPAQ questionnaire can also be expressed by using the estimated caloric cost expressed in kcal × week⁻¹ or kcal × day⁻¹. To do so, the data obtained from respondents must be supplemented with data about their current weight and then, energy expenditure of physical activity must be calculated according to Paffenbarger’s [20] formula:

\[
\text{PAC [kcal × week⁻¹]} = \text{MET × PA[h] × BM [kg]}
\]

In order to utilise in this equation the final result of the IPAQ questionnaire expressed in MET min × week⁻¹, it must be converted to METh × week⁻¹. We get the following equation, which was used to estimate the weekly volume of the study group in units of caloric cost – kilocalories [20]:

\[
\text{PAC [kcal × week⁻¹]} = \text{WPA [MET min × week⁻¹]} \times 60 \min \times 1 \times \text{BM [kg]}
\]

where:

- PAC = total weekly caloric cost of the three levels of physical activity (in kcal × week⁻¹),
- WPA = Weekly volume of physical activity presented in MET min × week⁻¹,
- BM = body mass in kilograms.

Survey results presented in this way can be compared with the recommended weekly volume of physical activity that many authors express in kcal × week⁻¹. Paffenbarger [19] assumes that the recommended volume of physical activity for adults weighing 70 kg should result in a caloric expenditure of at least 2,000 kcal × week⁻¹ (approximately 300 kcal × day⁻¹). This assumption enables us to determine the recommended volume of weekly physical activity for each person.

Statistical analysis of test results was performed using Microsoft Office Excel 2007. Basic parameters of descriptive statistics, i.e. arithmetic means, standard deviations, and extreme values (minima and maxima) were calculated. Structure analysis was also performed by calculating the number and frequency of subjects meeting the prescribed standards of volume of weekly physical activity.

Results

The average weight in the study group was 52.24 kg. The lowest body mass recorded was 30 kg, with the highest 75 kg. The total required volume of weekly physical activity ratio in the study group averaged at 3363.58 MET min × week⁻¹. The minimum ratio was 789.07 MET min × week⁻¹, while the maximum 9890.67 MET min × week⁻¹. The average total weekly caloric cost of the realised physical activity was 3,091.33 kcal × week⁻¹, and the value recommended by Paffenbarger is 1477.09 kcal × week⁻¹. The lowest value of total caloric cost in one of the respondent amounted to 876.77 kcal × week⁻¹, with the highest at 10,719.54 kcal × week⁻¹. The respondents most often undertook physical efforts of high intensity. The average weekly volume of physical activity with such intensity amounted to 1,795.98 MET min × week⁻¹, with the average weekly caloric cost of 1538.76 kcal × week⁻¹. The second most frequently undertaken level of intensity of physical activity was low. The average weekly volume of physical exertions intensity in the study group was 1,371.87 MET min × week⁻¹, while the average caloric cost of this kind of physical activity amounted to 1217.15 kcal × week⁻¹. The surveyed male youths from Spain undertook physical efforts of moderate intensity least frequently. The average weekly volume of this type of physical activity in the analysed group was 799.12 MET min × week⁻¹, and its average caloric cost 687.09 kcal × week⁻¹ (Table 2, Figure 1 and 2).

Figure 3 shows the percentage of respondents from Spain, who filled the criteria for groups with high, sufficient or insufficient levels of physical activity, adopted by the creators of the IPAQ. It has been shown that 77.02% of the respondents met the criteria for sufficient level of activity formulated by the IPAQ. At the same time, in 22.98% of respondents, physical activity in a typical week of their life must be considered insufficient. A smaller percentage of respondents fulfilled the standards of recommended weekly volume of physical activity, beneficial to health (according to Paffenbarger). According to these criteria, the recommended weekly caloric cost of the physical activity undertaken was achieved by 61.70% of the surveyed boys, but has not been achieved by 38.30% of them.

Discussion

Regulatory efforts on the necessary physical parameters (volume, frequency and intensity) for children and young people are much more rigorous than for adults. This is primarily due to the increased need for movement of the human body during development. The results of empirical studies indicate that physical activity is critical to the biological development of the young generation,
Table 2. Characteristics of the numerical variables in studied boys

<table>
<thead>
<tr>
<th>Variables</th>
<th>Arithmetic mean</th>
<th>Standard deviation</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>BM [kg]</td>
<td>52.24</td>
<td>4.23</td>
<td>30.00</td>
<td>75.00</td>
</tr>
<tr>
<td>PA1 [METmin × week⁻¹]</td>
<td>1,795.98</td>
<td>125.87</td>
<td>720.11</td>
<td>3,500.24</td>
</tr>
<tr>
<td>PAC1 [kcal × week⁻¹]</td>
<td>1,538.76</td>
<td>90.32</td>
<td>520.99</td>
<td>4,224.01</td>
</tr>
<tr>
<td>PA2 [METmin × week⁻¹]</td>
<td>799.12</td>
<td>79.98</td>
<td>240.87</td>
<td>3,760.12</td>
</tr>
<tr>
<td>PAC2 [kcal × week⁻¹]</td>
<td>687.09</td>
<td>89.90</td>
<td>220.78</td>
<td>3,375.17</td>
</tr>
<tr>
<td>PA3 [METmin × week⁻¹]</td>
<td>1,371.87</td>
<td>111.12</td>
<td>199.98</td>
<td>5,201.76</td>
</tr>
<tr>
<td>PAC3 [kcal × week⁻¹]</td>
<td>1,217.15</td>
<td>100.96</td>
<td>167.98</td>
<td>3,448.73</td>
</tr>
<tr>
<td>WPA [METmin × week⁻¹]</td>
<td>3,363.58</td>
<td>195.77</td>
<td>789.07</td>
<td>9,890.67</td>
</tr>
<tr>
<td>PAC [kcal × week⁻¹]</td>
<td>3,091.33</td>
<td>162.27</td>
<td>876.77</td>
<td>10,719.54</td>
</tr>
<tr>
<td>RPAC [kcal × week⁻¹]</td>
<td>1,477.09</td>
<td>232.29</td>
<td>211.55</td>
<td>3,498.44</td>
</tr>
</tbody>
</table>

