REGULATIONS FOR ARTICLE PUBLICATION

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 (anthropomotorsics) 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.

In accordance with the aim of the journal, the subject of the article should fall under one of the four thematic categories:

I. Theoretical and applied aspects of kinesiology (Fundamental and Applied Kinesiology).
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 (Varia).

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Example:
Tabela 1., Ryc. 1., Objaśnienia, Chłopcy
Table 1., Fig. 1., Commentary, Boys

• Figures and tables should be placed on separate pages (See: Illustrative material);

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**The main body of the text (in English and Polish)**

The main body of the text should include the following parts:

**Introduction.** Introduction acquaints the reader with the subject of the article and places it against the background of existing research (literature review).

At the end of the introduction, the aim, research problems and hypotheses should be clearly stated.

**Material and methods.** An accurate description of the research subject (material) should be presented in the methodological part. The number of subjects, their age, sex and other characteristics of the participants should be indicated. Additionally, information regarding the conditions of testing, time and methods, techniques and research instruments, with particular emphasis on the description of the used apparatus should be given. The name and address of its producer should be given. If an original method or technique of research was used, it should be described precisely by presenting its validity and reliability (reproducibility). In the case of modifying already recognized methods, the applied changes must be described and the need for these changes must be justified. Statistical methods should be explained so that it can be easily determined whether they are properly suited for the purpose of research. The author of the review or meta-analysis should provide methods of searching for materials, methods of selection, etc.

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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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**Bibliographic description of the article should include:***

\[\text{the name of the author(s), initial(s), surname(s), title of the article, name of the journal in functioning abbreviated form, year of publication, issue, volume number, pages, DOI number (if the publication has one). Bibliographic description should end with a full stop.}\]

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Monograph publisher (collaborative work)

Chapter in the monograph (collaborative work)

Conference reports (papers)

Monographs published in electronic version

Articles in journals. Standard, list only six authors, above six — abbreviated: et al.


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Example:


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  Tables – standardized format, reducing grid lines to a minimum.

Example:

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>A Me</th>
<th>SD</th>
<th>B Me</th>
<th>SD</th>
<th>d</th>
<th>Significance level p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age [years]</td>
<td>21.5</td>
<td>3.2</td>
<td>22.0</td>
<td>1.5</td>
<td>–0.5</td>
<td></td>
</tr>
<tr>
<td>Body height [cm]</td>
<td>176.2</td>
<td>3.3</td>
<td>178.0</td>
<td>4.1</td>
<td>–1.8</td>
<td>0.567 =</td>
</tr>
<tr>
<td>Body mass [kg]</td>
<td>68.3</td>
<td>2.7</td>
<td>79.4</td>
<td>3.5</td>
<td>–11.1</td>
<td>0.005 *</td>
</tr>
<tr>
<td>BMI [kg/m²]</td>
<td>22.3</td>
<td>2.2</td>
<td>25.7</td>
<td>2.8</td>
<td>–3.4</td>
<td>0.006 *</td>
</tr>
</tbody>
</table>

NS – statistically non-significant difference
* – p<0.05; ** p<0.05; ***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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EDITOR-IN-CHIEF’S FOREWORD

HIGH-LEVEL ACTIVITY IN 2016 – ANTROPOMOTORYKA. JOURNAL OF KINESIOLOGY AND EXERCISE SCIENCES (JKES)

The seventy-sixth issue of Antropomotoryka. Journal of Kinesiology and Exercise Sciences (JKES) is the last one in 2016. Both its volume and subject matter testify to continuously great activity of the authors conducting research in the field of determinants of broadly-defined human activity, and thus, to the vitality and activity of the journal on the publishing market. What should also be remembered are the difficulties and obstacles that had to be overcome by the Editorial staff, so that another issue of our Krakow and Wrocław-based quarterly journal could appear. The eight articles addressed to our recipients in December add to the total of 31 dissertations and scientific papers published this year in the four thematic sections of the journal. Certainly, such an achievement cannot be satisfying. In a sense, it is partly a result of the interest of the authors in the journal’s scope, but also (and, above all) of the requirements put on print publications. We hope that readers will share our opinion that close reading of the papers in the last issue of Antropomotoryka. Journal of Kinesiology and Exercise Sciences (JKES) is worth the time. What can be found in them?

The chapter Theoretical and applied aspects of kinesiology contains the article Body posture, postural stability and body composition (Fundamental and Applied Kinesiology). The first one shows the results of the diagnosis of posture, stability and body composition of 11 young handball players from the best sports clubs in Poland. Based on the results of the measurements, the strength of the relationships between the above-mentioned anthropometric indices was examined. Appropriate measurement methods were applied at the Institute of Physiotherapy, Faculty of Medicine and Medical Technology, UJK, Kielce.

As we all know, playing handball involves asymmetric movements. As a result of their frequent use by goalkeepers, they can help develop body posture defects; the study confirms this hypothesis. A flattening of the thoracic kyphotic angle and lumbar lordotic angle was observed. The majority of the examined adolescents had residual scoliosis. No significant correlations were found between body posture variables and body composition, or between postural stability and body composition. A positive correlation was observed between trunk length from vertebra C7 to the midpoint between the sacral dimples (Trunk length VP-DM), and trunk length VP-SP from C7 to the beginning of the groove between the buttocks (mm) (Trunk length VP-SP) (mm), and the percentage of in Quadrant 1 (% Time In Quadrant I), i.e. sway to the right anterior.

Taking into account the systematic increase in the level of intensity of the training programme for young people, the issue was raised to perform medical examinations at least twice a year to monitor their health status. In addition, it would be appropriate to introduce corrective and posture-equalizing exercises to the sports training programme.

The results of further studies in the "Scientific basis of motor function training in sports and recreation (Sport Sciences)" chapter are interesting from the cognitive perspective. They also point out the possibility of using them in sports practice and in physical education. In the first of these articles, the authors address the problem of the health effects of physical activity on individuals not adapted to exercise in the environment that causes hypoxia. The topic is not new, but the observations made in natural conditions and the results obtained in them are unmatched on a global scale.

The study was conducted in Nepal, in the Himalayas, during a trekking trip to the Mount Everest Base Camp. The expedition took place between 6th and 28th October 2015. During the trek, participants crossed the distance separating Lukla (2840 m a.s.l.) and the Everest base (5364 m a.s.l.), passing through the Sagarmatha National Park and back through the Chola Pass and the Gokyo area. The purpose of the observations was to determine the effect of intensity of physical activity accompanying extreme tourism (high mountain climbing) on selected physiological and psychological indices. The subsequent trekking stages in the Himalayas (6 sections, from 2800 m a.s.l. to 5300 m a.s.l.) were investigated from the point of view of the their impact on adaptation of the cardiopulmonary system and general well-being. Measurements were being made only until the Everest base was reached.

Another article, “Once again about the methods of determining sensitive and critical periods”, relates to the
problem of the influence of children’s physical activity on their intellectual and physical fitness, with particular emphasis on the sensitive and critical periods that were discovered in the early twentieth-century by analogy to the stages of Larvae and poppy seeds development by doctor and pedagogue Maria Montessori. Even though it is well-known that the concept of existence of the phenomenon has far-reaching application effects in pedagogy, its existence and location have not yet been scientifically confirmed. The results of the study encourage further experimental research to determine whether the Montessori concept (transferred even to the selection problem in competitive sports without any afterthoughts), as well as the impact of the suggested influence of physical activity on human intellectual development are scientifically true or rather mythical.

The chapter Teaching, controlling and monitoring motor functions. Scientific basis, formation and evaluation of activity and physical fitness (Exercise Sciences) contains three thematically and methodologically related papers: “Physical activity and drugs among youth”; “Physical activity of first-year students”; “The level of motor ability among young pupils and selected determinants.”

The research problems the papers address may be related to the intention of exploring the differentiation of development of motor activity among children and adolescents due to the style and quality of life, results at school and the level of somatic development, examined with the help of the IPAQ questionnaire. Interesting and important are the documents confirming the state of the present determinant of biological development of man and, above all, the health of young Polish society in a united Europe. Even greater focus on the problem can be found in the fourth paper, found in the section: Level of motor ability of children in school age and its chosen determinants. The paper points to the effects of negligence in shaping healthy attitudes in young people from the chosen ecological niche of our country.

Traditionally, to end the survey of the content of further sections, we invite our readers – thanks to our permanent collaborator, still rarely called the “barbarian from the palace of science” – to the exclusive club of connoisseurs of science, to an intellectual feast of listening to an on-going discussion, whose mentor and narrator is the author of “Anticipation, a multimodal phenomenon.” Let me quote an unabridged part of a summary of his work:

“The author expresses the view that modern mathematics cannot be as useful in biology as it is in physics. So, in biology in general and in the study of human motor abilities (antropomotoryka) in particular, a particularly promising “ordering tool” seems to be the systematic-theoretical approach. Perhaps the most mature theory of human behaviour was created by N.A. Bernstein. He developed a five-level system of building movements (“a mental skyscraper”). Its base consists of evolutionary and neurophysiological knowledge, so the links to individual classes of human movements are quite complex. Instead, a simplified model of “modular ladders” is presented. The model follows from Bernstein’s theory, so it also has five levels, but it “distills” from it the main physical spatial and temporal relations, together with the level-specific information processing codes. Various modalities of information processing determine both its speed and depth, and consequently also the scope of prediction. In humans, accurate prediction compensates very well for sensory deficits (as compared to animals). In modern civilization it is essential in daily activities, such as driving a car …”

“Sport is one of the fields of human activity in which the most important is the perfection of movement (though not necessarily its sensibility). It is particularly important to have reliable predictions that allows man to build an answer even before an appropriate, sensible stimulus has been received. Analysis of the “predictive ladder” was depicted on the example of a knock-out in boxing …”

I do not know if by reviewing the content of the last 2016 issue I have proved it worth the time to study the eight scholarly dissertations. I believe that it will be confirmed by those for whom it is important to acquaint themselves with the latest works on human motor activity. I also encourage the readers to focus on the new issue, which will be released in 2017.

To end the presentation of the content of the issue 76, on behalf of the whole staff, I would like to wish all the readers a traditional Merry Christmas and a Happy New Year. At the end of the Old Year, the Editor-in-Chief wants to thank his deputys, editorial secretary, editorial team, dozens of reviewers scattered all over the world, the native speaker; for their mostly social work, dedication and hard work aimed at presenting dozens of new original reports from various scientific centres. I wish all those who have in any way contributed to these words of the chief editor: finis corat opus, that they, in the new year, reach the stars through hardships, not only in the words of the Latin maxim, but also in their professional activities and personal life.

Edward Mleczko
Editor-in-Chief
BODY POSTURE, POSTURAL STABILITY AND BODY COMPOSITION IN GOALKEEPERS OF THE POLISH NATIONAL JUNIOR HANDBALL TEAM

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Key words: body posture, postural stability, body composition, goalkeepers of the Polish National Junior Handball Team

Abstract

Aim. The objective of the study was to evaluate body posture, postural stability as well as body composition and to analyze the relationship between these parameters in goalkeepers of the Polish National Junior Handball Team.

Basic procedures. The study covered 11 goalkeepers of the Polish National Junior Handball Team, aged 15-19. Body posture was evaluated by the Diers Formetric III 4D optoelectronic method. Postural stability was examined using the Biodex Balance System platform. The study was conducted in the Posturology Laboratory at the Institute of Physiotherapy at the Faculty of Medicine and Medical Sciences, UJK in Kielce.

Results Main findings. The flattening of the thoracic kyphotic angle and lumbar lordotic angle was observed. The majority of adolescents in the study had residual scoliosis (12.36°). During the Postural Stability Test, all of them remained in Zone A (the best stability), and in the majority of cases had a tendency towards sway to the right posterior (% Time In Quadrant I). A positive correlation was found between the trunk length from vertebra C7 to the central point between the sacral dimples (r=0.6507; p=0.030) and the trunk length VP-SP from C7 to the beginning of the groove between the buttocks, and the percentage of staying in Quadrant 1 (% Time In Quadrant I), i.e. sway to the right anterior (r=0.6317; p=0.037).

Conclusions. Handball is a discipline of sports discipline asymmetric in nature, which may be the cause of the occurrence of posture defects. Postural education exercises should be included in the training programme of juniors.

Introduction

Individual sports disciplines, through the specific form of movement, exert an important effect on the course of physical development of adolescents in whom the efficiency of the body systems has not yet fully developed, and the ossification period has not been completed. Handball is characterized by high diversity and dynamics of movement. High technical and tactical requirements of contemporary handball require a tremen-
dous outlay of work and effort on the part of a player, and a large amount of time to train individual elements of the game. Thus, do the high intensity and training loads negatively affect the body posture in athletes? Is there enough time during the entire training cycle for total body conditioning and compensatory exercises, which provide balance in physical development and eliminate the effects of one-sided sports specialization?

Body posture is currently defined as the way of maintaining an upright position, the outer manifestation of which is the spatial system of individual segments of the body and body silhouette. Posture is perceived as a dynamic act, maintaining proper body position against the force of gravity and in unfavourable conditions of unstable equilibrium. The human body is not a rigid body, but rather a dynamic system; therefore, the maintenance of a vertical position is a kind of motor act. The maintenance of a specified posture is the ability of coordination, while the development of coordination is a long-lasting process which requires a great amount of repetitions [1].

The maintenance of balanced posture by an individual is a specific motor activity which requires precise cooperation of all segments of the body as a result of dynamic processes taking place outside the consciousness. The CNS is a mediator in the registration and processing of the afferent signals and generalization of decisions in the efferent pathways [2]. This requires constant cooperation of the sensory systems: proprioceptive, vestibular, visual and hearing, as well as extero- and mechano-receptors registering the deviations of the projection of the centre of body mass from the set-point, with the executory system performing compensations to minimize these deviations. Humans maintain balance due to the work of skeletal muscles under the control of the nervous system. The nervous system, based on the obtained information, mobilizes motor units, selects threshold values of the stimulation of particular muscles, establishes the principles of their coordination and affects the characteristics of movement by means of the processes of stimulation and inhibition. This causes changes in visco-elastic properties of the whole body, performing the characteristic oscillatory movements, so-called postural sways [3].

By human balance we should also understand the capability for maintaining the projection of the centre of gravity (COG) within the support surface determined by the outline of the feet. This is a purely functional characteristic, measured based on the registration of a signal representing the point location of the COG (so-called postural sway). The stability of body posture is a considerably more complex concept, related with the capabilities, dynamic properties and characteristics of all the systems engaged in the maintenance of balance. This concerns, among others, the efficiency of the motor system, speed of reaction and decision-making and the skills of correct analysis of contradictory information concerning the present state of the body, including the position of its segments, their velocity and acceleration [2].

Assessment of this stability is possible due to the analysis of a signal representing the point location of the vertical ground-reaction-force vector, defined as the centre-of-foot pressure (COP). This signal is the superposition of the COG with adjustment effects of the motor system, aimed at the provision of a stable standing position. The COP and COG signals are consistent only in static conditions, when the COP is the projection of the COG on the support surface. The COP signal of a person performing free-standing with both feet dislocates by approximately 0.4 cm in the sagittal plane, and by approximately 0.18 cm in the frontal plane. The COG sways are slightly lower. The differences in the COG and COP dislocations in the sagittal plane are associated with moments of force generated in the knee joints. In turn, a lower amplitude of the COG sways in the frontal plane is the result of work of the adductor and abductor muscles in the hip joint. The essential mechanisms maintaining equilibrium are anticipatory and compensatory postural adjustments. Control of body equilibrium and the time needed for the performance of voluntary movements require, especially at an initial stage, anticipatory adjustment. Body posture maintenance is primarily the result of the functioning of the mechanism of compensatory adjustments. Both of these mechanisms require the engagement of various levels of the CNS [2, 4].

The aim of the study was to evaluate body posture, postural stability as well as body composition and to analyze the relationship between these parameters of goalkeepers of the Polish National Junior Handball Team.

**Material and methods**

The study covered 11 goalkeepers of the Polish National Junior Handball Team aged 15-19; mean age 16.82; standard deviation 1.6; median value 17; inter-quartile range from 15–19; and the total range from 15–19 (Tab. 1). The apprenticeship training of the adolescents in the study was from 5-10. They trained every day, and the duration of the training unit was 90 minutes. The study was conducted on 11 February 2014, in the Laboratory for Posturology t the Institute of Physiotherapy at the Faculty of Medicine and Medical Sciences, UJK in Kielce.

Body posture was examined by the optoelectronic test body posture Formetric Diers Method III 4D using the raster stereography. Three dimensional analysis of the spine conducted using a combination of the most modern optical technique and digital data processing.
This is quick and touchless non-tactile photometric 4D measurement and analysis of the patient’s back surface and spine. The examination was performed using DICAM software by means of average measurements consisting in the performance of 12 images which, by creating the mean value, reduce postural variances and, consequently, improve the clinical value of the test. The computer performed the averaging of the images and recorded one of them. Due to this, the clinical value of the examination was very high.

The following parameters describing body posture were analyzed:
- kyphotic angle ICT-ITL (max.)°; kyphotic angle inflexion point cervical thoracic- inflexion point thoracic lumbar max°. This is the maximum kyphotic angle measured between the tangents to the upper cervical thoracic inflexion point (ICT) in the vicinity of the vertebrae prominens (VP), and the thoracic lumbar inflexion point (ITL). The normal value for the kyphotic angle is 47°-50°; lordotic angle ITL - ILS (max.)° (lordotic angle inflexion point thoracic lumbar- inflexion point lumbar sacral max°). This is the maximum lordotic angle measured between the tangents to the surface of the thoracic lumbar inflexion point (ITL), and the lower lumbar-sacral inflexion point (ILS). The normal value for lordotic angle is 38°-42°; scoliotic angle. Measurement with the Diers formetric III 4D exclusively concerns the spine and shows the curvature angle from 1°; trunk length VP-DM (mm) (trunk length vertebra prominens - dimple middle). This is the distance between the VP point (vertebra prominens) and the DM point (dimple middle). DM is the middle point located between the sacral dimples DL–DR (dimple left - dimple right); trunk length VP-SP (mm) (trunk length - vertebra prominens-sacrum point). This is the distance between the VP point (vertebra prominens), and the SP point (sacrum point) which is the beginning of the groove between the buttocks (rima ani). This is independent of the patient’s position with respect to the measurement system; pelvic tilt in degrees (°). Pelvic tilt refers to the difference in the height of the sacral dimples DL-DR (dimple left - dimple right), with reference to the transverse surface (cross-section). A positive value means that the right dimple is higher than the left dimple, whereas a negative value occurs when the right dimple is located below the left dimple; pelvic tilt (mm). Pelvic tilt refers to the difference in heights of the sacral dimples DL-DR (dimple left - dimple right), with reference to the transverse surface (cross-section). A positive value means that the right dimple is higher than the left dimple, whereas a negative value occurs when the right dimple is located below the left dimple; surface rotation max°. This parameter means a maximum rotation of the surface of the vertebrae on a symmetry line. Positive values mean a maximum surface rotation to the right, while negative values mean maximum surface rotation to the left side; surface rotation (+ max.)°. This parameter means a maximum right-side rotation of the surface of the vertebrae on the symmetry line to the right side. Normal values for the measurements with the Diers formetric III 4D were compiled by Harzman [6,7].