Where:

- BM [kg] – body mass
- PA1 [METmin × week⁻¹] – weekly volume of physical activity of high intensity
- PAC1 [kcal × week⁻¹] - weekly caloric cost
- PA2 [METmin × week⁻¹] – weekly volume of physical activity of high intensity
- PAC2 [kcal × week⁻¹] - weekly caloric cost
- PA3 [METmin × week⁻¹] – weekly volume of physical activity of low intensity
- PAC3 [kcal × week⁻¹] - weekly caloric cost
- WPA [METmin × week⁻¹] – total weekly volume of physical activity ratio
- PAC [kcal × week⁻¹] - total weekly caloric cost of physical activity
- RPAC [kcal × week⁻¹] – Paffenbarger’s recommended weekly caloric cost of physical activity

Figure 1. Arithmetic means of total weekly volume of physical activity and for the three levels of intensity

Figure 2. Arithmetic means of weekly and total caloric cost of physical activity and for the three levels of intensity
particularly in relation to the sphere of motor abilities [6, 9, 13, 15, 16, 17, 21, 22]. Despite these irrefutable scientific facts proving the favourable effects of physical exertions on the processes of development, numerous publications emphasise, however, a significant drop in youth participation in extracurricular physical activity. A report published by Health Behaviour in School-aged Children [23] shows that in 2010, only 10.3% of young people aged 16 to 18 years, including 17.9% of boys and 4.2% girls, undertook daily physical exertions of moderate or high intensity for at least one hour. In the light of these data physical activity status of the surveyed boys from Puerto de Mogan should therefore be assessed positively. As many as 77.02% of them met the standards of physical activity formulated by the IPAQ, suitable for normal development and health, and 61.70% met more radical recommendations by Paffenbarger. A comparative analysis enables us to see that the level of physical activity among the surveyed boys puts them on a favourable position when compared to Polish youth. The research by Drygas et al. [24] showed that about 50% of children and adolescents in Poland are not at all physically active in their leisure time. The research by Drygas et al. [24] showed that about 50% of children and adolescents in Poland are not at all physically active in their leisure time. According to the same study, as much as 42% of children in developmental age spend about three hours a day watching TV or in front of the computer monitor. Similar negative trends can be observed in the case of the adult population of Poles, among which as many as 35% do not engage in any physical exertions in their leisure time. Poles are also the least active people in Poland [23]. Studied boys from Puerto de Mogan were however somewhat less physically active than respondents of the studies by Mynarski et al. [20] and Dinger et al. [26]. It should be noted, however, that in the cited studies older men, attending universities, were put under analysis. Respondents from Puerto de Mogan undertook most often physical exertions of high intensity. Other researchers reached similar conclusions [20, 27]. This is probably due to the fact that men, more often than women, engage in intensive forms of physical activity, including team sports, mainly football, basketball and tennis, as well as strength sports. As the results of empirical studies show, women usually choose less intensive physical exertions, such as walking, jogging, cycling or swimming [28].

Conclusions

Analysis of the results of the study allows us to draw the following conclusions:

1. The ratio of the total volume of weekly physical activity in the surveyed group averaged 3,363.58 METmin × week⁻¹, while the average total weekly caloric cost amounted to 3,091.33 kcal × week⁻¹.
2. Respondents most often undertook physical exertions of high intensity.
3. Physical activity of more than 77% of them (according to the IPAQ standards) and of almost 62% of them (according to Paffenberger’s recommendations) was satisfactory.

Huge importance of the issues analysed in this study makes it reasonable to conclude that continuous in-depth research on assessment of physical activity of the young generation is in order. Groups of young people of...
adequate numbers, living in different regions of the world should be taken into account. Very interesting, although rarely carried out in Poland, are studies on genetic and environmental determinants of physical activity. Proper diagnosis of the physical activity of specific populations will allow to plan and take appropriate steps to increase the amount of physical exertions undertaken by individuals. This ambitious and very important task should be carried out not only by public authorities responsible for public health issues, but also by specialists of physical culture and medicine, the educators, scientists and the media. Only such an integrated action may in fact contribute to an increase in physical activity level in modern humans, and consequently to improvement of their health.

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[21] Puciato D: Zróżnicowanie rozwoju somatycznego i motorycznego dzieci i młodzieży z Jedliny-Zdroju w aspekcie aktywności ruchowej ich rodziców. Antropomotoryka, 2009; 48: 83–89. [Diversity of somatic and motor development of children and youth from JedlinyZdroj from the angle of their parents’ physical activity]
The Evaluation of the Declared Level of Physical Activity Among Male Youths from Spain...