Postural stability was evaluated using the Biodex Balance System platform. The Postural Stability Test was performed with both feet positioned on a stable background, with open eyes. The platform was blocked, which means that it was rigid and fully stable. After the introduction of personal data and body height, the patient’s position was determined. For this purpose, the centre line of the foot and platform axes were used as the points of reference. The position was determined by entering the angles of the position of the feet on the screen of the device, using the centre line separately for the right and left foot.

The Postural Stability Test consisted of three 20-second trials, divided by a 10-second break. During the examination, the patient’s sight was focused on the monitor screen, where a characteristic dot appeared (COP - centre of pressure), which was the symbolic presentation of the centre of feet pressure. The task of the patient was to balance the body in such a way that the dot (COP) was in the centre of the circle displayed on the monitor, at the point of intersection of the coordinate axes. During the examination, verbal correction of the patient was permitted. All the parameters registered by the posturological platform were collected in a totally non-invasive way, and the device was safe for the group.

For the assessment of postural stability, the following were used:
1. The Overall Stability Index (°). This index reflects variability of the positioning of the platform with respect to the horizontal plane expressed in degrees during all movements performed in the test. Its high value evidences a large number of movements performed during the test.
2. Anterior-Posterior Stability Index (°). This index reflects variability of the platform displacement for movements in the sagittal plane, expressed in degrees.
3. Medial-Lateral Stability Index (°). This index reflects variability of the platform displacement for movements in the frontal plane, expressed in degrees.
4. The percentage of time in the zone (%). This index is the time spent by a patient in a given zone. Target zones A, B, C and D are equal with respect to
the degree of platform tilt. They are determined by concentric circles with the middle in the centre of the platform.

- Zone A – from zero to five degree deviation with respect to the horizontal plane;
- Zone B – from six to ten degree deviation with respect to the horizontal plane;
- Zone C – from eleven to fifteen degree deviation with respect to the horizontal plane;
- Zone D – from sixteen to twenty degree deviation with respect to the horizontal plane.

5. Time in the Quadrant (%). This index is the time which the patient spent in a given quadrant. They represent four quadrants of the test graph between axis X and Y:

- Quadrant 1 – right anterior;
- Quadrant 2 – left anterior;
- Quadrant 3 – left posterior;
- Quadrant 4 – right posterior.

The patient’s scoring in the Postural Stability Test depended on the number of sways from the centre, which means that the lower the result, the better the postural stability [8].

Body composition was assessed using the method of bioelectrical impedance analysis (BIA), which consists in the evaluation of resistance to the flow of an electric current. For BIA analysis, knowledge is used concerning the prevalence of electrolytes and better electrical conductivity of muscle tissue, which contains a considerable amount of water. In turn, adipose tissue is less conductive. The BIA is a reliable, non-invasive and easily available means for the estimation of body composition parameters. As a research instrument, the Tanita MC 780 MA body composition analyser was used. As a result of the measurement, the following body composition variables were obtained: Body Mass (kg), Body Mass Index (BMI), Fat Mass FM (%), Fat Mass - FM (kg), Fat Free Mass – FFM (kg), Muscle Mass - MM (kg), Total Body Water - TBW (kg) and Total Body Water - TBW (mm) [8].

Statistical analysis was performed using the PQStat v. 1.6 package. Relationships between body posture, postural stability and body composition were analyzed by the estimation of Spearman rank correlation coefficients. The p values p<0.05 were considered statistically significant [9].

Results

The mean body height (cm) of the examined adolescents was 191.27; standard deviation 3.1; median value 191; interquartile range from 188–194; and total range from 187-196. The mean body mass (kg) was 88.41; standard deviation 12.26; median value 92.7; interquartile range from 78.7–95.7; and total range from 63–107.2. The mean BMI was 24.18; standard deviation 3.22; median value 24.7; and total range from 18.5–27.3; and total range from 17.3–27.9 (Tab. 1).

The mean kyphotic angle in the examined group was 41.09°; standard deviation 6.73; median value 40; interquartile range from 39–47; and total range from 28.52. The mean lordotic angle was 35.64°; standard deviation 8.78; median value 33; interquartile range from 31–42; and total range from 23.53. The mean scoliotic angle was 12.36°; standard deviation 4.65; median value 11; interquartile range from 9–16 and total range from 5–22 (Tab. 1). The mean trunk length (from C7 to the midpoint between the sacral dimples (mm) was 501.18 millimetres; standard deviation 14.61; median value 500; interquartile range from 485–514; and total range from 479–524. The mean trunk length (from C7 to the beginning of the groove between the buttocks) was 552.91 millimetres; standard deviation 13.63; median value 553; interquartile range from 538–565; and total range from 534–575. The mean pelvic tilt (+max.) was 2.09; standard deviation 1.04; median value 2; interquartile range from 0-3; and total range from 0-4. The mean pelvic tilt (mm) was 3.55; standard deviation 1.81; median value 3; interquartile range from 3–6; and total range from 0-6. The mean surface rotation (°) was 7; standard deviation 3.5; median value 6; interquartile range from 5–9; and total range from 3–13. The mean surface rotation (+max.) (°) was 6.36; standard deviation 3.98; median value 5; interquartile range from 4–9; and total range from 0-13 (Tab. 1).

The mean Overall Stability Index (°) in the examined group was 0.5 degree; standard deviation 0.12; median value 0.5; interquartile range from 0.4–0.6; and total range from 0.3–0.7. The mean Anterior-Posterior Stabil

ity Index (°) was 0.36 degree; standard deviation 0.1; median value 0.3; interquartile range from 0.3–0.5; and total range from 0.2–0.5. The mean Medial –Lateral Sta

bility Index (°) was 0.24 degree; standard deviation 0.1; median value 0.2; interquartile range from 0.2–0.3 and total range from 0.1–0.4. During the Postural Stability test, all the goalkeepers in the study (100%) remained in Zone A. During the trials for 20.73% of the time, the examined adolescents swayed to the right anterior (Quadrant 1), standard deviation 17.5; median value 15; interquartile range from 5–39; and total range from 2–47. The adolescents spent 12.91% of the time in Quadrant 2 (left anterior); standard deviation 10.63; median value 15; interquartile range from 2–20; and total range from 0–33. The mean time spent in Quadrant 3 (left posterior) was 15.27%; standard deviation 9.67; median value 12; interquartile range from 6–25; and total range from 3–30. The examined adolescents most frequently swayed to the right posterior, the mean time spent in Quadrant 4...
Table 1. Characteristics of body posture, postural stability and body composition

<table>
<thead>
<tr>
<th>Body posture variables</th>
<th>Mean</th>
<th>Standard deviation</th>
<th>Minimum</th>
<th>Lower quartile</th>
<th>Median</th>
<th>Upper quartile</th>
<th>Maximum</th>
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<tbody>
<tr>
<td>Kyphotic angle ICT-ITL max°</td>
<td>41.09</td>
<td>6.73</td>
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<td>39.00</td>
<td>40.00</td>
<td>47.00</td>
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<td>Lordotic angle ITL - ILS max°</td>
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<td>23.00</td>
<td>31.00</td>
<td>33.00</td>
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<td>53.00</td>
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<td>9.00</td>
<td>11.00</td>
<td>16.00</td>
<td>22.00</td>
</tr>
<tr>
<td>Trunk length VP-DM (mm)</td>
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<td>485.00</td>
<td>500.00</td>
<td>514.00</td>
<td>524.00</td>
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<tr>
<td>Trunk length VP-SP (mm)</td>
<td>552.91</td>
<td>13.63</td>
<td>534.00</td>
<td>538.00</td>
<td>553.00</td>
<td>565.00</td>
<td>575.00</td>
</tr>
<tr>
<td>Pelvic tilt (°)</td>
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<td>1.04</td>
<td>0.00</td>
<td>2.00</td>
<td>2.00</td>
<td>3.00</td>
<td>4.00</td>
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<tr>
<td>Pelvic tilt (mm)</td>
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<td>3.00</td>
<td>3.00</td>
<td>6.00</td>
<td>6.00</td>
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<tr>
<td>Surface rotation max°</td>
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<td>3.35</td>
<td>3.00</td>
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<td>6.00</td>
<td>9.00</td>
<td>13.00</td>
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<td>Surface rotation +max°</td>
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<td>4.00</td>
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<td>9.00</td>
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<table>
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<tr>
<th>Postural stability variables</th>
<th>Mean</th>
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<th>Median</th>
<th>Upper quartile</th>
<th>Maximum</th>
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<tr>
<td>Overall Stability Index (°)</td>
<td>0.50</td>
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<td>0.30</td>
<td>0.40</td>
<td>0.50</td>
<td>0.60</td>
<td>0.70</td>
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<td>Anterior-Posterior Stability Index (°)</td>
<td>0.36</td>
<td>0.10</td>
<td>0.20</td>
<td>0.30</td>
<td>0.30</td>
<td>0.50</td>
<td>0.50</td>
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<tr>
<td>Medial-Lateral Stability index (°)</td>
<td>0.24</td>
<td>0.10</td>
<td>0.10</td>
<td>0.20</td>
<td>0.20</td>
<td>0.30</td>
<td>0.40</td>
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<tr>
<td>Zone A (%)</td>
<td>100.00</td>
<td>100.00</td>
<td>100.00</td>
<td>100.00</td>
<td>100.00</td>
<td>100.00</td>
<td>100.00</td>
</tr>
<tr>
<td>Zone B (%)</td>
<td>0.00</td>
<td>0.00</td>
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<td>Zone C (%)</td>
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<tr>
<td>Zone D (%)</td>
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<td>0.00</td>
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<tr>
<td>Quadrant 1 (%)</td>
<td>20.73</td>
<td>17.50</td>
<td>2.00</td>
<td>5.00</td>
<td>15.00</td>
<td>39.00</td>
<td>47.00</td>
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<tr>
<td>Quadrant 2 (%)</td>
<td>12.91</td>
<td>10.63</td>
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<td>15.00</td>
<td>20.00</td>
<td>33.00</td>
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<tr>
<td>Quadrant 3 (%)</td>
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<tr>
<td>Quadrant 4 (%)</td>
<td>50.82</td>
<td>16.06</td>
<td>29.00</td>
<td>39.00</td>
<td>46.00</td>
<td>67.00</td>
<td>76.00</td>
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<table>
<thead>
<tr>
<th>Body composition variables</th>
<th>Mean</th>
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<th>Median</th>
<th>Upper quartile</th>
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<tbody>
<tr>
<td>Fat Mass (%)</td>
<td>16.71</td>
<td>4.12</td>
<td>10.70</td>
<td>14.30</td>
<td>15.10</td>
<td>19.40</td>
<td>24.50</td>
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<td>Fat Mass (kg)</td>
<td>15.01</td>
<td>5.14</td>
<td>8.90</td>
<td>9.90</td>
<td>14.00</td>
<td>18.20</td>
<td>23.90</td>
</tr>
<tr>
<td>Fat Mass (kg)</td>
<td>73.40</td>
<td>8.90</td>
<td>54.00</td>
<td>65.70</td>
<td>78.20</td>
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<td>83.30</td>
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<td>Muscle Mass (kg)</td>
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<td>51.30</td>
<td>62.40</td>
<td>74.40</td>
<td>75.60</td>
<td>79.20</td>
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<tr>
<td>BMI</td>
<td>24.18</td>
<td>3.22</td>
<td>17.30</td>
<td>22.50</td>
<td>24.70</td>
<td>27.30</td>
<td>27.90</td>
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<tr>
<td>Total Body Water (kg)</td>
<td>53.42</td>
<td>6.40</td>
<td>39.50</td>
<td>48.10</td>
<td>56.90</td>
<td>57.60</td>
<td>61.00</td>
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<tr>
<td>Total Body Water (%)</td>
<td>60.82</td>
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<td>59.00</td>
<td>61.80</td>
<td>62.70</td>
<td>63.60</td>
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</table>
The mean Fat Mass (%) was 16.71; standard deviation 4.12; median value 15.1; interquartile range from 14.3–19.4; and total range from 10.7–24.5, whereas the mean Fat Mass (kg) was 15.01; standard deviation 5.14; median value 14; interquartile range from 9.9–18.2; and total range from 8.9–23.9. The mean Fat Free Mass (kg) was 73.4; standard deviation 8.9; median value 78.2; interquartile range from 65.7–79.5; and total range from 54–83.3. The mean Muscle Mass (kg) was 69.77; standard deviation 8.49; median value 74.4; interquartile range from 62.4–75.6; and total range from 51.3–79.2. The Total Body Water (kg) was 53.42; standard deviation 6.4; median value 56.9; interquartile range from 48.1–57.6; and total range from 39.5–61. The mean Total Body Water (%) was 60.62; standard deviation 2.75; median value 61.8; interquartile range from 59–62.7; and total range from 55.3–63.6 (Tab. 1).

Analysis of the relationships between the parameters of body posture and the parameters of postural stability showed a significant positive correlation between the trunk length (TL) from vertebra C7 to the midpoint between the sacral dimples, expressed in millimetres (Trunk length VP-DM (mm)) (\(r=0.6507\); \(p=0.030\)) and trunk length VP-SP from C7 to beginning of the groove between the buttocks, expressed in millimetres (Trunk length VP-SP (mm)) (\(r=0.6317\); \(p=0.037\)) and Quadrant 1 (%), i.e. sway to the right anterior. The remaining correlations were statistically insignificant. No statistically significant correlations were found between body posture and body composition variables (Tab. 3), or between variables of postural stability and body composition (Tab. 4).

<table>
<thead>
<tr>
<th>Postural stability variable</th>
<th>Kyphotic angle ICT-ITL max°</th>
<th>Lordotic angle ITL - ILS max°</th>
<th>Scoliotic angle (°)</th>
<th>Trunk length VP-DM (mm)</th>
<th>Trunk length VP-SP (mm)</th>
<th>Pelvic tilt (°)</th>
<th>Pelvic tilt (mm)</th>
<th>Surface rotation max°</th>
<th>Surface rotation +max°</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall Stability Index</td>
<td>(r=0.3265)</td>
<td>(r=0.3562)</td>
<td>(r=0.1998)</td>
<td>(r=0.1157)</td>
<td>(r=0.1178)</td>
<td>(r=0.2428)</td>
<td>(r=0.2803)</td>
<td>(r=0.1768)</td>
<td>(r=0.1486)</td>
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<td></td>
<td>0.327</td>
<td>0.282</td>
<td>0.556</td>
<td>0.735</td>
<td>0.730</td>
<td>0.472</td>
<td>0.404</td>
<td>0.603</td>
<td>0.663</td>
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<tr>
<td>Anterior-Posterior Stability Index (°)</td>
<td>(r=0.3381)</td>
<td>(r=0.1946)</td>
<td>(r=0.4299)</td>
<td>(r=0.0018)</td>
<td>(r=0.0455)</td>
<td>(r=0.1526)</td>
<td>(r=0.2055)</td>
<td>(r=0.3783)</td>
<td>(r=0.3557)</td>
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<td></td>
<td>0.309</td>
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<td>0.996</td>
<td>0.894</td>
<td>0.654</td>
<td>0.544</td>
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<td>0.283</td>
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<tr>
<td>Medical-lateral Stability Index (°)</td>
<td>(r=0.1394)</td>
<td>(r=0.3933)</td>
<td>(r=0.0533)</td>
<td>(r=0.2447)</td>
<td>(r=0.2261)</td>
<td>(r=0.2204)</td>
<td>(r=0.2789)</td>
<td>(r=0.0873)</td>
<td>(r=0.1112)</td>
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<td>0.876</td>
<td>0.468</td>
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<td>0.515</td>
<td>0.406</td>
<td>0.799</td>
<td>0.745</td>
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<tr>
<td>Quadrant 1 (%)</td>
<td>(r=0.1675)</td>
<td>(r=0.1223)</td>
<td>(r=0.5992)</td>
<td>(r=0.6507)</td>
<td>(r=0.6317)</td>
<td>(r=0.2257)</td>
<td>(r=0.0146)</td>
<td>(r=0.3619)</td>
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<tr>
<td></td>
<td>0.623</td>
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<td>0.030</td>
<td>0.037</td>
<td>0.505</td>
<td>0.966</td>
<td>0.274</td>
<td>0.387</td>
</tr>
<tr>
<td>Quadrant 2 (%)</td>
<td>(r=0.5211)</td>
<td>(r=0.1217)</td>
<td>(r=0.4479)</td>
<td>(r=0.2234)</td>
<td>(r=0.2518)</td>
<td>(r=0.0458)</td>
<td>(r=0.0595)</td>
<td>(r=0.2135)</td>
<td>(r=0.0865)</td>
</tr>
<tr>
<td></td>
<td>0.100</td>
<td>0.721</td>
<td>0.167</td>
<td>0.509</td>
<td>0.455</td>
<td>0.894</td>
<td>0.862</td>
<td>0.528</td>
<td>0.800</td>
</tr>
<tr>
<td>Quadrant 3 (%)</td>
<td>(r=0.0711)</td>
<td>(r=0.2476)</td>
<td>(r=0.5894)</td>
<td>(r=0.4733)</td>
<td>(r=0.5320)</td>
<td>(r=0.1909)</td>
<td>(r=0.0608)</td>
<td>(r=0.3277)</td>
<td>(r=0.2601)</td>
</tr>
<tr>
<td></td>
<td>0.835</td>
<td>0.463</td>
<td>0.056</td>
<td>0.141</td>
<td>0.092</td>
<td>0.574</td>
<td>0.859</td>
<td>0.325</td>
<td>0.440</td>
</tr>
<tr>
<td>Quadrant 4 (%)</td>
<td>(r=0.1945)</td>
<td>(r=0.3658)</td>
<td>(r=0.0164)</td>
<td>(r=0.5707)</td>
<td>(r=0.5351)</td>
<td>(r=0.1420)</td>
<td>(r=0.0657)</td>
<td>(r=0.3386)</td>
<td>(r=0.1052)</td>
</tr>
<tr>
<td></td>
<td>0.567</td>
<td>0.269</td>
<td>0.962</td>
<td>0.067</td>
<td>0.090</td>
<td>0.677</td>
<td>0.848</td>
<td>0.308</td>
<td>0.758</td>
</tr>
</tbody>
</table>

\(^1\) Statistically significant at \(p<0.05\).
Table 3. Body posture and body composition