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THE RELATIONSHIP BETWEEN THE QUALITY OF LIFE OF ELDERLY WOMEN AND THE STANDARDS IN THEIR PLACES OF RESIDENCE

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Key words: elderly women, social welfare centres, physical activity, quality of life

Study aim: Comparison and assessment of the quality of life of elderly women residing in houses of social services where the number of activating exercises vary.

Material and methods: The research was conducted on 124 women, aged 60 – 89, who were residents of social welfare centres. Women included in the study were divided into two groups on the basis of their age: 60-74 and 75-89 years old. Based on the number of medical rehabilitation and therapeutic activities offered to residents, the social welfare centres were divided into two kinds. The first one – centres where the women in question had an opportunity to take part in various medical rehabilitation activities and occupational therapy. In this paper, these centres are referred to as DPS-A. The second kind – houses which offer only basic medical rehabilitation activities. These centres are referred to as DPS-B. To evaluate quality of life, the EuroQol questionnaire was used, and supplemented by evaluation of health condition according to the Mac Master index as well as evaluation of housing and financial conditions. Additionally, the synthetic index of satisfaction with life was taken into consideration.

Results: The evaluation of the quality of life in relation to standards offered by the social welfare centres was more satisfactory in the DPS-A group. It concerns the assessment of self-service, health, housing and financial conditions as well as satisfaction with life. The assessment of mobility and performing everyday tasks is varied. Experiencing anxiety and depression is similar.

Conclusions: One can expect that physical activity together with active and diversified ways of spending free time will help lengthen the period of good functional ability, independence and self-reliance, as well as entail heightening the quality of life.

Introduction

The quality of human life has long been the subject of interest of many researchers. Despite its widespread use, there exists no clear definition of the term; for it refers to individual phenomena, different for every human being [1, 2].

From the medical point of view, quality of life is conditioned by individual health, diseases or natural ageing processes [3, 4]. It is the patient’s perception of the disease, its progress and the impact of treatment on both functioning and a general sense of self-satisfaction in life [5]. The study of quality of life related to health is presently an important element in comprehensive assessment of the effects of medical and therapeutic treatment [1, 6, 7].

Attempts at investigating the quality of life of the elderly did not bring conclusions that would clearly describe the nature of the problem. Despite the physiological and pathological distinctiveness of old age having
been proven, Polish gerontology still shows a tendency to join, even identify old age with disability, numerous diseases, reduced intellect, activity loss and lack of long-term planning. However, experience of old age often differs from the above description. Becoming old does not have to block the feeling of quality of life [8, 9, 10, 11].

The factor assumed to play a significant role in shaping the quality of life of the elderly is place of residence [12]. Some people age surrounded by family. Other, living alone, maintain more or less regular contacts with their relatives. Finally, there are those who either want or need to move to a Social Welfare Centre [8]. Living in a welfare centre can restrict daily activity of the residents, which translates into a lower functional ability and reduced quality of life. More and more research involving functional ability and physical activity of older people is conducted [13]. In these studies, women are the more eager candidates. Also due to the length of their lives, women comprise the most of welfare centres’ inhabitants.

The aim of the study is to compare and evaluate the quality of life of elderly women living in welfare centres with different amount of motivating activities.

**Material and methods**

The study group consisted of 124 women, aged 60-89 years, who were residents of social welfare centres (Backów, Dobrzeń Great, Kluczbork, Milicz, Namysłów, Nowa Ruda Oborniki Śląskie, Olawa, Zabkowice, Ziebi-ce). The surveyed women were divided into two age groups: 60-74 years and 75-89 years. Almost half of the women in each age group has spent over 5 years in the institution. All subjects gave written consent to participate in the study. All the centres had equal payment for a resident.

Based on the amount of rehabilitation and therapeutic services offered to residents, the centres are divided into two types: DPS-A and DPS-B. DPS-A are those centres where women surveyed were able to participate in a diversified programme of rehabilitation and occupational therapy activities. Rehabilitation consisted of Kinesitherapy – therapeutic exercises performed at the gym and in the fresh air and physical therapy (if needed). Gym classes included individual exercises on instruments (exercises in a Universal Exercise Unit with no load and with resistance; self-aided exercises) as well as group exercise, such as morning exercises and general facilitating exercises. When the weather was suitable, the group activities were carried out in the fresh air. The residents also participated in walks and excursions as well as sports competitions and dancing evenings, often organized together with other welfare centres. The occupational therapy programme was also rich: embroidery, knitting, art, music classes, playing chess and checkers. The personnel offered this comprehensive programme and participation in the activities was voluntary; it was attended by approximately 90 percent of the residents.

The second type, namely DPS-B, are welfare centres run properly, but where rehabilitation is used at a very basic level, often the result of inadequate number of physical therapists and occupational therapy specialists employed. In those centres, rehabilitation activities addressed mainly people who were ill or in pain. The most commonly conducted exercises were passive, supported, verticalisation and physiotherapy. There were no general facilitating exercises which would engage all residents. Occupational therapy was carried out to a limited extent or not at all.

As the result of this division, four groups of women studied emerged:

1) the group of younger women in DPS-A – 20 people,
2) the group of younger women in DPS-B – 22 people,
3) the group of older women in DPS-A – 34 people,
4) the group of older women in DPS-B – 48 people.