<table>
<thead>
<tr>
<th>Body posture variables</th>
<th>Fat Mass (%)</th>
<th>Fat mass (kg)</th>
<th>FFM (kg)</th>
<th>Muscle mass (kg)</th>
<th>BMI</th>
<th>TBW (kg)</th>
<th>TBW (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kyphotic angle ICT-ITL max°</td>
<td>r = -0.1056</td>
<td>r = -0.0923</td>
<td>r = 0.1586</td>
<td>r = 0.1594</td>
<td>r = 0.1680</td>
<td>r = 0.1175</td>
<td>r = 0.0145</td>
</tr>
<tr>
<td>Lordotic angle ITL - ILS max°</td>
<td>r = 0.1990</td>
<td>r = 0.1952</td>
<td>r = 0.0288</td>
<td>r = 0.0278</td>
<td>r = -0.0222</td>
<td>r = 0.0178</td>
<td>r = -0.2317</td>
</tr>
<tr>
<td>Scoliotic angle (°)</td>
<td>r = -0.1790</td>
<td>r = -0.1566</td>
<td>r = -0.1075</td>
<td>r = 0.1071</td>
<td>r = 0.0489</td>
<td>r = 0.1267</td>
<td>r = 0.2401</td>
</tr>
<tr>
<td>Trunk length VP-DM (mm)</td>
<td>r = -0.1610</td>
<td>r = -0.1799</td>
<td>r = -0.1805</td>
<td>r = 0.2225</td>
<td>r = -0.1666</td>
<td>r = 0.2209</td>
<td></td>
</tr>
<tr>
<td>Trunk length VP-SP (mm)</td>
<td>r = -0.1709</td>
<td>r = -0.1788</td>
<td>r = -0.1567</td>
<td>r = -0.1570</td>
<td>r = -0.1899</td>
<td>r = -0.1408</td>
<td>r = 0.2365</td>
</tr>
<tr>
<td>Pelvic tilt (°)</td>
<td>r = -0.4271</td>
<td>r = -0.4008</td>
<td>r = -0.1491</td>
<td>r = -0.1494</td>
<td>r = -0.3173</td>
<td>r = -0.1383</td>
<td>r = 0.4803</td>
</tr>
<tr>
<td>Pelvic tilt (mm)</td>
<td>r = 0.599</td>
<td>r = 0.664</td>
<td>r = 0.753</td>
<td>r = 0.754</td>
<td>r = 0.887</td>
<td>r = 0.710</td>
<td>r = 0.477</td>
</tr>
<tr>
<td>Surface rotation max°</td>
<td>r = -0.3319</td>
<td>r = -0.3652</td>
<td>r = -0.2357</td>
<td>r = -0.3246</td>
<td>r = -0.2289</td>
<td>r = 0.3944</td>
<td></td>
</tr>
<tr>
<td>Surface rotation +max°</td>
<td>r = -0.4735</td>
<td>r = -0.5628</td>
<td>r = -0.3808</td>
<td>r = -0.484</td>
<td>r = -0.3873</td>
<td>r = 0.5217</td>
<td></td>
</tr>
</tbody>
</table>

Table 4. Postural stability and body composition

<table>
<thead>
<tr>
<th>Postural stability variables</th>
<th>Fat Mass (%)</th>
<th>Fat mass (kg)</th>
<th>FFM (kg)</th>
<th>Muscle mass (kg)</th>
<th>BMI</th>
<th>TBW (kg)</th>
<th>TBW (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall Stability index</td>
<td>r = 0.0082</td>
<td>r = 0.0641</td>
<td>r = 0.0788</td>
<td>r = 0.0807</td>
<td>r = 0.0446</td>
<td>r = 0.0357</td>
<td>r = -0.1229</td>
</tr>
<tr>
<td>Anterior-Posterior Stability Index (°)</td>
<td>r = 0.1827</td>
<td>r = 0.2641</td>
<td>r = 0.2441</td>
<td>r = 0.2454</td>
<td>r = 0.3152</td>
<td>r = 0.1883</td>
<td>r = -0.3551</td>
</tr>
<tr>
<td>Medial-Lateral Stability Index (°)</td>
<td>r = -0.1426</td>
<td>r = -0.1599</td>
<td>r = -0.1423</td>
<td>r = -0.1410</td>
<td>r = -0.2426</td>
<td>r = -0.1564</td>
<td>r = 0.1320</td>
</tr>
<tr>
<td>Quadrant 1 (%)</td>
<td>r = 0.1131</td>
<td>r = 0.0732</td>
<td>r = -0.0998</td>
<td>r = -0.1000</td>
<td>r = -0.0744</td>
<td>r = -0.0821</td>
<td>r = -0.0660</td>
</tr>
<tr>
<td>Quadrant 2 (%)</td>
<td>r = -0.1426</td>
<td>r = 0.2840</td>
<td>r = 0.1005</td>
<td>r = 0.1008</td>
<td>r = 0.2314</td>
<td>r = 0.1298</td>
<td>r = -0.3436</td>
</tr>
<tr>
<td>Quadrant 3 (%)</td>
<td>r = 0.242</td>
<td>r = 0.189</td>
<td>r = 0.769</td>
<td>r = 0.768</td>
<td>r = 0.494</td>
<td>r = 0.704</td>
<td>r = 0.301</td>
</tr>
<tr>
<td>Quadrant 4 (%)</td>
<td>r = -0.1706</td>
<td>r = -0.1633</td>
<td>r = 0.0982</td>
<td>r = 0.0978</td>
<td>r = 0.0739</td>
<td>r = 0.0901</td>
<td>r = 0.1511</td>
</tr>
</tbody>
</table>
**Discussion**

The presence of physical activity in the daily life of an individual is an indispensable condition for maintaining normal body posture. An organized process of sports training is a specific form of motor activity. It is associated with regular and intensive loads on an athlete’s body affecting body posture [10]. Training, as a strong stimulus for the organism, exerts an effect on the functioning of the majority of systems and organs. The greatest changes take place in the muscular system, in which there occurs an increase in muscle mass and a change in the distribution of muscle tone. In other Polish studies, numerous asymmetries in the frontal plane were observed in persons training for team games, compared to judo players [11]. Studies by Jankowicz-Szynska and Imiolek confirmed the frequent occurrence of asymmetry of the cervicobrachial angles, waist triangles and pelvic position in persons training for handball, compared to those not training. In addition, in handball players, a tendency was observed towards a higher position of the right shoulder, the right shoulder blade and the right hip, as well as an increased waist triangle [12]. According to many researchers [13,14], the degree of changes in body posture may depend on the age at which a child starts regular sports training. Other studies [15] showed that training for competitions should not start earlier than after the completion of bone growth. During the training of handball, endurance and strength of physical effort, are characteristic. They determine specific motor behaviours and the assumption of typical postures during the game. The character of work is reflected by body posture in both the sagittal and frontal planes [16,17]. Although it has been widely shown that physical fatigue affects static postural sway, it is still questionable as to what extent these adaptations are relevant for dynamic, sports-related situations. The results showed that although fatigue affects static postural control, sensorimotor mechanisms responsible for regaining dynamic balance in healthy athletes seem to remain predominantly intact [18].

In other studies, expertise in gymnastics seemed to improve postural performances only in situations for which their practice is related to, i.e. the unipedal with open eyes. These reveal the importance of choosing a relevant postural configuration and visual condition according to the people’s training or by extension experience [19].

In our other studies on goalkeepers of the Polish National Junior Handball Team, balance reactions and body posture were analyzed. Balance was examined by means of the AMTI AccuGait dynamographic platform. An increase was noted in the balanced reactions with closed eyes, among others, on the example of pathway length ($t=3.59; p=0.0049$). Analysis of correlations between posture parameters and balance reactions showed a negative correlation between the kyphotic angle and the average load point X (mm) ($r=-0.7651; p=0.001$), and a positive correlation between the value of the lordotic angle and average load point X (mm) ($r=0.6434; p=0.0033$) [20]. Handball is a sports discipline asymmetric in nature, which may be the cause of the occurrence of posture defects. Postural education exercises should be included in the training programme of juniors. Posture defects have their source in physiological, morphological and environmental spheres. They occur at all body planes, most often during the growth period. The growing skeletal system is especially susceptible to any effects of loading. Hence, an asymmetry of loads unnoticed at the time and persisting for a long period may cause asymmetric bone growth and consequently, fixation of the defect already in the background of the structural changes. Changes caused by training are the function of its intensity and long-lasting duration. The majority of the examined adolescents started training approximately at the age of 12-13; therefore, during the period especially susceptible to changes in body posture due to the acceleration of the development of the skeletal system, with other systems not being able to simultaneously keep up with this acceleration, mainly the muscular, ligamentous and articular systems [20]. One-sided specialization during this developmental period may lead to disorders in body statics. The existing body posture defects may also develop as a result of frequently assuming a posture typical for this sports discipline. The observed postural defects in the adolescents in the study might have even occurred before they started to practice this sports discipline, or irrespective of it. The recruitment for sports is often a coincidence, and from a medical perspective, it is not always based on proper selection criteria [21]. Considering a systematic increase in the level and intensity of the training programme, there is an absolute need for thorough medical examination during recruitment, and subsequently, for carrying out health check-ups at least twice a year. Long-term examinations are aimed at securing an optimum state of health of the training adolescents, as well as the necessity for evaluation of the effect of systematically increasing and variously directed physical loads on the developing organisms. Supplementary exercises are of great importance in the formation of body posture of players in any sports discipline, aimed at an improvement in exercise capacity, state of health, improvement of the function of individual systems, organs and the body as a whole. It should be considered as necessary to carry out proper selection, based on systematic medical examinations, and aim at comprehensive training of adolescents and development of the functional balance of individual groups of muscles [22].
Mechanical perception of the role of muscles in postural re-education results in unjustified concentration on the formation of a so-called muscular corset, more precisely, on exercises shaping the strength and endurance of postural muscles. This element of the above-mentioned procedure is obviously important; however, the approach to the functioning of these muscles must be completely different. There is sufficient evidence that, despite the considerable strength and endurance of postural muscles, incorrect posture is often assumed, or even, a postural defect develops, while compensatory management does not bring about the expected effects [23]. Development of posture is the effect of gradual integration of muscle tone during the development of postural reactions [24]. Body posture is conditioned by many factors, primarily by systemic regulation, the quality of which is related to the postural system gradually developing in ontogenesis [25]. A correctly functioning postural system contains mutually dependent components, such as correct tone of the postural muscles, proper reciprocal innervation and appropriate postural and motor patterns [26]. Postural defects are the consequence of spontaneous compensation of postural dystonia [27]. The shaping of body posture habits is not exclusively associated with the strengthening of individual groups of postural muscles, but primarily with the integration of their functions in compensatory and balance reactions.

Conclusions

1. A flattening of the thoracic kyphotic angle and lumbar lordotic angle was observed. The majority of the examined adolescents had residual scoliosis.
2. During the Postural Stability Test, all the adolescents in the study remained in Zone A, and most of them remained in Quadrant 1 (% Time In Quadrant I) (right posterior).
3. A positive correlation was observed between trunk length from vertebra C7 to the midpoint between the sacral dimples (Trunk length VP-DM), and trunk length VP-SP from C7 to the beginning of the groove between the buttocks (mm) (Trunk length VP-SP) (mm), and the percentage of in Quadrant 1 (% Time In Quadrant I), i.e. sway to the right anterior.
4. No significant correlations were found between body posture variables and body composition, or between postural stability and body composition.
5. Handball is a sports discipline asymmetric in nature, which may be the cause of the occurrence of posture defects. Postural education exercises should be included in the training programme of juniors.

References


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ANALYSIS OF EXERCISE INTENSITY AND THE LEVEL OF THE BODY’S ADAPTATION TO HIGH ALTITUDE CONDITIONS WHILE TREKKING IN THE HIMALAYA MOUNTAINS

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Key words: active-sport tourism, trekking, high altitude, exercise intensity, Himalayas

Abstract

Aim. The authors submitting this article considering that hiking at high altitudes is a form of active sport tourism, which enjoys growing popularity among tourists worldwide, assumed that the practice of trekking at altitudes above 2,500 meters (above sea level) is equivalent to activity of high intensity and carries a risk of high-altitude diseases.

Basic procedures. The authors claim that despite the rapid progress of medical science, the problem of the economy of oxygen at high altitudes is not clearly understood. It is still the subject of many discussions and theoretical considerations.

Main findings. The analysis were conducted in Nepal, in the Himalaya Mountains, during a trekking expedition to the Mount Everest Base Camp, in October 2015. The study group consisted of 10 people (5 women and 5 men). The study used specialized measurement equipment- a heart rate monitor (sport-testers).

Results. During the studies, data from heart rate monitors from the six days of trekking were collected. The presented data demonstrate the influence of height above sea level on the average heart rate in the study group.

Conclusions. On balance, the average heart rate in the study group decreases in direct proportion to the increase in altitude. The final analysis shows that the correct process of acclimatization is the most important factor in this research.

Introduction

Mountain areas provide a very attractive leisure area and are one of the most popular destinations for active tourism. With the current development of transport, the availability of equipment and information, higher mountain ranges, once reserved exclusively for professional climbers, mountaineers and climbers, today, are available to almost every tourist [1].

In recent years, the popularity of skiing, trekking or even mountaineering has increased, and therefore, activity with marks of extremism. Such forms can be classified into the so-called active tourism related to out-of-residence trips for physical activity, which is currently one of the most dynamically developing branches of tourism. Its basic type is hiking [2]. Trekking in the Himalayas, analyzed in this work, can qualify as extreme tourism treated as a form of active tourism. It requires participants to have above-average skills and psychomotorics connected with real risk and most often ambitious motivations for it undertaking [2]. Being at high altitudes is risky and not without significance for the human body. The division of the mountain heights into several degrees is popularly assumed. The term moderate altitude is used in reference to
heights in the range of 1,500–2,400 m a.s.l., high altitude is the level from 2,400 to 4,300 m a.s.l., very high altitude is used for the height of 4,300–5,500 m a.s.l. Extreme heights are considered to be altitudes above 5,500 m a.s.l. Health problems caused by high altitudes rarely appear at the threshold below 2,500 m a.s.l. [3]. The region of the highland is defined as areas situated above 2,500 m a.s.l. Lack of elementary knowledge on the nature of existing threats can have fatal consequences resulting in loss of health or life.

The risks associated with physical activity in high altitude conditions are largely attributed to specific climatic and terrain conditions. The underlying cause of ailments associated with high altitude hypoxia is hypobaric hypoxia induced by atmospheric pressure as the height increases above sea level. In general, the principle of atmospheric pressure decreases by 1 hPa for every 8 meters vertically [4]. To illustrate this phenomenon, Gdansk is the closest to the sea level, where the average atmospheric pressure is 1,013 hPa, in the Rysy, it is already about 746 hPa, while at the Everest base, it is 506 hPa. The health problems that may be encountered at high altitudes, i.e. above 2,500 m, may include the following:

- altitude sickness with subtypes such as Acute Mountain Sickness (AMS), High Altitude Cerebral Edema (HACE) and High Altitude Pulmonary Edema (HAPE);
- disorders related to periodic breathing type (PB) respiratory disturbances during sleep [4].

The occurrence of altitude sickness is possible, especially when covering the height too quickly. Effective prevention is therefore essential to reduce the likelihood of subordinate symptoms and to inhibit the development of a disease that can lead to serious and lasting damage to the human body or even endanger life. The overriding factor determining the appearance of symptoms of altitude sickness are compensatory possibilities of the body [5]. In addition, before departure into the high mountains, examining one’s current state of health is a must. Many illnesses may be asymptomatic and manifest themselves in a full clinical image only under extreme conditions associated with environmental factors such as low blood pressure, hypoxia or low air temperature, as well as increased energy expenditure during high mountain climbing [6].

Material and methods

The study was conducted in Nepal, the Himalayas, during a trekking trip to the Mount Everest Base Camp. The expedition was held on October 6th–28th, 2015. During the trek, the participants covered the distance separating Lukla (2,840 m a.s.l.) and the base at Everest (5,364 m a.s.l.), passing through Sagarmatha National Park.

During the expedition, exercise intensity measurements were taken using Polar V800 heart rate monitors with a Polar H7 transmitter. During the subsequent stages of trekking, the study participants were equipped with sport-testers, monitoring their heart work, duration of the effort and the covered distance. For the purposes of the study, maximal heart rate was determined from the formula $HR_{max} = 208 - 0.7 \times \text{age}$ [7]. In order to compare the intensity of exercise between the subjects, the relative average heart rate (HR rel aver) was used, which was calculated as a percentage of HR max. In addition, variables such as the daily distance covered and duration of covering each trekking stage were measured. Based on these two parameters, the pace of the march and the sum of the ascents and descents on each day of the expedition were also calculated.

10 participants (5 women and 5 men), age 39 (±10 years), height 172 (±6) cm and body mass 71 (±11) kg were included in the study. Nine people achieved their goal, that is reaching the Mount Everest Base Camp at 5,364 m a.s.l. One female participant was diagnosed with incessant symptoms of altitude sickness and was transported to hospital in Kathmandu by helicopter from the altitude of 5,140 m a.s.l.

The data obtained in the course of the study were coded in a database and then statistically analyzed using the Statsoft® Statistica programme. The research results were initially analyzed using basic methods of descriptive statistics. The arithmetic mean (\(\mu\)), standard deviation (\(S\)), minimum (\(Min\)) and maximum values (\(Max\)) were determined. Asymmetry (\(A\)) and kurtosis (\(K\)) indicators were used to evaluate the normality of distribution of the analyzed variables. Furthermore, one-way analysis of variance was applied to verify the significant differences between the individual days of trekking. Its assumption of homogeneity of variance was checked using the Levene test, and the differences between the groups using the NIR test. In the absence of homogeneity of variance, the Kruskal-Willis test was used. Finally, we sought relationships between variables using the Pearson’s correlation coefficient test. The minimum significance level of the variables was assumed at $p<0.05$.

Study aim

The aim of the study is to analyze the intensity of physical activity accompanying active tourism in high mountain conditions. Consecutive stages of trekking in the Himalayas were analyzed (6 sections, from 2,800 m to 5,300 m a.s.l.) and the level of the body’s adaptation (circulatory-respiratory system) was verified.

Results

Data was collected from cardiac monitors in the form of graphic readings and numerical data from the course of each trekking day to the Everest base (6 days of as-
cents, excluding 2 days of acclimatization, due to the fact that these excursions were optional and not all participants in the expedition participated in them) for ten participants in the study. In addition, complete data from the questionnaires were collected.

The table shows the distribution of the average heart rate, movement pace and duration of the trek. The mean heart rate in the study group ranged from 52% (min) to 84% (max) of the maximal heart rate, movement pace was 37 min/km, and mean daily exercise was less than six hours (5:51:41) The above variables have normal distribution, as indicated by asymmetric indices ($A_c <-2, 2>$) and kurtosis ($K_c <-3, 3>$) [8].

Analysis of variance of average heart rate (HR relat aver) ($F_{5, 53}=3.396, p<0.05$) showed that the variance was statistically significant during trekking (Fig. 1). It was also possible to reject the assumption of variance inequality of this variable (Levene test: $F_{5, 53}=1.563, p=0.187$). Detailed analysis of the results indicates that the fourth, fifth and sixth days had significantly lower HR relat aver values compared to the first two days of trekking.

The next two variables, pace and duration had similar dynamics of behaviour (Fig. 2). Both variables, due to day five, significantly differed in terms of variance (the Levene test results were, respectively, $F_{5, 53}=11.493, p<0.05$).