The quality of life questionnaire selected was Euro-Qol [14]. The women assessed movement, self-service, daily activities, pain and discomfort, and the presence of anxiety or depression. As a complement, the state of their health was assessed on the basis of the Mac Master index [15]; and housing conditions and financial conditions were also assessed. Additionally, the synthetic index of satisfaction with life was used [16]. This index takes into account the answers to four questions concerning the assessment of one’s own life and happiness.

**Results**

In the younger group, more than half of the studied women in DPS-A move with ease. The percentage in DPS-B is much lower – 22.7%. In the older group in DPS-B more women find no problem in moving around (Table 1A). The main problems with moving women from the older group of DPS-A have are pain in the joints, balance and amblyopia. Despite the above-mentioned problems, 90 percent of the residents.

In the studied age groups a greater proportion of women with DPS-A independently perform self-service activities – 85% of younger women and 55.8% of seniors. In DPS-B more women surveyed require assistance in carrying out these activities – 72.7% of younger women and only 41.6% of older women are independent in self-service (Table 1B). In both age groups of DPS-A, a much higher percentage of women surveyed carries out daily activities independently than in DPS-B – 40% of residents in the
Table 1. Quantitative and percentage evaluation of the answers to survey questions asked among women in DPS-A and DPS-B

<table>
<thead>
<tr>
<th>Answers</th>
<th>Aged 60–74</th>
<th></th>
<th>Aged 75–89</th>
<th></th>
<th>IN TOTAL</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td><strong>DPS-A</strong></td>
<td>%</td>
<td><strong>DPS-B</strong></td>
<td>%</td>
<td><strong>DPS-A</strong></td>
</tr>
<tr>
<td>A : MOVEMENT</td>
<td></td>
<td><strong>N</strong></td>
<td><strong>%</strong></td>
<td><strong>N</strong></td>
<td><strong>%</strong></td>
<td><strong>N</strong></td>
</tr>
<tr>
<td>• no problems</td>
<td>11</td>
<td>55.00</td>
<td>5</td>
<td>22.73</td>
<td>5</td>
<td>14.71</td>
</tr>
<tr>
<td>• experiences problems</td>
<td>9</td>
<td>45.00</td>
<td>17</td>
<td>77.27</td>
<td>29</td>
<td>85.29</td>
</tr>
<tr>
<td>• cannot move on her own</td>
<td>0</td>
<td>0.00</td>
<td>0</td>
<td>0.00</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>B : SELF-SERVICE</td>
<td></td>
<td><strong>N</strong></td>
<td><strong>%</strong></td>
<td><strong>N</strong></td>
<td><strong>%</strong></td>
<td><strong>N</strong></td>
</tr>
<tr>
<td>• no problems</td>
<td>17</td>
<td>85.00</td>
<td>16</td>
<td>72.73</td>
<td>19</td>
<td>55.88</td>
</tr>
<tr>
<td>• experiences problems</td>
<td>3</td>
<td>15.00</td>
<td>6</td>
<td>27.27</td>
<td>15</td>
<td>44.12</td>
</tr>
<tr>
<td>• cannot perform</td>
<td>0</td>
<td>0.00</td>
<td>0</td>
<td>0.00</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>C : EVERYDAY ACTIVITIES</td>
<td></td>
<td><strong>N</strong></td>
<td><strong>%</strong></td>
<td><strong>N</strong></td>
<td><strong>%</strong></td>
<td><strong>N</strong></td>
</tr>
<tr>
<td>• no problems</td>
<td>8</td>
<td>40.00</td>
<td>8</td>
<td>36.36</td>
<td>11</td>
<td>32.35</td>
</tr>
<tr>
<td>• needs help</td>
<td>10</td>
<td>50.00</td>
<td>13</td>
<td>59.09</td>
<td>20</td>
<td>58.82</td>
</tr>
<tr>
<td>• cannot perform</td>
<td>2</td>
<td>10.00</td>
<td>1</td>
<td>4.55</td>
<td>3</td>
<td>8.82</td>
</tr>
<tr>
<td>D : FEELING OF PAIN/DISCOMFORT</td>
<td></td>
<td><strong>N</strong></td>
<td><strong>%</strong></td>
<td><strong>N</strong></td>
<td><strong>%</strong></td>
<td><strong>N</strong></td>
</tr>
<tr>
<td>• does not feel any</td>
<td>9</td>
<td>45.00</td>
<td>6</td>
<td>27.27</td>
<td>2</td>
<td>5.88</td>
</tr>
<tr>
<td>• mild pain</td>
<td>9</td>
<td>45.00</td>
<td>15</td>
<td>68.18</td>
<td>26</td>
<td>76.47</td>
</tr>
<tr>
<td>• huge pain</td>
<td>2</td>
<td>10.00</td>
<td>1</td>
<td>4.55</td>
<td>6</td>
<td>17.65</td>
</tr>
<tr>
<td>E : FEELING OF ANXIETY/DEPRESSION</td>
<td></td>
<td><strong>N</strong></td>
<td><strong>%</strong></td>
<td><strong>N</strong></td>
<td><strong>%</strong></td>
<td><strong>N</strong></td>
</tr>
<tr>
<td>• does not feel any</td>
<td>16</td>
<td>80.00</td>
<td>16</td>
<td>72.73</td>
<td>23</td>
<td>67.65</td>
</tr>
<tr>
<td>• mild anxiety/depression</td>
<td>4</td>
<td>20.00</td>
<td>6</td>
<td>27.27</td>
<td>10</td>
<td>29.41</td>
</tr>
<tr>
<td>• huge anxiety/depression</td>
<td>0</td>
<td>0.00</td>
<td>0</td>
<td>0.00</td>
<td>1</td>
<td>2.94</td>
</tr>
<tr>
<td>F : GENERAL HEALTH</td>
<td></td>
<td><strong>N</strong></td>
<td><strong>%</strong></td>
<td><strong>N</strong></td>
<td><strong>%</strong></td>
<td><strong>N</strong></td>
</tr>
<tr>
<td>• excellent</td>
<td>0</td>
<td>0.00</td>
<td>0</td>
<td>0.00</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>• quite good</td>
<td>15</td>
<td>75.00</td>
<td>12</td>
<td>54.55</td>
<td>23</td>
<td>67.65</td>
</tr>
<tr>
<td>• bad</td>
<td>5</td>
<td>25.00</td>
<td>10</td>
<td>45.45</td>
<td>11</td>
<td>32.35</td>
</tr>
<tr>
<td>G : HOUSING CONDITIONS</td>
<td></td>
<td><strong>N</strong></td>
<td><strong>%</strong></td>
<td><strong>N</strong></td>
<td><strong>%</strong></td>
<td><strong>N</strong></td>
</tr>
<tr>
<td>• good</td>
<td>19</td>
<td>95.00</td>
<td>15</td>
<td>68.18</td>
<td>27</td>
<td>79.41</td>
</tr>
<tr>
<td>• average</td>
<td>1</td>
<td>5.00</td>
<td>6</td>
<td>27.27</td>
<td>7</td>
<td>20.59</td>
</tr>
<tr>
<td>• Below average</td>
<td>0</td>
<td>0.00</td>
<td>1</td>
<td>4.55</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>H : FINANCIAL SITUATION</td>
<td></td>
<td><strong>N</strong></td>
<td><strong>%</strong></td>
<td><strong>N</strong></td>
<td><strong>%</strong></td>
<td><strong>N</strong></td>
</tr>
<tr>
<td>• excellent</td>
<td>0</td>
<td>0.00</td>
<td>0</td>
<td>0.00</td>
<td>2</td>
<td>5.88</td>
</tr>
<tr>
<td>• good</td>
<td>12</td>
<td>60.00</td>
<td>10</td>
<td>45.45</td>
<td>17</td>
<td>59.00</td>
</tr>
<tr>
<td>• bad</td>
<td>8</td>
<td>40.00</td>
<td>12</td>
<td>54.55</td>
<td>15</td>
<td>44.12</td>
</tr>
</tbody>
</table>
younger group and 32.3% in the older group, compared to 36.3% and 12.5% of DPS-B residents respectively. Fewer people in DPS-A need help – 50% and 58.8% in DPS-A, as opposed to 59% and 70.8% in DPS-B. In DPS-A, fewer older women are not able to perform daily activities – 8.82% in DPS-A and 16.67% in DPS-B, with slightly more younger women unable to perform daily activities – 10.00% in DPS-A and 4.55% in DPS-B (Table 1C).