Table 1. Distribution of average heart rate, movement pace and duration of trekking

<table>
<thead>
<tr>
<th></th>
<th>N significant</th>
<th>X</th>
<th>Min</th>
<th>Max</th>
<th>S</th>
<th>$A_c$</th>
<th>$K_c$</th>
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</thead>
<tbody>
<tr>
<td>HR relat aver</td>
<td>59</td>
<td>66</td>
<td>52</td>
<td>84</td>
<td>6.24</td>
<td>0.06</td>
<td>0.31</td>
</tr>
<tr>
<td>[%]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pace [min/km]</td>
<td>59</td>
<td>37</td>
<td>27</td>
<td>49</td>
<td>6.33</td>
<td>0.36</td>
<td>-1.0</td>
</tr>
<tr>
<td>Duration [hh:mm:ss]</td>
<td>59</td>
<td>5:51:41</td>
<td>3:20:37</td>
<td>8:39:20</td>
<td>1:31:50</td>
<td>0.11</td>
<td>-0.69</td>
</tr>
<tr>
<td>Ascent [m]</td>
<td>59</td>
<td>688</td>
<td>200</td>
<td>1050</td>
<td>262</td>
<td>-0.65</td>
<td>-0.14</td>
</tr>
<tr>
<td>Descent [m]</td>
<td>59</td>
<td>289</td>
<td>65</td>
<td>490</td>
<td>150</td>
<td>-0.17</td>
<td>-1.36</td>
</tr>
</tbody>
</table>

Fig. 1. Mean and standard deviation of relative average heart rate (HR relat aver) values during each trekking day (*- significant statistical difference ($p<0.05$) between first and second, fourth, fifth and sixth day of trekking)
**Fig. 2.** Mean and standard deviation of movement pace during individual days of trekking

**Fig. 3.** Distribution of daily altitude above sea level on individual days of trekking
p < 0.05 and $F_{5, 59} = 9.080, p < 0.05$), and thus, the Kruskal-Wallis test was used. Its results showed large differences between the days of trekking: pace ($H_{5, 59} = 44.480, p < 0.05$) and duration ($H_{5, 59} = 50.775, p < 0.05$). The lowest values of these variables occurred on the first day, and the highest on the last. Day five did not differ significantly compared to the second and third days.

The smallest change in level above sea level took place on the second day of trekking (260 m), while the greatest change occurred during the third day, on which the trekking participants covered a total of 678 meters of altitude. In subsequent days, the height above sea level increased regularly.

The conducted research shows that the longer the duration of exercise, the lower the average heart rate. Similarly, in the case of a slower pace of marching, the average heart rate is reduced. This may be due to the fact that, in the case of prolonged exercise duration, the body is unable to maintain heart rate or march pace at a high level, which is in line with previous studies on aerobic efforts [10]. Another relationship demonstrated by the research regarded a decrease in the average heart rate with increasing altitude, i.e. each consecutive day of trekking. The significant difference in average relative heart rate was observed between the first two days and the subsequent trekking period (4-6 days), which is not reflected in the analysis of daily differences linked to external effort - distance covered, pace and ascent. The causes of such relationships can be found in the proper acclimatization process during the expedition, and it can be a resultant of adaptation processes of the body and relatively favourable external conditions (no extreme low or high air temperatures, precipitation, strong and gusty winds). According to Peacock (1998), the acclimatization process largely depends on the time of exposure to high mountain conditions. In earlier studies (Barry and Pollard 2003), high physical fitness was not shown to be protective against the typical symptoms of high altitude sickness. Similarly, no correlation was observed in the study group (50% declared regular physical activity). Cibella et al. (1999) note that energy expenditure during respiration increases directly in proportion to the atmospheric pressure drop, thus possibly decreasing the marching pace in the study group along with the increase above sea level [11].

Despite the rapid advances in medical and related sciences, the problem of oxygen economy at high levels is unclear and remains the topic of many discussions and clinical considerations [12]. Meanwhile, the intense development of high-altitude tourism makes it increasingly common for people to suffer from high altitude

### Table 2. Correlation of average relative heart rate with duration, distance, pace, sum of ascents and descents and the average daily height above sea level (*- statistically significant $p < 0.05$)

<table>
<thead>
<tr>
<th></th>
<th>Duration</th>
<th>Distance</th>
<th>Pace</th>
<th>Ascent</th>
<th>Descent</th>
<th>Average daily altitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>HR relat aver (%)</td>
<td>-0.30*</td>
<td>-0.13</td>
<td>-0.36*</td>
<td>0.03</td>
<td>0.16</td>
<td>-0.46*</td>
</tr>
<tr>
<td>Duration</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.85*</td>
<td>0.92*</td>
<td>0.58*</td>
<td>-0.00</td>
<td>0.52*</td>
<td></td>
</tr>
<tr>
<td>Distance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.59*</td>
<td>0.73*</td>
<td>0.11</td>
<td>0.38*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pace</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.42*</td>
<td></td>
<td>-0.15</td>
<td>0.54*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ascent</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-0.24</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.09</td>
</tr>
<tr>
<td>Descent</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-0.42*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

There was a slight negative correlation between walking speed of the participants and average relative heart rate ($r = -0.36$). There is a strong positive correlation between the sum of ascents and the distance covered ($r = 0.73$). At the same time, as the sum of the ascents increases, the duration of exercise increases ($r = 0.58$). There is also a moderate positive correlation with the distance covered ($r = 0.59$). Average daily height above sea level positively correlates with the movement pace ($r = 0.54$) and the duration of the individual trekking stages ($r = 0.52$). The analyzes showed a negative correlation of daily altitude above sea level with the relative average heart rate in the study group ($r = -0.46$).

### Discussion

The popularization of high-altitude tourism encourages multi-faceted research in this area. To date, it has not been shown that a high level of physical fitness is a protective factor against the occurrence of typical symptoms of altitude sickness. However, excessive physical activity during the development of the disorder may further intensify its course. In addition, there were no significant gender-related differences in earlier studies regarding the incidence of altitude sickness [9].
disorders. The inability to accurately determine changes occurring in organisms exposed to high alpine factors causes the pathophysiology of diseases closely related to aerobic disorders to still remain, to a large extent, at the level of theoretical considerations.

**Conclusions**

Performing active high-altitude tourism is equivalent to an increased intensity effort.

As a result of the research, several conclusions can be drawn. The longer the duration of the exercise, the lower the average heart rate, and similarly, the slower the pace of movement, the lower the average heart rate. In addition, research shows that the average height above sea level, rising with each subsequent trekking day, is equivalent to a decrease in the average heart rate in the study group, most likely associated with adaptation of the vasculature to being at high altitudes.

The average heart rate in the study group decreases directly in proportion to the increase in height above sea level which is due to proper acclimatization of the body to high mountain conditions, elongation of the covered distances and slowing the pace of the march.

**References**


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ONCE MORE ON THE METHODS FOR DETERMINING SENSITIVE AND CRITICAL PERIODS IN THE MOTOR DEVELOPMENT OF CHILDREN AND THE YOUTH

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Key words: longitudinal research, children aged 7-14 years, somatic and motor development of sensitive and critical periods, research methods, comparative analysis of methods.

Abstract

Aim. Two objectives were set for realization in this paper: 1. To identify the cohort dynamics of the development of selected physical fitness components in girls and boys studied longitudinally as a basis for distinguishing sensitive and critical periods proposed in sports theory. 2. To carry out a comparative analysis of the individual and cohort development pace of selected motor abilities, taking into account the absolute and relative ages of the subjects in order to confirm the validity of distinguishing the limits of sensitive and critical periods limits with methods used in sports practice.

Basic procedures. The research incorporated the results of an eight-year continuous study on 401 children from Krakow. Basic somatic features and anthropometric indicators were measured. Traditional methods were used to distinguish periods of increased dynamics of motor development and of reaching puberty leaps. The age of reaching peak body height was determined using an original computerized method. In the distinguished fractions of biological development advancement, the individual pace of motor development of 401 boys and girls was determined. Comparative analysis of the cohort development pace of motor skills was conducted using traditional methods in our own and comparative studies, and the individual rate of development of random children who reached puberty at different times.

Results. Comparative analysis showed no coherence in the occurrence of dynamic development periods of motor abilities distinguished in the materials from studies on both cohort and individual cases.

Conclusions. 1. Differences in studying motor skill development using various methods support the lack of a basis for the use of growth dynamics as a criterion for determining sensitive and critical periods. 2. Using the Montessori concept to designate sensitive and critical periods in the motor development of a child should be considered unfounded.
I. Introduction

In the didactics of physical education and in sport theory there is a popular view on the existence of particularly favourable stages of acquiring skills in ontogenesis (including motor ones) and of exceptional biological conditions for the improvement of a child’s motor abilities [1-4]. Such periods in personal development were called sensitive, and the moment of losing sensitivity to pedagogical influence was called the critical period. For the first time, the possibility of their occurrence in the mental development of a child was highlighted by Maria Montessori - the early 20th century Italian doctor and excellent pedagogue [5-7]. Her views on intentional education were shaped on the basis of Hugo de Vries’s observations - botanist and geneticist, the precursor of research on heredity, variability, the emergence of new races and species in the process of evolution. According to an analysis of available documents, the Dutch researcher gave M. Montessori the results of his own observations on susceptibility (sensitivity) of the maturation of poppy seedlings to sunlight only at appropriate stages of their development [1, 5-9]. He also noted the existence of similar phenomena in the formation of heliotropic movements of the *pothesia chrysorrhoea* butterfly larvae¹. In both cases, the delayed exposure of solar energy does not imply the continuation of subsequent ripening sequences.

The identification of some regularities in the maturation of plants and insects has been transferred to the intellectual development of children. Based on them, Montessori built her own system of pre-school education [5-7]. The concept of periods of particular susceptibility to pedagogical influence is still valid today [10-12]. Her credibility has been confirmed by the instances of language inability of children isolated after birth [13-14]. It is assumed that delayed pedagogical influence on mental processes does not produce the desired effects. It is believed that better results in the acquisition of intellectual or motor skills can be obtained if the teaching and learning processes surpass the completion of biological maturation.

In Eric Lenneberg’s [13] or Noam Chomsky’s [14] nativist theory, it can be argued that one’s native language (especially a second language) can only be properly mastered before puberty. Without penetrating the discussion between linguists on the behavioural and nativist approaches to interpreting language teaching and the role of biological maturation processes in the stimulation of teaching, it must be said that pedagogy is still regarded as a certainty of occurring sensitive periods, without delving into the genesis of their creation. This may be demonstrated by the curriculum created by Fernando Corominas [15], the president of the European Institute for Educational Research (IEEE). Citizenship law in the concept of the critical and sensitive periods is not questioned in developmental psychology [10-12].

The concept of education by Maria Montessori was adopted without proper reflection on the process of stimulating motor development in the former Union of Soviet Socialist Republics [3]. At the end of the 20th century, the Soviet approach to sensitive and critical periods became the basis for developing the theory of recruitment and selection of children and adolescents for competitive sports [16]. Numerous model solutions were designed and very rigorous practical recommendations were developed regarding the shaping of capacities and functional features at various stages of personal development [16-21]. The echo of the past epoch is still present in our country (Netography: 1-3), despite criticism of the methodological approach for determining the specific phases of sensitivity of a child’s selected motor components to training influence [22-33].

Reservations are raised both by the methodology used for determining the sensitive periods and the justification for their occurrence [23]. It has been assumed that an exceptional increase in susceptibility to environmental stimuli, especially to training, known as the sensitive phase (period), occurs when there is a significant increase in the dynamics of a child’s natural development [2-4]. Then, genetic control was supposed to be weakened. Since the development of motor skills is heterochronological in nature, it was thought that there is a need to designate such periods separately for each type of motor ability.

According to the Cracovian theory of human motor ability, the above mentioned conceptual assumption and methodological approach “is completely wrong and even anty-biological” [23]. It is believed that the process of human adaptation to physical efforts (defined with the help of terms such as trainability, adjustment changes, post-training) is individual in nature. It depends on the genotype of the individual, heritability of the feature, the period of ontogenesis and the strength of the training stimulus [23]. In such a case, it would seem unreasonable to seek population-based or only cohort developmental norms, or sensitive and critical periods.

¹ According to the most recent research by Uma Ramani [9], the director of the Montessori Institute of North Texas, Hugo de Vries referred to his own observations on the maturation of the heliotropic movements of the *pothesia chrysorrhoea* butterfly larvae. He was, after all, a botanist. As Uma Ramani believes [9], probably during a conversation with the eminent physician and pedagogue, H. de Vries referenced the results of the discovery of his American friend - zoologist Jacques Loeb, regarding sensitive periods in the development of the butterfly larvae. Nonetheless, it was mistakenly attributed to H. de Vries. Such information can be found in the autobiographical book by Maria Montessori [5]. The outstanding Soviet educator - Lev Vygotski also cites it [1, 8].
J. Raczk [31] based his criticism on different evidence, stating that methodological arbitrariness is too excessive in determining the limits of periods particularly susceptible to ability and motor training, and in particular, adopting the occurrence of “critical periods” as authentic in motor development. These “critical periods” are called the “last chance” in which stimulation has to take place to achieve a positive effect. Much evidence has already been gathered in Polish studies showing that people are “trained” (susceptible to environmental stimuli) at all stages of their lives [25, 27-28, 30-31, 34-37]. Additionally, the theoretical justification for criticizing sensitive and critical periods can be found in the assumptions of the contemporary Life-Span psychology of human development [11, 38-51]. It is emphasized that development is a process that takes place throughout an individual’s whole life. Its essence is change taking place in time. Considering the perspective of the human life span, researchers from the younger generation of psychologists have “gone beyond” the one-dimensional and unidirectional models of the classic psychology regarding the development of children and adolescents, and have noted that an important feature is its plasticity and multi-directionality. They have stopped concentrating on what is permanent and regular. In turn, they proposed to also try and understand what is variable and unique in the development of a human.

The potential options for using the new trends in developmental psychology have given a new impulse to research human motor development and find a theoretical basis to justify the thesis that: “the concept of motor stimulation based on the use of sensitive phases should be treated as an unverified hypothesis, which does not provide any basis for formulating conclusions on the possibility to specifying methodological-training guidelines” [31]. It should be noted that if transferred to our country (although with some delay), the new trend of developmental psychology by Maria Tyszkowa [48] and Maria Przetacznik-Gierowska [11, 49] today, is a signpost in the study of human psychological development, the concept of motor development [4] based on it barely acquired the right of citizenship in the theory and practice of sport.

The debatability of the distinction between sensitive and critical periods at strictly defined phases of ontogenesis, based on the dynamics of motor development indicators, is indicated by the effects of the team auxologics studies conducted in Mexico under the supervision of Napoleon Wołański [55-59]. Based on the analysis of the individual somatic development of Mexican children in Yucatan, examined monthly (March 2002 - November 2003), the existence of a regularity has been demonstrated, the essence of which accurately reflects the title of one of the published works: Each child and each one of their traits has its pace of development, modified by living conditions at a given period [57-58]. The conclusion that the pace of development of each biological feature is individual can be achieved during the review of world literature, in which the individual pace of development of somatic features in children over shorter amplitudes of time is confirmed [60-66].

Therefore, it is very likely that both the views of the new Life-Span physiological development psychology and the results of empirical studies by Polish and foreign auxologists can support the thesis of the unjustified distinction of children’s and adolescent’s sensitive periods during ontogenesis, stimulating motor development. Apart from this, as already noted, not only is the concept of existence in human motor functioning erroneous, but above all, the methodology of their determination on the basis of analyzing the development dynamics of measurements derived from cross-sectional studies is improper. Critically referring to the results of research based on them, it should be emphasized that - so far - no material from longitudinal studies has been collected which would allow the falsification of previous views on the existence of sensitive and critical periods in human motor ability. It can be assumed that the gap in this area will be supplemented by an analysis of the results of continuous research carried out in the cohort of children from Cracow.

The so-called Life-Span developmental psychology was born at the end of the 20th century, after the period of postmodernism, proclaiming relativism in the world of values and knowledge. In some university environments, a new paradigm emerged in psychological research called human development during his/her lifetime, thanks to, among others, such German-English empiricists as: [40, 43, 46-47, 52-53]. The seminars initiated by them in 1969 under the title Life-span development and behaviour [54] yielded a harvest in the form of over a dozen volumes of publishing series under the same title [39]. According to the creators of the paradigm [38-47], life-span psychology is not a single theory or coherent theoretical system. It is considered only some general orientation, theoretical perspective or the direction of thinking about humans and his/her development [51].

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3 Generally speaking, thinking about the phenomenon of development, a breakthrough in meaning occurred, as Tremplaa put it well [51], which can be compared to the transformations that have taken place in physics along with the appearance of relativity. With the new developmental psychology from the life-span perspective, contemporary psychology of human development over the course of life - undermining the normative model of research realized within the classical psychology of development of children and youth - has discussed several key issues: a return to the issue of the concept of development and developmental change, an expansion in research and proposal of a new research paradigm called Contextualism [51].
Aim of own research

1. Knowledge of cohort dynamics of the development properties of selected physical fitness components in girls and boys studied longitudinally as a basis for distinguishing between sensitive and critical periods using methods proposed by sports theory.

2. Conducting a comparative analysis of the individual and cohort pace of development of selected motor abilities, taking into account the absolute and relative ages of the studied subjects, to confirm the validity of distinguishing the limits of sensitive and critical periods used in sports practice.

Research issues

1. In which periods of ontogenesis will the greatest amplitude of the development pace of the fitness and coordination abilities of the children being tested occur in a continuous manner, giving the basis for distinguishing the sensitive periods using the postulated method in sports theory?

2. Does the individual pace of development of selected motor abilities in children continuously reflect the specificity of the developmental rhythm determined on the basis of averaged values?

Research hypotheses

1. The pace and rhythm of motor development of the longitudinally studied children will reflect the specific environmental characteristics of a given cohort, which may support the existence of a basis for the falsification of the concept for determining universal sensitive periods within strictly defined limits of ontogenesis.

2. The individual motor development pace of a child should reflect the developmental dynamic characteristics of a given cohort. Determining allometry may suggest that there is no justification for declaring sensitive and critical periods using a nomothetic approach.

II. Research material and methods

Research subject and method

In the study, we used the results of longitudinal, annual anthropometric and motor ability measurements of children from the Cracow metropolitan population within the age group 7.5 to 14.5 years. They were students of randomly selected primary schools from four districts of Cracow, i.e. the city centre, Podgorze, Krowodrza and Nowa Huta. The 8-year research period was competed by a total of 401 children, including 197 girls and 204 boys. In the study, we used the observation method. For the purposes of carrying out the research objectives adopted in this paper, the only included measurements refer to the elements of motor structure.

Scope of research

For the purposes of the research objectives adopted in this paper, among the considered measurements, we only used those referring to the elements of motor structure. Additionally, two basic somatic features were considered. According to traditional taxonomy used in motor theory, the following division can be made:

1. Morphological predispositions: body height and mass, and their components,

2. Functional predispositions: aerobic capacity, maximal anaerobic work,

3. Motor abilities:
   a) speed: 10-m run, agility run,
   b) strength: pull strength, explosive strength of the lower limbs,
   c) endurance: 20x20-m zig-zag run, forward bend from position of laying on one’s back,
   d) coordination motor skills: visual-motor coordination, spatial orientation, balance, adaptation of movements.

Measurement techniques and tools

- Body height (B-v) was measured using an anthropometer at the Frankfurt plane.
- Body mass was weighed using the Tanita type scale.
- An anthropometer and calliper were used for measurements of components of basic somatic features.
- Visual-motor coordination was examined using the Piorkowski U-6 apparatus.
- Spatial orientation was assessed using the AKN-102 crossed apparatus, using a forced stimuli emission programme.
- Balance was determined using a modified version of the Eurofit, Flamingo Balance test, measuring the time until the first loss of balance [68].
- The ability to develop strength was tested using:
  - The Push & Pull test [69] (in Newtons) on a Tie demann-Netz ring dynamometer. In the study, we considered the better of the two results from two measurements.
  - The Standing Broad Jump Test (explosive strength test) – Eurofit [67].
  - The double-leg vertical jump test [70].
- Speed abilities were assessed using:
  - 10-m run with flying-start and max. 10-m run-up
  - Agility running test [69].
- Endurance abilities were assessed using:
  - The modified trial of the Eurofit Run Test [67].
  - The imposed zig-zag run intensity of 20x20 m was applied at a sports hall. The time to cover the distance and the number of repetitions were measured.
Once more on the methods for determining sensitive and critical...

- Measurement of the abdominal muscle strength endurance [67].
- Aerobic capacity was determined using the modified version of the test by Januszewski [71] and Margaria et al. [72].
- Maximal anaerobic work was calculated from measurements of body mass and the length of the double-leg long and high jump using Januszewski’s method [73].
- Flexibility was examined using the modified Eurofit test [67]. From the simple seat position, the subject tried to mark the bend depth on the pulpit of a bench with his/her fingers. The level of “0” — supporting the feet on the leg of the bench — was assumed as 50 cm.

Methods of material analysis

1. Using the material collected during the 8-year continuous observation period, we calculated the values of arithmetic means and standard deviation (including sex and the 7.5-14.5 calendar age) after checking the normality of distribution of the measurements performed using the Kolomogorov-Smirnov test.

2. We calculated the fixed base development dynamics index (FBDDI) between the ages 7.5 – 14.5 years (also called development pace index) using the following formula:

\[ FBDDI = \frac{\Delta_t}{y_{t-1,n}} \]

assuming that: \( \Delta_t = y_t - y_{t-1,n} \) = absolute increases in variable value; \( y_t \) in the period (t-1, t), \( y_{t-1,n} \) means the range of the characteristic’s variability from the initial to final observation periods.

a) for the arithmetic mean values of all studied features and physical fitness components in the group of boys and girls,

b) for each individual case (207 boys and 197 girls), considering all examined somatic features and physical fitness components. Due to the large number of calculations (42,420), we used the so-called macro/macro-command software development programme designed by Dr. Tomasz Klocek (co-author of the report).

3. Accelerated developmental periods, Peak Height Velocity (PHV) and mid-growth spurts were determined using the macro/macro-command programme.

4. The study participants were divided into three maturation categories: developing at a normal pace, accelerated and delayed in biological development, taking into account the age of peak body height (PHV) and the number of subjects experiencing such a moment in their development.

5. At the distinguished age groups of biological development, we characterized the variability of the individual development pace of chosen strength-fitness, endurance, flexibility and coordination abilities (spatial orientation, visual and motor coordination and balance).

Table 1. Variability of the development dynamics index values (FBDDI) of boys’ fitness components along with age (calculations from arithmetic means)

<table>
<thead>
<tr>
<th>Feature / age</th>
<th>7.5-8.5</th>
<th>8.5-9.5</th>
<th>9.5-10.5</th>
<th>10.5-11.5</th>
<th>11.5-12.5</th>
<th>12.5-13.5</th>
<th>13.5-14.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pull strength</td>
<td>10</td>
<td>10</td>
<td>11</td>
<td>11</td>
<td>16</td>
<td>18</td>
<td>25</td>
</tr>
<tr>
<td>Lower-limb strength – leap</td>
<td>12</td>
<td>14</td>
<td>12</td>
<td>14</td>
<td>15</td>
<td>16</td>
<td>17</td>
</tr>
<tr>
<td>Lower-limb strength – jump</td>
<td>13</td>
<td>10</td>
<td>13</td>
<td>13</td>
<td>13</td>
<td>19</td>
<td>19</td>
</tr>
<tr>
<td>Max. anaerobic work</td>
<td>9</td>
<td>8</td>
<td>11</td>
<td>12</td>
<td>16</td>
<td>22</td>
<td>24</td>
</tr>
<tr>
<td>Relat. Max. anaerobic work</td>
<td>27</td>
<td>26</td>
<td>-2</td>
<td>26</td>
<td>-3</td>
<td>21</td>
<td>4</td>
</tr>
<tr>
<td>Endurance (No.) (-)</td>
<td>22</td>
<td>21</td>
<td>26</td>
<td>11</td>
<td>8</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Endurance (sec) (-)</td>
<td>30</td>
<td>21</td>
<td>11</td>
<td>8</td>
<td>9</td>
<td>9</td>
<td>11</td>
</tr>
<tr>
<td>Speed</td>
<td>22</td>
<td>15</td>
<td>12</td>
<td>13</td>
<td>11</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>Agility run</td>
<td>23</td>
<td>19</td>
<td>17</td>
<td>13</td>
<td>10</td>
<td>8</td>
<td>10</td>
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<tr>
<td>Abdominal muscle strength</td>
<td>21</td>
<td>24</td>
<td>14</td>
<td>11</td>
<td>5</td>
<td>13</td>
<td>12</td>
</tr>
<tr>
<td>Spatial orientation</td>
<td>33</td>
<td>21</td>
<td>14</td>
<td>13</td>
<td>7</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>Movement adaptation</td>
<td>44</td>
<td>23</td>
<td>10</td>
<td>-4</td>
<td>9</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>Visual-motor coordination</td>
<td>19</td>
<td>24</td>
<td>24</td>
<td>13</td>
<td>8</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Aerobic capacity</td>
<td>-8</td>
<td>30</td>
<td>2</td>
<td>4</td>
<td>20</td>
<td>18</td>
<td>39</td>
</tr>
</tbody>
</table>

Own elaboration based on 8-year continuous research
Note. Gray colour marks periods of increased development dynamics of articular motor fitness components, and white – peak of development pace
III. Research results

1. Development dynamics of physical fitness components in children from Cracow on the basis of mean values and sensitive periods

One of the most important objectives of this study was to determine the pace of motor development in girls and boys studied over a series of eight-year annual observations. On this basis, attempts were made to demonstrate periods of dynamic growth. According to the traditionally used methodology in sport theory, a sensitive period during this time should occur. Tables 1-2 show the variation in time for both sexes of all fixed base development dynamics indices (FBDDI) of the considered components of motor efficiency. It was assumed that an increase or decrease by at least 5 FBDDI pts from the average rate of the preceding or subsequent increase in the amplitude of the development rate may indicate that the threshold of relative developmental stability has been exceeded or lowered.

On this basis, the following growth periods in the development dynamics of the individual signs of the examined children's motor components were determined, which according to the relevant methodology, should be considered as sensitive periods. As it can be deduced from this statement, so far, no link between the phases of dynamic growth of physical fitness components [16-21 and Netography: 1-3] and the results obtained in our research can be found. So as to illustrate, an example of one of the many models of sensitive phases [4] is given below (Fig. 1).

Undoubtedly, these differences may be due to the inclusion of materials from continuous research in our own elaboration. However, the impact on the rate of development of physical fitness components in subsequent years of researching environmental factors, including mainly physical activity, cannot be ruled out. Evaluating the course of volatility of the examined physical fitness components (Tab. 1, 2), it can be stated that, in the majority of cases, the characteristics of the observed pace of their development in both sexes are low dimorphic dynamics and relatively high stability. For example, in the development of explosive strength (long-jump and vertical-jump), there were no deviations from the average growth rate in the studied period of ontogenesis, which would qualify the increases into major categories (over 5%). The highest oscillations in the pace of development were recorded in maximal oxygen uptake (VO2 max x kg<sup>-1</sup>) and the accuracy of movements. In this case, we cannot rule out an error in indirectly measuring maximal oxygen uptake, or in the absence of providing adequate conditions for performing a psychomotor accuracy test.

Evaluating the variability of the examined fitness components (Tab. 1-2), it can be concluded that in most cases, the characteristics of the noted pace of their de-

| Table 2. Variability of the development dynamics index values (FBDDI) of girls’ fitness components along with age (calculations from arithmetic means) |
|---|---|---|---|---|---|---|---|---|
| Feature / age | 7.5-8.5 | 8.5-9.5 | 9.5-10.5 | 10.5-11.5 | 11.5-12.5 | 12.5-13.5 | 13.5-14.5 |
| Pull strength | 11 | 13 | 13 | 11 | 17 | 16 | 19 |
| Lower-limb strength – leap | 14 | 16 | 15 | 14 | 15 | 13 | 15 |
| Lower-limb strength – jump | 14 | 13 | 18 | 14 | 13 | 13 | 15 |
| Max. anaerobic work | 9 | 10 | 14 | 15 | 17 | 18 | 17 |
| Relat. max anaerobic work | 18 | 24 | 29 | -11 | 5 | 13 | 23 |
| Endurance (No.) (-) | 11 | 15 | 21 | 21 | 17 | 8 | 6 |
| Endurance (sec) (-) | 21 | 23 | 16 | 12 | 10 | 8 | 9 |
| Speed | 18 | 16 | 14 | 13 | 13 | 15 | 12 |
| Agility run | 41 | 17 | 14 | 11 | 6 | 7 | 5 |
| Abdominal muscle strength | 24 | 23 | 11 | 12 | 7 | 13 | 11 |
| Spatial orientation | 33 | 22 | 15 | 11 | 9 | 6 | 5 |
| Movement adaptation | 34 | 21 | 12 | -4 | 6 | 25 | 7 |
| Visual-motor coordination | 18 | 24 | 25 | 14 | 11 | 5 | 3 |
| Aerobic capacity | -13 | 9 | 14 | -42 | -3 | 34 | 38 |

Own elaboration based on 8-year continuous research
Note. Gray colour marks periods of increased development dynamics of articular motor fitness components, and white – peak of development pace
development in both sexes are small and relatively stable. For example, in the development of explosive strength (long-jump and vertical-jump), in the observed period of ontogeny, no deviations from the average growth rate, which would qualify for growth in the major category (over 5%), appeared during the period under review. The highest oscillations of development pace were noted in maximal oxygen uptake (VO₂ max ‘kg’⁻¹) and accuracy of movements. In this case, an error cannot be ruled out by indirectly measuring the maximal oxygen uptake, or in the absence of adequate conditions for a psychomotor accuracy test.

In addition, in the maximal strength abilities, the measurements of maximal anaerobic performance and aerobic capacity (only in girls) are most noticeable in the older generations (10-14 years). In turn, in coordination-speed, agility and endurance abilities (in boys), the same phenomenon was observed in younger generations. As is clear from the above information, in most cases, the greatest dynamics of development of motor function components occurred in younger children (7-10 years). This is confirmed by the well-known regularities of shaping motor development pace during ontogenetic development with the typical inter-characteristic variability, which is caused by the uneven rate of maturation of the development of organs and systems determining the level of motor skill development. The was a quite unexpected increase in endurance ability dynamics in older generations of girls, or in both sexes regarding the index of relative maximal anaerobic work. In such a case, their kinetic development variability may have been greatly influenced by the level of physical activity.

This may be validated by the suggestions of sport practitioners and the views of representatives of the new directions in human motor research [4], shaped by the psychological Life-span development al psychology (Entwicklung in der Lebensspanne) concept and the called selection-optimization-compensation (SOC) development model by P. B. Baltes [40, 41]. Confirmation of such a thesis can be found in the presented re-

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Age Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pull strength</td>
<td>11-14 years</td>
</tr>
<tr>
<td>Lower-limb strength – leap</td>
<td>none</td>
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<tr>
<td>Lower-limb strength – jump</td>
<td>12-14 years</td>
</tr>
<tr>
<td>Max. anaerobic work</td>
<td>none</td>
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<tr>
<td>Relat. Max. anaerobic work</td>
<td>7-9 years</td>
</tr>
<tr>
<td>Endurance (No.) (-)</td>
<td>7-10 years</td>
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<td>7-10 years</td>
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<tr>
<td>Speed</td>
<td>7-8 years</td>
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<tr>
<td>Agility run</td>
<td>7-10 years</td>
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<td>Abdominal muscle strength</td>
<td>7-9 years</td>
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<td>Aerobic capacity</td>
<td>8-9 years</td>
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<tr>
<td>Spatial orientation</td>
<td>7-10 years</td>
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<td>Movement adaptation</td>
<td>7-9 years</td>
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<tr>
<td>Visual-motor coordination</td>
<td>7-10 years</td>
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</table>
The results of our research. It turned out that there are potential opportunities for the development of motor skills at all ages of children. On the other hand, this statement undermines the point of determining the phases particularly susceptible to training influence based on the increased pace of development of fitness test results. The paces of development of fitness components can be traced both to the genetically controlled individual rate of biological maturation and the influence of physical activity and lifestyle.

<table>
<thead>
<tr>
<th>age</th>
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<th>8</th>
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<td>ability to react to acoustic and visual stimuli</td>
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<td>spatial orientation ability</td>
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<td>speed of cyclical movements</td>
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Fig. 1. Model of sensitive phases in human motor ability [28]
Once more on the methods for determining sensitive and critical periods using motor development pace. Solving the issue of the possible influence of advancement in biological development on the individual pace of somatic and motor development in children attaining Peak Height Velocity (PHV) at various times was undertaken. It was thought that in this way, one could assess the effects of biological maturation on the accuracy of determining sensitive periods using motor development pace indices.

2. The rate of somatic development as a tool for determining advancement in biological development

In order to divide the subjects according to level of advancement in biological development, we used a popular, non-invasive method for determining the age of attaining the peak in annual body height increases - called Peak Height Velocity (PHV). PHV is the most commonly used indicator of biological development in adolescence [74, 75]. It provides an accurate reference point for determining the leap in body height during puberty and occurring increases in development pace of other body dimensions, which is determined as a sequence of puberty leaps. This method of determining the degree of sexual maturity has already been well-known for 100 years [75-82]. In a number of sports development programmes for children and adolescents, it is a reference point for the application of different training loads [80, 83]. The stage preceding it (and sometimes after it) was regarded as a sensitive and critical period in Eastern European countries [84] and in English terminology, it was termed "windows of opportunity" for some time [83], only after its criticism [80, 85, 86] to be considered as "periods of accelerated adaptation".

There are different existing methods for its determination. Current methods most often aim at capturing the moment of growth of body length dimensions in a given population or at making predictions using a specific model for their calculation. Examples of this may include mathematical models and applications, found in the works of sports theorists from Cracow [79-82]. It should be noted that in most studies, only the average Peak Height Velocity (PHV) for a given year is determined [87-89]. In our research, the method proposed by Szymańska [90] for the development of individual results derived from the continuous research on Cracow children was used to predict peak body height increases. Its novelty was based on using an original macro/command computer programme for analyzing the individual body height growth rate. Peak Height Velocity (PHV) was determined on the basis of the highest values of development pace indices (%) and absolute body height increases (mm). In addition, the leap increases of body parts constituting the sequences of puberty leaps were taken into account. Depending on the order of the onset of the pubertal leap (PHV) in the study of individual

<table>
<thead>
<tr>
<th>%</th>
<th>Inclusion into groups according to n and age of achieving PHV</th>
<th>FBDDI</th>
<th>7.5–8.5</th>
<th>8.5–9.5</th>
<th>9.5–10.5</th>
<th>10.5–11.5</th>
<th>11.5–12.5</th>
<th>12.5–13.5</th>
<th>13.5–14.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.94%</td>
<td>4 group: n= 8 individuals mm 53.0 58.1 58.1</td>
<td>96.5</td>
<td>46.9</td>
<td>64.5</td>
<td>47.9</td>
<td></td>
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<tr>
<td></td>
<td>Early maturation</td>
<td>% 12.5 13.7 13.7</td>
<td>22.7</td>
<td>11.0</td>
<td>15.2</td>
<td>11.3</td>
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<tr>
<td>15.76%</td>
<td>5 group: n= 32 individuals mm 49.5 54.5 54.3</td>
<td>56.2</td>
<td>99.9</td>
<td>64.5</td>
<td>47.0</td>
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<tr>
<td></td>
<td>Early maturation</td>
<td>% 11.6 12.8 12.7</td>
<td>13.2</td>
<td>23.5</td>
<td>15.1</td>
<td>11.0</td>
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</tr>
<tr>
<td>30.54%</td>
<td>6 group: n= 62 individuals mm 51.4 56.1 49.2</td>
<td>44.4</td>
<td>63.7</td>
<td>102.8</td>
<td>61.2</td>
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<tr>
<td></td>
<td>Normal maturation</td>
<td>% 12.0 13.1 11.5</td>
<td>10.4</td>
<td>14.8</td>
<td>24.0</td>
<td>14.3</td>
<td></td>
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</tr>
<tr>
<td>30.50%</td>
<td>7 group: n= 68 individuals mm 47.4 52.9 49.4</td>
<td>44.5</td>
<td>51.7</td>
<td>59.0</td>
<td>88.3</td>
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<tr>
<td></td>
<td>Normal maturation</td>
<td>% 12.1 13.5 12.6</td>
<td>11.3</td>
<td>13.1</td>
<td>15.0</td>
<td>22.5</td>
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<tr>
<td>9.36%</td>
<td>1 group: n= 19 individuals mm 100.1 53.3 51.4</td>
<td>48.7</td>
<td>48.1</td>
<td>50.5</td>
<td>58.1</td>
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<td></td>
<td>Late maturing</td>
<td>% 24.4 13.0 12.5</td>
<td>11.9</td>
<td>11.7</td>
<td>12.3</td>
<td>14.2</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>3.94%</td>
<td>2 group: n= 8 individuals mm 52.8 75.6 43.9</td>
<td>37.9</td>
<td>47.0</td>
<td>57.4</td>
<td>59.6</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Late maturation</td>
<td>% 14.1 20.2 11.7</td>
<td>10.1</td>
<td>12.6</td>
<td>15.3</td>
<td>15.9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.96%</td>
<td>3 group: n= 6 individuals mm 47.2 43.5 72.8</td>
<td>31.8</td>
<td>52.8</td>
<td>51.0</td>
<td>56.8</td>
<td></td>
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<tr>
<td></td>
<td>Late maturation</td>
<td>% 13.2 12.2 20.5</td>
<td>8.9</td>
<td>14.8</td>
<td>14.3</td>
<td>15.0</td>
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</tbody>
</table>
cases and the number of subjects who reached the peak body height during the period (and therefore, a high degree of pubertal maturation), the children were divided into the following groups: early, average (normal) and late maturation (Tab. 3-4). It should be noted that inclusion into the: 

<table>
<thead>
<tr>
<th>Group Description</th>
<th>%</th>
<th>FBDDI</th>
<th>7.5–8.5</th>
<th>8.5–9.5</th>
<th>9.5–10.5</th>
<th>10.5–11.5</th>
<th>11.5–12.5</th>
<th>12.5–13.5</th>
<th>13.5–14.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early maturation</td>
<td>13.26%</td>
<td>2 group: n= 26 individuals</td>
<td>mm</td>
<td>51.7</td>
<td>83.2</td>
<td>55.0</td>
<td>59.1</td>
<td>48.3</td>
<td>34.6</td>
</tr>
<tr>
<td>Normal maturation</td>
<td>22.45%</td>
<td>3 group: n= 44 individuals</td>
<td>mm</td>
<td>50.1</td>
<td>60.3</td>
<td>91.8</td>
<td>57.6</td>
<td>47.4</td>
<td>24.7</td>
</tr>
<tr>
<td>Normal maturation</td>
<td>16.84%</td>
<td>4 group: n= 33 individuals</td>
<td>mm</td>
<td>49.5</td>
<td>56.4</td>
<td>58.2</td>
<td>83.4</td>
<td>53.4</td>
<td>37.5</td>
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<tr>
<td>Late maturation</td>
<td>29.08%</td>
<td>5 group: n= 57 individuals</td>
<td>mm</td>
<td>48.7</td>
<td>54.0</td>
<td>57.4</td>
<td>56.5</td>
<td>85.4</td>
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<td>Normal maturation</td>
<td>13.78%</td>
<td>6 group: n= 27 individuals</td>
<td>mm</td>
<td>42.9</td>
<td>53.4</td>
<td>50.6</td>
<td>53.2</td>
<td>54.9</td>
<td>79.3</td>
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<tr>
<td>Late maturation</td>
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<td>7 group: n= 6 individuals</td>
<td>mm</td>
<td>49.7</td>
<td>52.0</td>
<td>50.0</td>
<td>50.2</td>
<td>61.0</td>
<td>56.0</td>
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<tr>
<td>Late maturation</td>
<td>1.53%</td>
<td>1 group: n= 3 individuals</td>
<td>mm</td>
<td>97.7</td>
<td>55.7</td>
<td>62.7</td>
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<tr>
<td>Late maturation</td>
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<td>14.2</td>
<td>16.0</td>
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<td>17.1</td>
<td>7.9</td>
<td>5.4</td>
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</tbody>
</table>

From the analysis of the presented data (Tab. 3-4), it was found that (similarly as in the mean values, Tab. 5-6), a pubertal leap was more quickly noted in the girls than the boys.