In the younger group, DPS-A more women surveyed did not feel any pain or discomfort – 45%, but more felt huge pain – 10%. The respective rates in DPS-B are 27.2% and 4.5%. In the older group, fewer women in DPS-B did not feel any pain – 5.8% but fewer felt great pain – 17.6% (Table 1D).

The women in both DPS-A and DPS-B experience anxiety or depression similarly. The vast majority of women in both types of welfare centres and in both age groups are in a cheerful mood. A smaller percentage of respondents are cheerless and only one person from the group of older DPS-A residents feel depressed (Table 1E).

Both age groups in DPS-A were assessed better than the DPS-B as far as general health is concerned (Table 1F). In DPS-A, 75% of younger women and 67.6% of older women rated their health as very good. The respective rates in DPS-B were 54.5% in the younger group and 58.3% in the older group. None of the women assessed their health as very good.

A supplement to the life quality assessment is the assessment of housing conditions and financial situation. Women in DPS-A assessed their housing conditions higher than the women from average houses (Table 1G). A clear difference can be seen in the younger group, where the vast majority of women in DPS-A assessed their housing conditions as good. The high standard of rooms and the availability of rehabilitation and occupational therapy translates into a high assessment of housing conditions of the welfare centre.

People from the DPS-A also found their financial situation better, both younger as well as older women (Table 1H). More than a half of the women in DPS-A assessed their financial situation as good, and even as very good in the older group. Among people in DPS-B, negative assessment of financial situation prevails.

Mean values of satisfaction with life index are higher in the DPS-A than in DPS-B in both age groups (Figure 1). The residents of social welfare centres with a rich curriculum of motivating activities are more satisfied with life than the residents of centres with only basic curriculum.

To sum up the assessment of the quality of life in terms of housing standards, it was generally higher in DPS-A. This is particularly true as far as self-service, health, housing conditions, financial situation and life satisfaction evaluation is concerned. Evaluation of movement and performing daily activities is diversified. Anxiety and depression levels are similar.

**Discussion**

An important factor in evaluating the quality of life of elderly people may be their place of residence and the consequent level of daily activity. Living in a social.
welfare centre limits the resident’s activeness, and for this reason it seems important to implement a program of physical activity. This study shows that participation in the diversified programme of physical activity has a positive effect on the quality of life. Similar results were also obtained by other authors.

Studies by Tobiasz-Adamczyk and Brzyski show that the self-evaluation of health in old age increases with the level of functional activity [17]. Studies of Hungarian scientists show that, regardless of its type, physical activity has a positive impact on health and quality of life [18].