The conducted analysis of the results (Tab. 4), however, showed that in some of the examined girls, the peak body height development (PHV) occurred at the of age 8-9 years, and the end of the peak increase process could have occurred after the observation period (age 14). Taking into account the averaged measurements, it could be assumed that peak body height increases in the girls from Cracow only occurred between the age of 8 and 12 (Tab. 6). On the basis of analysis of the results of our own research, it can be assumed that, apart from the youngest age group (7-8 years), for every generation, a certain proportion of female subjects reached peak body height, signalling entry into the intensive biological maturation process. The period of peak growth for them was lower than for the boys, which is a phenomenon that had already been noted in studies on children in Poland [91-94].

Moreover, in boys, taking into account the results of individual case studies (Tab. 3), the incidence of entering the stage of peak body height development (age 10-11) one year earlier than concurred from the analysis of the mean values (Tab. 5). In this case, there was a large possibility that peak increases in body height would occur, similarly as in girls after turning 14.

Comparing the variability of the development pace indices of the averaged measurement values (Tab. 5-6) with the dynamics of the pace in the individual cases (Tab. 3-4), it can be concluded that the research method used in this study allowed to establish an objective image of the development course and the biological maturation of children over a longer time-frame than resulting from the analysis of mean values. The results of our research may therefore support previous observations suggesting [95] that the period during which a child reaches an important stage of puberty is environmentally conditioned. According to the newer views proposed by Siniarska and Wolanński [56]: "Much data indicate that the pace of development is primarily regulated by dietary factors, while the age of overgrowth of the long bone roots, mainly by genetic factors". The large dispersion of the biological maturation age suggested the possibility of demonstrating a similar phenomenon in motor development. Such
Table 5. Variability of values of somatic build component development dynamic indicators in boys (JIDR) along with age, calculated from arithmetic means

<table>
<thead>
<tr>
<th>Feature / age</th>
<th>7.5-8.5</th>
<th>8.5-9.5</th>
<th>11.5-10.5</th>
<th>10.5-11.5</th>
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<th>12.5-13.5</th>
<th>13.5-14.5</th>
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</thead>
<tbody>
<tr>
<td>BM (kg)</td>
<td>11</td>
<td>11</td>
<td>12</td>
<td>12</td>
<td>16</td>
<td>18</td>
<td>19</td>
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<tr>
<td>LBM (kg)</td>
<td>4</td>
<td>3</td>
<td>18</td>
<td>18</td>
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<td>28</td>
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<tr>
<td>BF (kg)</td>
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<td>38</td>
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Own elaboration based on 8-year continuous research
Note. Gray colour marks periods of increased development dynamics of articular motor fitness components, and white – peak of development pace

Explanations:
BM – body mass; B-v – body height; LBM – lean body mass; BF – body fat; B-a - acromion height; B-da – dactylion height; B-sy – symphysion height; a-a – shoulder width; ic-ic - hip width; FM - forearm measurement; AMR - arm measurement – relaxed; CM - calf measurement; TM - thigh measurement; sty-da – hand length; mr-mu – hand width; pte-ap – foot length; mtt-mtf – foot width; SSFF - sum of skin – fat folds; NR - navel region; sc – subscap – SC; triceps – T; a-da – upper limb

Table 6. Variability of values of somatic build component development dynamic indicators in (FBDDI) girls along with age, calculated from arithmetic means

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Elzbieta Szymanska, Stanislaw Zak, Edward Mleczko, Renata Nieroda, Tomasz Klocek

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Explanations as in Tab. 1.

Fig. 2. Variability of fitness and coordination ability development pace in selected boys from the fractions: early, normal and late maturation.
a phenomenon could be proof of questioning the establishment of sensitive and critical periods within strict limits during the progressive development of children.

In order to confirm such a hypothesis, analysis of the individual dynamics of physical fitness components was conducted in three groups of biological development advancement.

3. The dynamics of the individual development of physical fitness components in three groups of biological development and the methodology for determining sensitive and critical periods

Considering the issue of individual variability in motor development component dynamics using the macro/macro-command programme, it was necessary to consider the number of computational operations (42420!).

It is impossible to present all the test results even from a synthetic perspective. In connection with this, it was decided to investigate the relationship between the simplified method of determining sensitive periods using the mean values and the effects of the applied method, based on the study of individual cases, taking into account the results of analyzing the development dynamics of fitness and coordination abilities of only three randomly selected boys and girls belonging to different groups of developmental advancement.

In Figures 2-3, the development dynamics of basic fitness motor abilities, commonly referred to as: strength, speed and endurance and coordination motor abilities (visual-motor coordination, spatial orientation, adaptation of movements) in three fractions of children’s puberty: accelerated, normal (mostly occurring) and delayed, are demonstrated in comparison to the body...
height development between the age of 7 and 14. Placed on the axis of the absenteeism (Fig. 2-3), the height of the bars corresponds to the adequate value of the growth rate index, which is given in percentages on the ordinate.

Its highest value is equal to the incremental increase in body height, meaning the studied child attains Peak Height Velocity (PHV). According to the accepted criterion of division into three fractions (Fig. 3-4), the peak height of the body was at the following age, boys: age 10 - maturing early, age 14 – normally maturing, and the PHV age was not determined for those maturing late after the age of 14 and girls: age 9 – maturing early, age 11 - normally maturing (most often) and age 13– late maturation. In turn, the development dynamics of the selected motor abilities are illustrated by continuous lines in three colours, mystically passing through or also above or below the bar graphs of the body height development pace. The reference points to comparative analysis of the pace of development of motor abilities on the basis of average and individual values determined in this way introduced a factor relativizing the dynamics of development due to the advancement of biological development of children. This limits the possibility of conducting analysis compared to a normally developing group. Otherwise, the earlier or later occurring peak in body height prefers the pubertal or pre-pubertal period.

Explanation of abbreviations used in the figures: abilities – motor abilities; mat. fract. – maturation fraction according to Peak Height Velocity (PHV); strength – strength abilities; speed – speed abilities; endurance – endurance abilities; orientation – spatial orientation abilities; coordination – visual-motor coordination abilities; adaptation – abilities to adapt movements

Referring the defined periods of increased development dynamics of individual motor abilities, which were determined on the basis of mean values (juxtaposition, Chapter 2), to the individual courses of development pace of the fraction of normally developing boys and girls, it can be stated that the temporal convergence of this phenomenon did not occur frequently. Such a categorical observation gives rise to falsifying the hypothesis suggesting the possibility of setting universal periods of increased development dynamics, which were debatably identified with sensitive periods.

**Discussion**

In accordance with the assumed aim of the study, in the analysis of the observation of 401 children from the Cracow population, we sought evidence of the hypothesis that sensitive and critical periods in motor ability could be designed using the variability in the pace of physical activity component development during ontogenesis of a child between the age of 7 and 14. As stated in the introductory section, the concept of phases in ontogenesis in which there are favourable conditions for mental and physical development is recognized as a paradigm in pedagogy and psychology [1, 8, 10-12] and even in linguistics [13, 14], despite the rather doubtful theoretical basis for the occurrence of such a phenomenon. They were developed 100 years ago by Maria Montessori [5, 6, 7], based on the observations of the development of certain plant species by the Dutch geneticist de Vries [1, 5], and insects by the American physiologist Jacques Loeb [9]. The regularities discovered by the zoologist and botanist were used for the concept of intentional upbringing of a developing human being, which has not yet been empirically confirmed or decisively criticized. So far, there is a great deal of research carried out, with different outcomes, in which the effects of brain activity and cognitive functions on the various stages of ontogenesis are sought [96-101]. The foundation of Maria Montessori’s theory, based on very strong scientific stances, continues to lead the way in new directions of pedagogy, as exemplified in the work of the methodological approach to raising children and youth by Fernando Corominas [15], the co-founder and long-term president of the European Institute for Educational Research (IEEE).

Without proper scientific reflection, an attempt to use the theory of Maria Montessori’s sensitive and critical periods for the purpose of creating the concept of motor development of young organisms in sport champion candidates was also undertaken [3, 16-20, 26, 27, 84, 102, 103 and Netography: 1-4]. The view regarding the existence of phases in biological development susceptible to environmental influences, in which optimal performance in functional development and motor skills can be achieved, is still treated as a given in Polish sports theory [102, 103 and Netography: 1-4]. As if not perceived, their existence has long been questioned by European researchers [4, 22, 23, 25, 29-32, 36] and thanks to the article by Viru et al. [84], also by American and Australian scientists [80, 83, 86, 104].

As already pointed out, in our research, attention was focused mainly on the attempt to verify the assumptions for determining sensitive and critical phases based on the development pace of motor structure components during the ontogenesis of children. In this way, the obtained results were the basis for conducting assessment of the theoretical assumptions regarding the above mentioned phenomena. Consequently, the research hypothesis assumes that the results of continuous observations of individual biological development rates may be the basis for determining the pace of somatic and motor development in children during their progressive development. Accordingly, if the current findings of periods of exceptional training susceptibility are credible, such
periods should occur at the same stage of ontogenetic development irrespective of the origin of the materials from continuous or cross-sectional studies.

The results of the comparative analysis have unambiguously confirmed the lack of convergence between the effects of determining the limits of sensitive periods based on continuous and cross-sectional materials. This undoubtedly proves the usage of an erroneous methodological approach to traditionally determining sensitive and critical periods with the implementation of materials from non-random trials. In our own research, the scope of hypotheses verification has been extended beyond the easily falsified assumption. Attention was drawn to the relative approach to assessing the dynamics of motor development, considering averaged values and the study of individual cases as a reference point. In this way, two methods were used to estimate the pace of motor development in children tested annually between the ages of 7 and 14. The first one may be called traditional, with the help of which development indicators are calculated on the basis of average values. In the second case, the individual motor development pace was considered using original PC software, i.e. macro/macro-command. A similar research approach was used in the monthly carcinogenic studies on Mexican children in Yucatan [56]. What were the main findings of the comparative analysis?

The indicators of somatic and motor development pace, calculated from the averaged values of somatic structure component and motor efficiency measurements, allowed to establish other periods of somatic and motor development than in the comparative materials. The variation in the indicators of biological maturation pace and motor efficiency in the groups of girls and boys could prove that the dynamics of human biological development is determined by lifestyle and physical activity. This conclusion is supported by the lack of compatibility between the pace of motor development and body height, and thus, a feature characterized by a high level of genetic conditioning [23].

A characteristic feature of somatic and motor development revealed in the studied population of children on the basis of indices of the development pace determined using the traditional method was also that along with the age of the subjects, there was a systematic increase in somatic characteristics apart from a few exceptions (e.g. fat mass), and in the considered measurements of speed, endurance and coordination abilities, the reversed phenomenon was observed: the highest rate was noted in the younger children between the age of 7.5 and 10.5. Without penetrating into the aetiology of biological causes for the motor development decline in the age group of 11.5-14.5-year-olds, it would be difficult to ignore the possible deficiencies in the stimulation of the motor structure components in proportion to the needs of the developing organism. That this is a period equally susceptible to burdening stimuli may be evidenced by the large amplitude of rhythm disturbances in the pace of motor development shown in our research. Undoubtedly, the reasons for this phenomenon should be related to the different susceptibility of human genotypes to environmental stimuli at each period of ontogenesis [23]. This has also been demonstrated by experiments conducted in Poland on the ‘trainability’ of people at different ages [34-37, 105-107].

Thus, the results of our research prove that adaptation processes did not occur in the examined children according to a defined, standardized programme, but in a variable and flexible manner. This may indicate that, as stated by Preilowski [108] – according to whom J. Raczek refers his views [4]: "biological potential in humans has a very broad norm of reactivity and adaptation". The results of our research have confirmed such a property. This could, on the one hand, be proof of the children’s susceptibility to the stimuli in the desired direction, and, on the other hand, the possibility of decreasing the efficiency of the organism within the same scope in the absence of adapting effects. It appears that this way, further evidence has been gathered to support the efforts to validate the already proposed development model of Selection-Optimization-Compensation (SOC) by P. B. Baltes [40, 41], based on the assumptions of Life-Span Development Psychology.

In summary of the ongoing considerations, it should be stated that, although it was possible to distinguish periods of increased development dynamics of physical fitness components on the basis of motor development indices, traditionally determined on the basis of materials from continuous tests, nonetheless, the observed, large allometry in the dynamics of motor and somatic development suggests environmental and even population-based reasons for it. Therefore, it would be unreasonable to transfer theories of sensitive, critical periods to the specifics of biological phenomena development, based on the rather unreasonable premises [1, 5-9, 10-14, 109]. These should undoubtedly include ontogenetic variability of motor efficiency components.

Such a conclusion has been confirmed by the results of our analyzes on the variability of the rate of somatic development irrespective of the origin of the materials from continuous or cross-sectional studies.
and motor development, based on the study of individual cases of somatic structure and motor performance dynamics. In the somatic development of the examined children, a tendency towards stability of development dynamics emerged. In body height, there were manifestations of "normal human" development. It was possible to identify the 'at one's own time' development of the feature, and the occurrence of positional stability of the subjects in the age group during articular years of observation. Similar phenomena, although to a lesser degree, revealed the sequential development of particular body height segments. This created the basis for grouping the subjects into three categories of morphological development: normal (average), early and late.

On the other hand, in the results of the pace of motor development there was such a large and diverse type of variability in all the components of the involved motor skills that it was impossible to make any generalizations rationally. Attempting to characterize the statistics of growth rates in each time interval would obliterate the distinct nature of individual variability. Not only due to volume limitations of the article did we resign from the presentation of all the analyzed cases and thus, only the selective results of the individual rate of development of chosen fitness indicators were presented. Their individual nature was so extensive (as already mentioned) that the course of development appeared to be an open system with many degrees of freedom, diverse and multidirecional changes, unstable and often chaotic progressions, which (as it may have been deduced) was not determined by any deterministic laws. Recognizing that 'trainability' is individualistic and not population-based in nature [23], it was decided to discontinue any intervention in the actual motor development of the study participants, maintaining the position that was justified by the conclusions of the study among Yucatan children: "Each child and each of his/her characteristics has its own pace of development, modified by living conditions at a given period" [110].

In the present situation, discussion on the division of ontogenesis into sensitive and critical periods due to the pace of motor development did not make sense. Support for such a position could be found in J. Raczek's view [4] on the statistical approach to the development of the results of auxological research: "Unfortunately, in the sciences of physical culture, the linear-deterministic model for interpreting processes and mechanisms of development still prevails. The traditional, nomothetic development research methodology also dominates. The situation often leads to erroneous cognitive effects and consequently, to the formulation of inapt postulates of practice" [4].

The presented examples may clearly demonstrate that the dynamics of the development of motor performance components cannot be explained using the traditional model for its analysis and description. In none of the analyzed cases were there any similarities between the individuals in the course of development of motor function components. Also, large variation in the pace of development could be found for each of the subjects. The results of our research have thus, provided further evidence for the falsification of the concept of determining the period of exceptional susceptibility to the training of motor components only in certain aspects of their ontogenetic development.

The correctness of such a statement has already been confirmed by the lack of convergence between the peaks in body height and the greatest leap of the motor component. This led to the conclusion that there was no link between the pace of motor development and the speed of biological maturation. Only in a few cases was there a positive effect of developmental delays on motor performance, which was signalled in some studies [4]. In turn, the smaller number before and after puberty leaps differed in the pace of somatic structure component development from the components of motor structure. Also noted was the amplitude range of the motor development pace. In the fitness capacities, the vertexes of the sine waves regarding the pace of development were even from several dozen to several hundred percent higher than the peak of the puberty leap in body height (significantly higher than in body height), and the high liability of the onset time of the increase in dynamics of the motor structure components at the distinct stages of puberty were unambiguously attributed to environmental causes of the occurring differences in motor and somatic development dynamics.

Additionally, high plasticity of the structure of the physical fitness components (susceptibility to environmental factors) was found. Evidence for this phenomenon was revealed in girls during the final stages of ontogenesis in the form of an increase in strength abilities along with a decrease in body mass (a different dependence should be expected, resulting from Newton's second law of dynamics: \(F = ma\)). However, in a different case, along with a higher index of the subjects' body mass development pace, an increase in the relative indicators anaerobic work was observed. In the studies to date, during the pubertal phases as well as the phases

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5 Borrowing terminology from the concept of motor development by J. Raczek [4], the following types of variability can be distinguished at individual paces of the development of motor structure components: interindividual - determines differences in level, pace, duration, size and course of developmental changes among individuals; intraindividual - determines differences in the developmental components of one individual; intrafunctional - defines the differences in the development of various aspects of functions or components of functional competence; inconsistency - characterizes shorter and longer periods of stabilization or recession.
of increases in body mass, there was a decrease in aerobic and anaerobic capacity, especially in girls [106, 111, 112]. Perhaps the results of our research prove the positive influence of the broadly understood environmental stimuli on shaping the discussed motor predispositions in the Cracovian population. It seems that the demonstrated phenomenon confirms the suggestion visible in some papers [23, 24] stating that physical fitness is susceptible to training stimulation, mainly through increased physical activity. The variability in motor development found in our study had to lead to the conclusion that in each case, an attempt at a statistical approach to develop research results would cause obliteration of the essence of individual development. Such a manner of interpreting research results directs our attention to the views of human motor ability researchers. J. Raczek [4], summarizing the results of the auxiological studies to date stated: “The reality concerning motor properties is very diverse, showing, among others, significant dispersion within particular age groups. Development is a process of many degrees of freedom and never occurs in an ‘averaged’ manner. This indicates the necessity to relativize the findings resulting from average values for a given population. Mean values are therefore important only for comparative, mainly interpolation purposes”.