Barthalos et al. [19] examined women in Hungary residing in nursing homes and women from seniors clubs. Quality of life and level of physical fitness among women were higher in senior clubs. A sedentary lifestyle and low volatality of daily activities in the institution have negative impact on the level of fitness and quality of life of the residents. Active lifestyle, regular and diversified programme of activities seem to play the leading role in maintaining the quality of life among the population of elderly people. Similar results were reported by Jaracz and Woźna [9], who investigated the quality of life of residents in social welfare centres and people living at home. Evaluation of the quality of life of people living on their own was higher than of those living in welfare centres. Les and Gaworska [20] investigated men and women living in nursing homes and day care homes. People from day care homes perceive their daily functioning, health and well-being favourably.

Positive assessment of the quality of life in institutions was reported by Budzyńska-Kapczuk [21]. The study included people living in social welfare centres and a care and treatment centre. Residents of social welfare centres express satisfaction with the conditions. A stay at a long-term care facility has significantly improved the quality of life of patients in the sphere of cultural life and care for their own health. For the studies to be comparable, the socio-economic conditions in social welfare centres would have to be specified, since they affect the test results.

Our findings show that residents of social welfare centres positively assess their living conditions. Positive rating prevails especially among residents of DPS-A, most of whom assess positively the standard of the place of residence (nice rooms and bathrooms, rehabilitation and therapeutic rooms). Ślusarska et al. [22] investigated the relationship between functional performance and evaluation of housing conditions and the level of life satisfaction among elderly people living in welfare centres. The study showed that the functional efficiency of seniors and assessment of housing conditions affect the sense of satisfaction with life significantly.

Financial situation is evaluated lower. The main source of income of the elderly are pensions, which are often insufficient. When asked to assess the financial situation, the elderly often reply “not bad, because it has to be so.” Material security in old age is one of the factors which determine the degree of life satisfaction [23]. Their financial situation is more favourably assessed by the ladies in DPS-A. This may be because these centres have more to offer to their residents – properly conducted rehabilitation, interesting activities, library tours; thus, residents do not need to spend so much of their often modest income on medications, books, magazines, etc.

Subjective assessment of quality of life and functional ability shows the ability to function in life. The possibility of locomotion is one of the conditions for independent functioning of elderly people in a community. Maintaining physical fitness allows one to perform everyday activities.

Our findings show that a large percentage of surveyed women from both age groups (over 60% in the younger group and over 70% in the older group) has problems with mobility and in carrying out daily activities; self-service capabilities are evaluated higher. The women are often pain. These results seem to be justified, since one of the criteria for admission to a social welfare centre (apart from old age) is having difficulty living independently.

Residents of the older age group in DPS-A report more problems with movement. These problems include joint pain due to degenerative changes and imbalance. The surveyed women also classified amblyopia among difficulties with movement, although it is not connected with the state of the musculoskeletal system. Despite having problems with moving, the residents, thanks to well-conducted rehabilitation, move independently; moreover, a greater proportion of older women in DPS-A is independent in self-service and carrying out daily activities, as compared to women with DPS-B.

To sum up, higher assessment of the quality of life, functional ability and health status was reported in DPS-A, where residents have more opportunities to participate in rehabilitation, walks, occupational therapy and pleasured trips. It may be expected that physical activity, as well as active and diverse ways of spending leisure time will contribute to extending the period of good functional ability, autonomy and independence, and thus have a positive impact on improving the quality of life.
Literature


THE MOBILITY OF THE THORACOLUMBAR SPINE AND ITS RELATIONSHIP WITH RANGES OF MOVEMENT OF THE LOWER LIMBS IN THE HIP JOINT IN FEMALE STUDENTS

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Key words: correlation, mobility of the spine, hip, range of motion

Summary

Aim. The aim of the study is to compare TH-L spine motion with normative values and evaluate the relationship between mobility of TH-L and ranges of motion of the lower limbs of the hip joints.

Material and methods. The research involved a group of 40 II-III year female students from Holy Cross College in Kielce. We measured the motion of TH-L according to SFTR. The TH-L motion of the students was compared with the normative values for this age category. We used a goniometer to measure the range of the motion of hip joints.

Results. The side bend of TH-L, extension and flexion of the lumbar (L) spine of the females are less than the normative values. The side bend of TH-L is correlated with extension and adduction. The extension of the L correlates with the abduction of the left and right lower limbs. The flexion of the L correlates with the adduction of the left and right lower limbs.

Conclusions. The students have less range of TH-L motion, but this trend should be verified with a more representative research group. Larger range of side bend of TH-L depends on bigger extension and adduction of the lower limbs. Bigger extension of L depends on bigger abduction of the lower limbs, and bigger spine flexion depends on bigger adduction of the lower limbs.

Introduction

Anatomy and biomechanics of the spine are viewed as a whole determining locomotor activity in terms of statics and dynamics. Bipedal mode of locomotion, performing daily activities in a standing position, poor movement habits, sedentary lifestyle and obesity are just some of the causes of TH-L spine overload disease. Chronic overloading mechanism leads to pain, which if left untreated promotes morphological and functional changes in the spine, eliminating human socio-professional activity [1, 2, 3, 4].

The evaluation of the anatomic and biomechanic build of the TH-L spine has really been the topic of scientific research, although there are no comparative papers regarding motion of the TH-L spine of adults from a local environment with the normative values for this age category. The evaluation of the relationship of the TH-L spine motion with the motion range of the lower limb hip joints of adults was not also shown in a satisfying way. That is why we conducted research which became the starting point in formulating the following research questions:
1. Are there any significant differences between the TH-L spine motion of the examined female students and the normative values for this age category?
2. What is the relationship between mobility of the TH-L spine and hip movement of female students?

Material and methods

Cross-sectional studies were conducted in a randomly selected group of 40 II-III year physiotherapy students, enrolled in part-time B.A. studies at Holy Cross School in Kielce. The study was conducted in January 2012. The average age of students was $\bar{x} = 22.9 \pm 4.6$ years. There were no obese persons in the research group. Basic statistical characteristics of the lower limb range of motion in the left and right hips are presented in Table 1.

The subjects represented an urban environment. To ensure homogeneity of the test, the material was approved to study only right-handed subjects, in whom no anatomical abnormalities of the spine were observed. Students included in the study were not professionally involved in sports and did not report any history of previous injuries or diseases of the musculoskeletal system. All the participants were informed about the objectives, safety measures and how research was to be conducted. All persons agreed to participate in the research. The study was carried out in a gym, where the temperature did not exceed 20°C.

The basic research method was line measurement of the TH-L spine motion according to SFTR with the accuracy of 1mm. We compared the TH-L spine motion of the female students with the normative values suggested by Zembaty [5] for this age category. In addition we measured the range of left and right hip joints of the lower limbs with the accuracy of 1° goniometrically. The measurements allowed to determine whether the mobility of the spine has a relationship with ranges of movement of the lower extremities in female students.

Statistical distribution of the analyzed features of the Kolmogorov-Smirnov test were examined. Due to the fact that the features of the investigated parameters

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<th>min-max</th>
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<td>110-130</td>
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<td>15-45</td>
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<td>9.1</td>
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<td>9.1</td>
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<td>2-3</td>
<td>2.5</td>
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<td>0.6</td>
<td>7-9</td>
<td>9.0</td>
<td>-2.7806**</td>
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<td>8.5</td>
<td>0.7</td>
<td>7-9</td>
<td>9.0</td>
<td>-2.6141**</td>
<td>0.0055</td>
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<td>4.5</td>
<td>0.8</td>
<td>4-6</td>
<td>4.3</td>
<td>0.0000</td>
<td>0.5000</td>
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<tr>
<td>Turn toward the right Th-L</td>
<td>4.5</td>
<td>0.8</td>
<td>4-6</td>
<td>4.5</td>
<td>0.0000</td>
<td>0.5000</td>
</tr>
<tr>
<td>Extension L</td>
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<td>0.7</td>
<td>6-9</td>
<td>8.0</td>
<td>-5.4568**</td>
<td>&lt; 0.0001</td>
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<td>0.5</td>
<td>5-7</td>
<td>6.0</td>
<td>-7.5955**</td>
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Statistical significance at the level is marked with an asterisk: **p ≤ 0.01
were normal, for this type of distributions, relevant tests were performed. In order to show if there are any significant differences between the TH-L spine motion and the normative values we used the Student t-test. To assess the relationship between spinal mobility of the TH-L and range of movement of the lower limbs of the hip, Pearson’s linear correlation was used, in various combinations, taking into account the value of the calculated coefficients of t and r, as well as the level of statistical significance: p ≤ 0.05; p ≤ 0.01 [6]. The calculations were done in the Computing Facility of the Oncology Center in Kielce using MedCalc software – version 11.4.3.0., licensed by the Holy Cross Oncology Center.

Results

The comparative research of the spine motion showed that the side bend of the TH-L spine, the extension and flexion of the lumbar spine of the female students from Holy Cross College are less than the normative values, and the differences are statistically significant at p ≤ 0.01 (Table 2). We found positive correlations between both left and right side bends of the TH-L spine and the extension and adduction of the hip joints of the lower limbs. And thus, the left side bend of the TH-L spine correlated with the extension and adduction of the left lower limb at the level of p ≤ 0.05. In turn, the right side bend of the TH-L spine correlated with the extension of the right lower limb at the level of p ≤ 0.05, but with the adduction of the right lower limb at the level of p ≤ 0.01 (Table 3). We noted positive correlations between the L spine extension and the abduction of the left and right lower limbs at the level of p ≤ 0.05. The L spine flexion positively correlated with the adduction of the left lower limb at the level of p ≤ 0.05 and with the adduction of the right lower limb at the level of p ≤ 0.01 (Table 3).

Discussion

The spine is the main kinematical chain of mobility. From the biomechanical point of view, the anatomical structure of the spine is comprised of relatively rigid band members – bones connected by joints, a certain motion, moving against each other in a muscle system [1].