Such a view of achievements in this field of research, supported by the stance of the German anthropomotoric scholars [113], has led the researcher to make a clear conclusion for the practice of sports: “there are no consequences of guiding the process of shaping and improving motor skills” [4].

The views of Polish auxologists even more strongly emphasize the lack of justification for using statistics when compiling the results of human biological development research. According to Sniarska and Wolański [56]: “Differences in the interpretation of incremental increases may be due to the cross-sectional or continuous nature of the data, the time intervals in measurements (daily, monthly, annual) and the method of analyzing the increases (using the equalization method). While the first two causes are to some extent an indispensable consequence, the third one is a distortion of the results of empirical research”. Such a finding has led researchers [56] to adopt the following assumption: “Mathematics operates on the basis of quantitative and formal reproduction of phenomena. Biology is a far advanced science in the experimental verification of its claims, psychology is still a science formulating conclusions on general manifestations, operating on axioms untested experimentally based on theoretical assumptions. There is, however, an objective reason for the differentiation of this division which, on the one hand, results from the nature of personality development, and on the other, the existence of certain latent phases at the time of biological development. These somatic and mental processes break away from the framework of mathematical correctness, and that is the importance of research for the theory and practice of biology and medicine”.

Based on the results of our research, it should also be added that learning and documenting processes that “break away from the framework of mathematical correctness” is also important for the theory and practice of sport, including, above all, competitive sports. The importance of this research approach is emphasized by the creator of the new concept of motor development [4] in the following manner: “To date, mainly forms of change, mechanisms of their formation and patterns of their progress have been described - nomotetically, from the normative point of viewing average values «the average person». However, today attention is focused on individual changes and the conditions under which these individual changes are best formed. At the heart of interest, there are no variables, functions or their generalizations, but there is a person”.

The presented examples point to the significant shortcomings and the great controversy around the concept of determining sensitive periods in the ontogenesis of children aged 7-14. Concluding the deliberations on the lack of arguments for the affirmation of views on their existence only at periods of increased development dynamics of motor function components in children, it would be appropriate to refer to the very aptly already quoted stance of J. Raczek regarding the applicative values of such concepts: “(...) basing motor stimulation on the use of these phases should be treated as an unverified hypothesis. This situation does not entitle us to derive categorical conclusions and define uniform methodological recommendations” [4, 31]. The presented analysis of the collected materials during the continuous research on children in Cracow and the discussion of the results obtained therein, allows for the falsification of the hypothesis that it is possible to set strict limits of specific susceptibility to the impact of environmental factors.

Conclusions

1. Differences in researching motor skill development pace using various methods support the lack of a basis for using development dynamic indices as a criterion for determining sensitive and critical periods.

2. Using Maria Montessori’s concept for determining sensitive and critical periods for the phenomena accompanying the motor development of a child should be considered unfounded.

3. The results of our research provided evidence for falsification of the hypothesis suggesting the possibility of setting strict boundaries of periods of particular susceptibility to the influence of environmental factors.
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Once more on the methods for determining sensitive and critical...
LEVEL OF MOTOR SKILLS IN YOUNGER PRIMARY-SCHOOL CHILDREN AND THEIR SELECTED CONDITIONS

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Key words: level of motor skills, younger primary-school children, selected conditions

Abstract

Aim. To assess the motor skill level of younger primary school children (grade 1-3) and the relationship between the motor skills of the participants and their knowledge on physical culture and physical activity.

Basic procedures. The study was conducted among randomly selected children enrolled in grades 1-3 of primary schools in Krakow. 334 students aged 7-8, 365 aged 8-9 and 317 aged 9-10 took part in the study. The basic method was a diagnostic survey, and the technique was a questionnaire and school achievement testing. The SPSS 21 (IBM Corp., 2012) programme was used for statistical analysis of the study results. Statistically significant correlations were assumed at $p < 0.01$ and were marked by two asterisks.

Results. The highest percentage of subjects regarding the level of motor skills was in the middle and high ranges. The analysis of the results also showed an average level of physical activity and knowledge about physical culture in the majority of participants. Research also showed a statistically significant positive correlation between motor skills and the level of physical activity of children and the level of knowledge about physical culture.

Conclusions. Younger school-girls and school-boys are generally above average in terms of selected motor skills. The age of the examined children clearly differentiated their level of motor skills. There was a statistically significant correlation between the motor skills and physical activity of children in their free time and their knowledge on physical culture.

Introduction

Motor skills are one of the most important determinants of human participation in physical culture. To a large extent, they determine not only the current but also future participation in its different forms. On the other hand, physical activity facilitates the development and consolidation of diverse skills. That is why it is so important to exercise daily or almost daily, because failure to do this cyclically, results in short-term effects [1]. In addition, regular physical activity, as it is well known, has many health benefits, and at the stage of early-education, it positively effects motor skill development, mental state and social behaviour [2]. Unfortunately, the results of studies conducted in different age groups, including among the youngest children, showed that the level of interest in physical activity, especially in leisure time, decreases with age [3-5]. Participation in physical activity is conditioned both by acquired motor skills as well as the level of possessed expertise (e.g. regarding the technique of the performed form of movement) and general knowledge (e.g. related to a healthy lifestyle). The transmission of knowledge is an extremely important and indispensable element of teaching new motor skills, in which the teacher not only gives starting and ending positions of the exercise but also explains the
entire structure of a movement in detail, notices the performed mistakes made and informs how to avoid them. As a consequence, this allows to master a motor task accurately. In turn, high levels and large resources of motor skills allow for participation in a variety of forms of movement and facilitates the choice of a lifelong form of physical activity. Through systematic participation in physical activity, the acquired motor skills are constantly improved, leading to a motorized habit. Thus, knowledge, motor skills and physical activity are complementary. Particular motor skills determine the quality of the motor skills to a different degree. It is also important to emphasize that children, gradually gaining control over their motor skills, improve the ones they have not been able to master before [7].

The range of required physical skills that a student should master during physical education at the level of early school education is included in the core curriculum. Of course, it can be freely extended by the teacher depending on his or her abilities or the possessed resource/didactic conditions. However, the core curriculum clearly states that the teacher must plan the classes in such a way as to maintain continuity in teaching and improving basic skills. The point is that the acquired skills are repeated many times, which in consequence will lead to their fixation and the gradual elimination of errors. Achieving a high level of motor skills during the first stages of education will make it easier for students to acquire further skills in following years of education.

The aim of the study was to assess the level of motor skills in early-education school children according to their age and to determine the relationship between their motor skills and knowledge on physical culture as well as their free-time physical activity. In our research, we sought answers to the following questions:
1. What is the general level of motor skills, knowledge on physical culture and physical activity of younger primary school children?
2. How different is the level of motor skills depending on the type of performed motor task?
3. To what extent does the age of the male and female pupils differentiate their level of motor skills?
4. How do the relationships between the level of motor skills and the level of physical activity of the examined students and their physical culture knowledge develop?

**Material and methods**

The study was conducted among randomly selected children enrolled in primary schools in Krakow. 334 students aged 7-8, 365 aged 8-9 and 317 aged 9-10 took part in the study. The basic method was a diagnostic survey, and techniques such as a questionnaire and school achievement testing were used.

The motor skills of the examined children were assessed using our own specially designed test. It was a modification of M. Jagusz’s concept for evaluating the motor skills of physical education students [8]. The test included ten tasks from different areas of physical activity that were included in the programme requirements for early childhood learners. The motor skills tests included: front support, candle position, forward and backward roll from supported squat to supported squat, returning jump over gym bench with bent legs, dribbling a mini-basketball while marching, bouncing a mini beach ball above one’s head using two hands, leading a mini-football with the inner part of one’s foot, double standing long jump.

The test was conducted in the presence of three competent judges. For the completed task, the child could receive from 0 to 6 points. The final result of the test was the sum of the scores (0-60) obtained by the child in all the tasks. Five levels of motor skills were set: very low, below 12.9 points, low 13-24.9 points, average 25-36.9 points, high 37-48.9 points, very high 49-60 points. The adopted scale allowed for fractions. The intervals were given to one decimal place.

The physical activity of the pupils was assessed using a questionnaire, and its level was determined based on frequency (number of days per week) and volume (number of hours per week) of organized and non-organized physical activity. In total, the studied student could obtain from 0 to 22 points, which were the basis for establishing five numerical ranges: very low below 4 points, low 4-8 points, average 9-13 points, high 14-18 points, very high 19-22 points.

In turn, knowledge on physical culture was examined by using Z. Żukowska’s drawing test [9], modified by E. Madejski [10]. The drawing test consisted of 17 sets of questions, including 21 scored questions and covered four areas of knowledge: knowledge of equipment and instruments, recognition of sports based on equipment and presented exercises, knowledge of exercises, exercise settings and starting positions for exercise and health-related behaviours. The subject could receive from 0-53 points, which were the basis for establishing the five numerical levels: very low 11 points, low 11-21 points, average 22-32 points, high 33-43 points, very high 44-53 points. The adopted point scale had discrete values. Ranges were given in integers since such a manner of accuracy was used in the calculations.

Prior to the study, the state of the resource and didactic base of the schools was checked in the inventory books. As it turned out, in most of the studied schools (73.7%), the state of the didactic resources
Level of motor skills in younger primary-school children... was provided for physical education in early school education was low and did not exceed 1/3 of the required equipment. It has also been found that in most cases, sports equipment intended for second level education was used. Physical education classes were held in gymnasiunms, but only once a week, and about one-third of the classes took place on the school pitch or corridors. 20.3% of gym classes took place in substitute-gymnasiums, while the rest were common-rooms or classrooms.

Statistical analysis of the research results was conducted using the SPSS 21 programme (IBM Corp., 2012). A description of the qualitative data is provided by means of the compilation of numbers and percentages. In contrast, the chi-squared statistical significance test was used to examine the relationship between the qualitative data. In turn, the analysis of the correlation between the estimated variables (ordinal variables - age of students) and the quantitative or quantitative variables, Spearman’s rho nonparametric correlation analysis was used [11]. Statistically significant correlations were assumed to be at the level of $p < 0.01$ and are marked by two asterisks.

Results

The results of research on the level of selected motor skills included in Table 1 show that the age of children clearly differentiates their skill level in the areas studied. The higher the graded, the higher the percentage of skills possessed in the “very high” and “high” ranges, and the lower in the “medium” and “low” ranges. This means that the level of motor skills increases with age. There was a statistically significant correlation between the level of motor skills and age at the level of $p < 0.001$.

According to the data in Table 2, among the two starting positions selected for assessment, front support was performed at an average level. The most common mistake is the incorrect alignment of the trunk and lower limbs, not forming a straight line. However, the correctness of this task increased with age. At the time of assuming this position, improper positioning of the hands was also observed in a fairly large group of subjects. In this case, there was an interesting relationship, namely with age, this mistake was made more and more often. The above analyzed age correlations are statistically significant ($p < 0.01$).

It was much more difficult for the students to assume the candle position. In the vast majority of the examined children, the torso and lower limbs were not in a vertical position. In the other three types of errors (balance disturbances, improper support of the back using the hands, legs not joined), correlations of significance at $p < 0.01$ were noted between particular age groups. The second most frequently made mistake was incorrect support of the back using one’s hands.

The analysis of selected skills regarding gymnastics exercises showed that the least properly performed task was the backward roll from supported squatting to squatting position (Tab. 3). Only a small number of respondents were able to correctly assume the end position after the roll. Also, the vast majority did not properly push their shoulders away from the ground. For each of the mistakes made, little progress was noted at the subsequent stages of education. This difference was statistically significant at $p < 0.01$. On the other hand, as for the forward roll, the students showed much better skills. The frequency of errors decreased with age. A significant statistical correlation ($p < 0.01$) occurred only with such errors as: absence of leg rebound and performing the roll on one’s head.

The best gymnastic exercise demonstrated was the returning jump over the gym bench with bent legs, although during the performance of this task, in the case of most children regardless of age, we noticed their legs

<table>
<thead>
<tr>
<th>Table 1. Level of motor skills of the studied children according to age</th>
</tr>
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<tbody>
<tr>
<td><strong>Level of motor skills</strong></td>
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<tr>
<td></td>
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<tr>
<td></td>
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<tr>
<td>Very low</td>
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<td>Low</td>
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<td>Average</td>
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<tr>
<td>High</td>
</tr>
<tr>
<td>Very high</td>
</tr>
<tr>
<td>Total</td>
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</tbody>
</table>

Correlation: $\chi^2(8) = 105.40; p < 0.001$
were not joined during the jump. By contrast, the vast majority of male and female pupils assumed the correct position after landing. In this exercise, there was a statistically significant correlation ($p < 0.01$) in the case of two errors (no double rebound and balance disturbance after landing).

Studying the motor skills of the younger school children in the field of handling a ball included four tasks: throwing a mini-handball against the wall towards the goal and then grabbing it, dribbling a mini-basketball while marching, bouncing a mini beach ball above one’s head using two hands, leading a mini-football
using the inner part of the foot. Their level was varied and depended on the type of task (Tab. 4). The exercise performed best was dribbling the ball, and secondly, leading the ball using the inner part of the foot. While dribbling, the students most often did not properly perform the work with the dribbling hand, but with age, the error was gradually eliminated (correlation at \( p < 0.01 \)). On the other hand, the lack of required control over the ball was observed in the majority of the students (correlation at \( p < 0.01 \)).

Based on the data in Table 5, it can be said that the students were fairly good at the double standing long jump. In most of the subjects, the correct rebound and position of the lower limbs after landing could be observed. Research showed that the age of the students had positive influence on the level of the standing long jump, and the differentiation of the results was statistically significant (\( p < 0.01 \)).

The study also examined the level of physical activity of students in their free time and their knowledge on physical culture. According to data in Table 6, the highest percentages among the respondents were recorded in the range of the average level of physical activity. Very high levels of this activity concerned a small group of male and female pupils, and for about 1/3 of the respondents, low and very low levels of activity were found. In

**Table 4. Level of children’s motor skills regarding handling a ball according to age**

<table>
<thead>
<tr>
<th>Task No.</th>
<th>Types of mistakes with set negative points</th>
<th>Subject’s age</th>
<th>Spearman’s rho correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>7-8 years</td>
<td>8-9 years</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( N )</td>
<td>%</td>
</tr>
<tr>
<td>1</td>
<td>a) incorrect stance during throw-2</td>
<td>37</td>
<td>11.1</td>
</tr>
<tr>
<td></td>
<td>b) incorrect throwing technique-2</td>
<td>62</td>
<td>18.6</td>
</tr>
<tr>
<td></td>
<td>c) missed throw or passing the penalty line-1</td>
<td>212</td>
<td>63.5</td>
</tr>
<tr>
<td></td>
<td>d) dropping the ball after grabbing -1</td>
<td>107</td>
<td>32.0</td>
</tr>
<tr>
<td>2</td>
<td>a) dribbling or catching the ball with two hands-2</td>
<td>258</td>
<td>77.3</td>
</tr>
<tr>
<td></td>
<td>b) incorrect work of the dribbling hand-1</td>
<td>23</td>
<td>6.9</td>
</tr>
<tr>
<td></td>
<td>c) losing the ball (1 pt – each time)</td>
<td>225</td>
<td>67.4</td>
</tr>
<tr>
<td></td>
<td>d) carrying the ball-2</td>
<td>324</td>
<td>97.0</td>
</tr>
<tr>
<td>3</td>
<td>a) ball thrown upwards using both hands-2</td>
<td>140</td>
<td>41.9</td>
</tr>
<tr>
<td></td>
<td>b) one-handed rebound-2</td>
<td>32</td>
<td>9.6</td>
</tr>
<tr>
<td></td>
<td>c) dropping the ball-1</td>
<td>97</td>
<td>29.0</td>
</tr>
<tr>
<td></td>
<td>d) no control over the ball-1</td>
<td>35</td>
<td>10.5</td>
</tr>
<tr>
<td>4</td>
<td>a) leading the ball other than with the inner part of the foot-2</td>
<td>132</td>
<td>39.5</td>
</tr>
<tr>
<td></td>
<td>b) losing the ball-1</td>
<td>236</td>
<td>70.7</td>
</tr>
<tr>
<td></td>
<td>c) hitting the cone with the ball-1</td>
<td>294</td>
<td>88.0</td>
</tr>
<tr>
<td></td>
<td>d) no control over the ball-2</td>
<td>53</td>
<td>15.9</td>
</tr>
</tbody>
</table>

**; \( p < 0.01 \)

Legend:
1. Throwing mini-handball at wall towards goal and grab.
2. Dribbling mini-basketball while marching.
3. Bouncing a small beach-ball above one’s head using two hands.
4. Leading the mini-football using the inner part of the foot.
the individual age groups, the highest values were recorded in the range of the mean level of organized and non-organized physical activity.

Based on the data presented in Table 7, it can be stated that the knowledge of younger school children on physical culture is mostly at an average level. Nearly one in four children reported low levels. None of the surveyed children obtained the score required to achieve a very high level of knowledge. There was a statistically significant correlation between the level of knowledge and the age of the subjects at \( p < 0.001 \). This means that the older the children, the higher the percentage of results in the high
level of knowledge. At the same time, as they age, they decreased in the lower range. It can therefore be assumed that, as expected, the level of knowledge of younger children on physical culture increases with age, however, the state of knowledge of children completing early education is not satisfactory.

In the study of motor skills, younger children were also tested to see to what extent their acquired motor skills influence their level of physical activity. Analysis of the results (Tab. 8) showed a statistically significant positive relationship between the tested variables ($p < 0.001$).

We also searched for the answer to the following question: How is the relationship between the level of children’s motor skills and their knowledge on physical culture shaped? The data in Table 9 show that the higher the children’s level of knowledge, the higher their level of motor skills. The high and very high levels of motor skills was accompanied by at least average and high levels of knowledge. There is a positive, statistically significant relationship between the tested variables at the level of $p < 0.001$. Among the respondents, none of the students showed a very high level of knowledge, but also only a small percentage of students achieved a very low level of motor skills.

### Discussion

In terms of the tested motor skills, the students of the younger grades showed average and high levels. With age, they obtained increasingly better results in almost all the motor tasks. The study also revealed that the level of the motor skills chosen for assessment, in most cases, correlated with the age of the students.

Children from the younger grades performed ball dribbling, the standing long jump, the returning jump over gym bench, leading a ball with the inner part of the foot and front support the best. In turn, the most problems were with the backward roll and the candle position. As it is well known, the teaching of motor skills should be accompanied by the transfer of knowledge, i.e. detailed explanation of the motor function in terms of technical accuracy and attention to the most common errors. The correct performance of the exercise with the
ball by the subjects can be referred to the results of the drawing knowledge test, where 77.3% of the students showed good knowledge of the ball dribbling technique, 67.3% indicated how to properly grip the ball and 59.9% how to properly throw the ball. On the other hand, the poor knowledge related to the performance of the candle position (0.1% of students) can be linked with poor level of performing this task during testing the skills.