In a standing position, the spine is subjected to significant loads, which as a result of deterioration of spine properties, gradually leads to congestion and pain. Shear muscle force is responsible for the formation of

<table>
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<tr>
<th>Type of motion</th>
<th>extension</th>
<th>flexion</th>
<th>abduction</th>
<th>adduction</th>
<th>external rotation</th>
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<tr>
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<td>p = 0.9609</td>
<td>p = 0.8612</td>
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<td>0.379*</td>
<td>-0.039</td>
<td>-0.089</td>
<td>0.385*</td>
<td>0.003</td>
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<td>p = 0.9838</td>
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<td>0.172</td>
<td>0.231</td>
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<td>-0.171</td>
<td>-0.065</td>
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<td>0.345*</td>
<td>0.210</td>
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<tr>
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<tr>
<th>Left lower limb</th>
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<tr>
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Statistical significance at the level is marked with an asterisk: * p ≤ 0.05; **p ≤ 0.01
pathological changes in tissues of the spine, balancing the load of the segment of the spine, not the vertical force. The mechanism of overload syndromes of the spine is the result of one-sided, repetitive work-related professions, with increased risk: industry, construction and transport. Team overload of the TH-L spine is manifested by pain, which in the initial period is short and goes away by itself after rest, but in advanced states, the pain persists for a longer period of time, radiating to the legs, causing numbness of the surface and paresis of certain muscle groups [1, 2, 4, 7, 8, 9, 10].

The scientific studies were conducted in order to find the reason for this pain and evaluate the effectiveness of physiotherapy in treatment of spine pain, still there are no comparative studies on linear TH-L spine motion of adults from local environments relative to the normative values for this age category. Attempts to estimate norms were undertaken by providing values for angular movement of the L spine in the sagittal, frontal and transverse planes. Troke et al. [11, 12] used a modified analyzer for testing spinal mobility (CA6000, Orthopedic Systems Inc., Union City, CA & Troke/University of Brighton), developing a standard range of motion of the L spine in 405 people, age 16 and. The average L spine flexion was 73° in the youngest age group and 40° in the oldest. The extension of the L spine was 29° and 6°, side bend – 28° and 16°, and the range of rotation remained constant at 7° in both groups. Hagner-Derengowska et al. [13] applied the three-dimensional motion analysis system based on active ultrasonic transmitters company ZEBRIS GMBH to evaluate the side bend of the L spine. Measurements taken in 30 patients aged 19-62 showed that the mobility of the L spine in the frontal plane was at an average of 19.5°.

Our research shows that the female students of the Holy Cross College have less side bend of TH-L spine, less extension and bend of the L spine than the normative values, and the differences are significant. But it should be pointed out that the spine motion was compared with the normatives developed in 1989 by Zembaty [5], which probably do not correspond with current changes in biological development of men, appearing as the consequences of civilization’s development. The normatives must be updated every 10-15 years, just because of the secular trend and accelerated development. That is why there is a need to make population studies in order to develop new – current normatives of spine motion for people in progressive developing periods and for adults. Only then will we be able to accurately compare the spine motion of the research group with the normative values for this age category. Therefore, results of our research should verify subsequent studies taking our assumptions into account.

Care for the spine begins when a person begins to feel discomfort or starts to become socially or professionally limited due to pain. Therefore, it is important to study the significance of determining the relationship between the degree of movement of the spine and range of motion of the lower limbs in the hips. The results of research can contribute to early prevention, eliminating the potential risk factors in people predisposed to dysfunction of the spine in the future.

Previous research has not clearly shown how the TH-L spine motion depends on the hip joints of the lower limbs motion range of adults. Gabryelski and Wojtkowiak [11] evaluated the relationship between spinal mobility and selected functional tests. Our study showed a positive correlation with the Patrick test in bend, slope side, rotation of the L spine; Laseque pseudo test with flexion, extension, rotation of the L spine; Thomas test with flexion, extension, lateral slope, rotation of the L spine. These relationships prove biomechanical dependencies between the elements included in the TH-L locomotor complex.

Our own research shows that bigger range of the side bend of TH-L spine determines bigger range of the extension and adduction of the hip joints of the lower limbs. Furthermore, a greater range of extension of the L spine accompanied by a greater range of abduction of the hip joints of the lower limbs, a greater range of flexion of the L spine fosters a greater adduction of the hip joints of the lower limbs. This means that these ranges of movement in the TH-L spine in the frontal and sagittal planes are determined, and strongly linked in the first instance to the ranges of extension, abduction and adduction of the lower limbs at the joints. It should be emphasized that the movement of the lumbar-pelvic complex is coordinated with the movement of the hips, causing lumbar-pelvic rhythm during flexion and extension movements. In a standing position with straight knee joints, motion is achieved by flexion in the joints of the hip, antversion of the pelvis and L spine flexion. The share of particular movements in the whole range of the bends depends on muscle length (e.g., knee flexors), joint mobility (e.g., hip joints, intervertebral joints and sacroiliac joints) and neural control. This observation may have important and practical significance, because biomechanical capabilities of the lower limbs in the hip joints should be used in the prevention of spinal disorders of the TH-L. The tangible results of the research can be found the fact that we should take prophylactic action which decreases the risk of overload disease of the spine in people at a productive age.

Conclusions

Correlation studies of the spine range of motion in the thoraco-lumbar spine with the range of body movement of the legs in the hips of students revealed:
The Mobility of the Thoracolumbar Spine and its Relationship with Ranges...

1. The female students have a lesser side bend range of the TH-L spine, extension and bend of the L spine than the normative values. The presented differences are significant. It should be pointed out that the results should be verified by population studies, and because there are no current spine motion normatives in SFTR – new ones should be developed for this age category.

2. Greater range of flexion lateral TH-L spine, both left and right, depend on a wider range of extension and greater adduction of the hip joints. In addition, greater extension in the L spine fosters a greater abduction of the legs at the hips, greater flexion of the L spine fosters a greater adduction of the lower limbs at the hips.

Literature


Word count: 2,640
Tables: 3
References: 14

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