Research showed a positive and statistically significant relationship between pupils’ knowledge and their motor skills, i.e., the higher their level of knowledge on physical culture, the higher their level of motor skills. It can therefore be stated that the correctness of a given skill depends on the level of its knowledge. Having the right knowledge is also one of the most important determinants of physical activity [12].

The results of the study also revealed a statistically significant correlation between the level of motor skills and the physical activity of children. Unfortunately, over 1/3 of the subjects reported low and very low levels of activity. Children aged 8–9 achieved the best results in the range of average and very high activity levels. However, the very low level was mostly comprised of 9–10 year-old male and female pupils. There was no statistically significant relationship between the age and physical activity levels of the subjects. This state may be surprising because, to some extent, it denies the ontogenesis of the inner need for movement in children during this period. Fears are all the more justified because, as it is well known, physical activity is the basis for a child’s well-rounded development. At this point, it is worth noting that the participation of school-children in physical activity is dependent on the physical activity of parents, as it has been repeatedly confirmed by studies [13–19, 10]. Sas-Nowosielski believes that “social imitation learning, also referred to as modelling or substitute learning, is recognized in social-cognitive theory as one of the most important mechanisms of social impact on the attitudes and behaviour of children and adolescents” [20]. Furthermore, as demonstrated by studies, the physical activity of children is also influenced by the education of parents [21, 17, 22–25].

The results of the research are primarily of applicable value as they approximate the actual functioning of physical education in early-school education in terms of student motivation, knowledge and physical activity among younger students. According to the authors, this information can contribute to teachers paying special attention to the skills which are the most problematic for students, and at the same time, improve the learning outcomes. This also shows the teachers which mistakes are most frequently made. It is worth pointing out that a disturbingly low percentage of respondents (0.6%–7–8 years, 1.6%–8–9 years, 8.2%–9–10 years) could be found in the very high motor skill range. This may be due to incomplete realization of objectives and tasks resulting from the curriculum. Naturally, the effectiveness of this process is also diminished by the lack of required resources and didactic conditions, the poor preparation of early-school education teachers to teach P.E., and the marginalization of physical education at this level of education, as highlighted in many publications [26–29, 10]. The results of this study will also shed greater light on the importance of properly prepared knowledge [12, 30] in teaching motor skills and motivating students to perform school and extracurricular forms of physical activity. This knowledge is the basis for the intellectual response of students to physical activity, which is needed not only to learn or understand, but for them to also want to be physically active in the time off from school and during his/her whole adult life.

Conclusions

Detailed analysis of the results of the conducted research allows to formulate the following conclusions:

1. Female and male early-education pupils are generally above average in terms of selected motor skills.

2. Among the individual tasks of the motor skills test, the studied students performed the following tests the best (respectively): ball dribbling, standing long jump, returning jump, leading the ball with the inner part of the foot and front support, and the most problematic were the backward roll and the candle position.

3. The age of the examined children was clearly differentiated by their level of motor skills, i.e., with age, the students made fewer mistakes while performing certain motor tasks. The exception was front support, where in the case of three errors, the situation was reversed. With age, there was also no noticeable progress in the area of such errors as back support after performing a forward roll or lack of pushing with the arms and completing the backward roll on one’s knees. This may mean that some teachers did not have enough knowledge about the technical correctness of the performed exercises and could not effectively eliminate the mistakes made by the students within three years. Another reason for the lack of significant progress may be the weak resource-didactic base for physical education at this educational level.

4. There was a statistically significant correlation between the motor skills and the physical activity of children in their free time and their physical culture knowledge. The higher the children’s knowledge,
the higher their level of motor skills and vice versa. High and very high levels of motor skills were accompanied by at least medium and high levels of knowledge. Approximate relationships occurred between children’s motor skills and their level of physical activity.

Reference


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PHYSICAL ACTIVITY LEVEL OF FIRST YEAR STUDENTS FROM JOZEF PILSUDSKI UNIVERSITY OF PHYSICAL EDUCATION IN WARSAW

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Key words: physical activity, IPAQ, students, physical education, sports

Abstract

Aim: The aim of the study was to evaluate the level of declared physical activity of first-year students from Jozef Pilsudski University of Physical Education in Warsaw by using the International Physical Activity Questionnaire (IPAQ). The paper presents physical activity according to the students’ chosen degree course and sex. The study also analyzes physical activity in relation to the BMI index according to the classification by the World Health Organization (WHO).

Basic procedures: The group of participants comprised 190 Physical Education (n = 115) and Sports (n = 75) students. The study was conducted in November 2015 and used the short version of the International Physical Activity Questionnaire.

Main findings: The results of the present study showed that the physical education students were characterized by a higher level of physical activity in each discussed type of physical activity than their peers studying sports. The study also revealed that the women showed greater physical activity than the men. It was only in vigorous-intensity physical activity that the men obtained higher results than the women.

Conclusions: The male first-year students of the University of Physical Education in Warsaw prefer vigorous-intensity physical activity, and the female students prefer both moderate-intensity activities and walking. With the development of sports infrastructure and the growing number of sports services, women have become more physically active and achieve results rivaling, or at times, surpassing the results obtained by men.

Introduction

Physical activity is one of the basic components of a healthy lifestyle. It increases the speed of metabolism and improves physical and mental state [1]. Thanks to physical activity, the body utilizes calories more efficiently, which in turn, helps maintain correct body mass. Physical activity also reduces stress and affects the functioning of the respiratory system, improving respiratory ventilation and mobility of the chest [2, 3, 4].

Currently, the pace of life, sedentary lifestyle and heating habits increase the incidence of diseases of influence such as diabetes, hypertension, heart disease or obesity. Numerous technological amenities lead to a decrease in physical activity, and excessive calorie intake
and stress in daily and professional life cause the abovementioned diseases [5, 6].

Attempts are made at investigating the purposeful and planned physical efforts undertaken during one’s free time, as well as the physical efforts performed during work, studying and domestic chores - for physical activity leads to a healthy lifestyle [7].

Regular physical activity is also a recommended and important measure in preventative healthcare [8, 9].

Youth spend the majority of their time using multimedia devices, despite the fact that the infrastructure of sports facilities is very well-developed nowadays, e.g. the “Orliki” sports grounds, sports halls and outdoor gyms, which allow both children and adults to train.

New facilities are being built which make it possible to properly workout, without fearing for one’s own health. There is also an increasing number of TV and Internet programmes about physical education. Such programmes may encourage the society to spend time actively and carry out one’s own goals. Experts assess that moderate- and vigorous-intensity physical activities performed daily for 60 minutes is optimal for children and youth [10]. Moreover, the appropriate consumption of food during physical effort is necessary to prevent exhaustion, injury and serious illness.

The extensive market of physical education services also allows for consultations with specialists, who teach us how to appropriately perform various physical exercises without the risk of injury. Today, it is possible to exercise not only at sports halls, gyms or swimming pools, but also outdoors. Furthermore, sports events that are aimed at encouraging youth and adults to spend their free time actively are being organized more and more frequently.

Universities, especially those specializing in physical education, are very important institutions that should encourage the society to spend their time actively. It is the students of teaching and biomedical degree courses that will be promoting physical activity in a few years, both among children and adult persons. The appropriate preparation of students for the promotion of physical activity and the correct ways of performing it becomes a key element in increasing society’s awareness of exercising needs.

The argument that each student who promotes an active lifestyle should be able to take care of both his or her own health and the health of others, along with the observed poor state of Polish youth’s knowledge about physical activity [11] constitute a valid reason for undertaking a study on the physical activity of students from the University of Physical Education in Warsaw.

Material and methods

This study analyzes data concerning the declared physical activity of first-year students from Jozef Pilsudski University of Physical Education in Warsaw. Study participants encompassed 190 students (women: n = 65, men: n = 125) of physical education (n = 115) and sports (n = 75).

The group of study participants comprised 40 female students and 75 male students of physical education, and 25 female students and 50 male students of sports.

The study was conducted in November 2015, according to the guidelines of the IPAQ Research Committee, and was based on the short version of the International Physical Activity Questionnaire (IPAQ). The questionnaire concerned the types of physical activity performed in everyday life over the last seven days. The respondents were also asked about the number of times a week they engaged in vigorous- and moderate-intensity physical activities, and about the time they spent walking and sitting [12].

Each type of physical activity was ascribed a MET score. Vigorous-intensity activities were ascribed 8.0 MET, moderate-intensity activities 4.0 MET, and walking 3.3 MET [12]. Next, the MET score was multiplied by the number of days and the total time (in minutes) spent on a given type of activity to obtain the total activity performed by a given person expressed in MET-minutes/week. This is a frequently used method to determine the level of physical activity of various social groups [13].

Bieriart and Tomaszewski [14] introduced a new category of physical activity, i.e. augmented physical activity, which allows for a more precise evaluation of a given person’s physical activity.

The results of the study were divided into the four categories of physical activity according to the IPAQ guidelines:

- Insufficient activity (less than 600 MET-minutes/week);
- Sufficient activity (600–1,500 MET-minutes/week);
- Augmented activity (more than 1,500 MET-minutes/week, but less than three days a week of vigorous-intensity activities);
- Health Enhancing Physical Activity (HEPA) (more than 1,500 MET-minutes/week, but at least three days a week of vigorous-intensity activity, or more than 3,000 MET-minutes/week).

The analysis of data used arithmetic means ($\bar{x}$), standard deviations (SD) and percentage shares within a set (%). Statistical significance of the differences between the values describing the declared physical activity of first-year students from Jozef Pilsudski University of Physical Education in Warsaw according to the students’ degree, sex and BMI was determined using analysis of variance (ANOVA, post-hoc Tukey test), with significance assumed at $p < 0.05$.

All calculations and statistical analyses were conducted using STATISTICA software (v.10, StatSoft, USA).
Results

Table 1 presents somatic characteristics of the researched students from the University of Physical Education in Warsaw. The analysis of values describing particular somatic traits of women and men showed statistically significant ($p < 0.01$) differences in the students’ body height and body mass. Compared to the women, the men had greater body height (by 8.3%) and body mass (by 19%). No statistically significant differences in the BMI values of the researched students were noted. The mean BMI value in both groups ranged between 22.3 and 23.2 kg/m², which denotes the correct body mass (Tab. 1).

The numerical analysis of each category of physical activity according to the IPAQ guidelines (Fig. 1) revealed that over 70% of the students from the University of Physical Education in Warsaw display HEPA or an augmented level of physical activity. Only 3.2% of the students declared an insufficient level of physical activity.

Table 2 shows energy expenditure of the students from the University of Physical Education in Warsaw connected with the declared physical activity. The study revealed that for augmented physical activity, the value of energy expenditure was statistically significantly ($p < 0.01$) higher (by 22.3%) among the women than the men. In the remaining categories, the study did not observe statistically significant differences between the

<table>
<thead>
<tr>
<th>Table 1. Somatic characteristics of study participants</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TOTAL (n = 190)</strong></td>
</tr>
<tr>
<td>** x ± SD**</td>
</tr>
<tr>
<td>Age [years]</td>
</tr>
<tr>
<td>Body mass [kg]</td>
</tr>
<tr>
<td>Body height [cm]</td>
</tr>
<tr>
<td>BMI [kg/m²]</td>
</tr>
</tbody>
</table>

Significant difference between men and women: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
female and male students. Furthermore, no cases of insufficient physical activity were observed among the women.

The analysis of the data presented in Figure 2 (concerning the mean values of energy expenditure among the students from the University of Physical Education in Warsaw, according to the type of performed activities) showed that total physical activity equaled 7,763.5 MET-minutes/week, and that the shares of vigorous-intensity activities (3,488.8 MET-min/week) and walking (2,926.5 MET-min/week) were the greatest. The lowest values concerned moderate-intensity activities (1,348.3 MET-min/week).

The analysis of the obtained values in the context of physical activity diversification according to the students’ sex (Fig. 3) showed a statistically significantly ($p < 0.05$) higher value (by 31.2%) of moderate-intensity activities among the women than the men. Moreover, the values of total physical activity and walking were slightly higher (no statistically significant differences) in the women than the men (by 628.9 MET-minutes/week and 330.9 MET-minutes/week, respectively), and the value of vigorous-intensity activities was lower in the women than the men (by 83.3 MET-minutes/week).

Table 3 presents the energy expenditure of the students from the University of Physical Education according to the declared physical activity.
Physical activity level of first year students...

It was observed that the students of physical education achieved significantly ($p < 0.05$) higher values (by 28%) of energy expenditure during augmented physical activity than the students of sports. A similar trend was also noted in the case of the values concerning HEPA and sufficient physical activity (by 8.4% and 3.8%, respectively); however, no statistically significant differences were observed.

The analysis of the obtained values in the context of physical activity diversification according to the selected degree course (Fig. 4) revealed that the value of vigorous-intensity activities was statistically significantly higher ($p < 0.05$) among the students of physical education than among the students of sports (by 37.8%).

The students of physical education showed higher total physical activity than the students of sports (by 1,809.8 MET-minutes/week); however, no statistically significant differences were observed in total activity or any other type of activity.

Analysis of the data concerning the types of physical activity among women according to their degree course type (Fig. 5) did not reveal any statistically significant differences. In comparison to the female students of sports, the female students of physical education displayed higher values of vigorous-intensity activities, moderate-intensity activities and total physical activity (by 1,780.3 MET-minutes/week, 536.1 MET-minutes/week, and 1,870.7 MET-minutes/week, respectively). On the other hand, in the case of walking, the women

Figure 3. Energy expenditure of students from the University of Physical Education in Warsaw according to the type of physical activity and sex

Table 3. Energy expenditure of students from the University of Physical Education in Warsaw according to the declared physical activity and degree course

<table>
<thead>
<tr>
<th>PHYSICAL ACTIVITY STUDENTS (n = 115) [MET-minutes/week]</th>
<th>SPORTS STUDENTS (n = 75) [MET-minutes/week]</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>$\bar{x}$</td>
</tr>
<tr>
<td>---</td>
<td>----------</td>
</tr>
<tr>
<td>Insufficient activity</td>
<td>-</td>
</tr>
<tr>
<td>Sufficient activity</td>
<td>29</td>
</tr>
<tr>
<td>Augmented activity</td>
<td>9</td>
</tr>
<tr>
<td>HEPA</td>
<td>86</td>
</tr>
</tbody>
</table>

Significant difference: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
studying physical education obtained lower values than women studying sports (by 444.8 MET-minutes/week).

The analysis of the data concerning the type of physical activity in the men according to their degree course (Fig. 6) did not reveal statistically significant differences. In comparison to the male students of sports, the male students of physical education displayed higher values in all of the following physical activities: vigorous-intensity

Figure 4. Energy expenditure of students from the University of Physical Education in Warsaw according to the type of physical activity and degree course

Significant difference: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Figure 5. Energy expenditure of female students from the University of Physical Education of Warsaw according to the type of physical activity and degree course

studying physical education obtained lower values than women studying sports (by 444.8 MET-minutes/week).
Figure 6. Energy expenditure of male students from the University of Physical Education in Warsaw according to the type of physical activity and degree course.

Figure 7. Energy expenditure of all questioned students from the University of Physical Education in Warsaw according to the type of physical activity and BMI value.
activities (higher by 740.7 MET-min/week), moderate-intensity activities (higher by 246.4 MET-min/week), total physical activity (higher by 1,740 MET-min/week) and walking (higher by 752.9 MET-min/week).

The analysis of the data concerning the type of physical activity according to BMI (as per the WHO classification) (Fig. 7) did not reveal statistically significant differences. The highest total physical activity was observed in overweight persons (8,603.5 MET-minutes/week). Underweight persons (n=8) and those with a correct BMI (n=151) value displayed a lower value of total physical activity than the overweight individuals (by 3.6% and 14.8%, respectively). The lowest total physical activity was observed in persons (n=6) with class I obesity (5,823.0 MET-minutes/week), which was lower by 32.3% in comparison to overweight students (n=25). Furthermore, the study revealed that students with class I obesity achieved the highest values in vigorous-intensity physical activity (4,200.0 MET-minutes/week), which are 8–53% higher than in the other groups. In comparison with the other groups, underweight students declared the highest value of moderate-intensity physical activity (2,760 MET-minutes/week), while overweight students displayed the highest value in walking (3,231.4 MET-minutes/week).

**Discussion**

The study presents the physical activity of first-year students from the University of Physical Education in Warsaw according to the students’ chosen degree course and sex. Moreover, physical activity was analyzed according to BMI and as indicated by the WHO classification.

The present study determined that the students from the University of Physical Education in Warsaw take care of their level of physical fitness and declare performing various types of physical activity. It is satisfying that over 70% of all the studied students displayed HEPA and augmented physical activity. It was also observed that 3.2% of the students from the University of Physical Education in Warsaw declared insufficient physical activity. It is an alarming result because, considering the curriculum of the studies and achieved educational outcomes, these individuals should care about their physical activity in order to promote physical activity and maintaining a healthy lifestyle among other people [15].

In particular, students who, in the future, plan on working with children as PE. teachers, facilitators, instructors or coaches should set their own example as physically active people [16, 17]. As role models for the youth, they should encourage young people to care for their health and spend their time actively, both during PE. classes and extracurricular activities. Moreover, PE. teachers play an important role in recognizing the potential of a future champion; therefore, they should encourage pupils to regularly engage in various forms of physical activity [18].

The observation of physical activity related to competitive sports and physical recreation shows that women are expanding their sports activity. More and more women, for various reasons (related to health, beauty or shaping physical fitness), decide to engage in regular physical activity. This is why the present study analyzed the declared physical activity of women and men. The study observed that the women achieved higher values of total physical activity than the men by 628.9 MET-minutes/week. However, the men surpassed the women in vigorous-intensity physical activity by 83.3 MET-minutes/week.

The results of the present study revealed that the students of physical education achieved much better results in each type of physical activity than the students of sports: in total physical activity by 1,809.8 MET-minutes/week, vigorous-intensity physical activity by 1,067.7 MET-minutes/week, moderate-intensity physical activity by 358.1 MET-minutes/week and in walking by 384.1 MET-minutes/week.

The reason for this may be the enrollment requirements of the University of Physical Education in Warsaw for the physical education degree course. During enrollment, students must pass complex fitness tests in various sports disciplines, including swimming and two other disciplines of choice. On the other hand, students of sports are required to choose only one sports discipline. These differences mean that physical education students have to display a high level of physical fitness in various disciplines in order to be accepted into the university.

Other studies [5, 9, 20] revealed a correlation between physical activity and sex. In their studies, these authors confirmed that men display higher physical activity than women. On the other hand, the presented results of the current study showed that it was women who displayed higher physical activity than men. The men achieved higher values than the women only in the case of vigorous-intensity physical activity. This shows that women studying at the University of Physical Education in Warsaw spend their time being active more often than men, and take care of their appearance, health and physical fitness. Only a decade or so ago, the sports infrastructure and the available sports classes or recreation activities for women were not as developed as they are today. Currently, there is an extensive market of services offering diversified classes for women, which is why women more and more frequently take care of their physical fitness and, therefore, can achieve better results than men.

The present study also showed that overweight persons displayed the highest physical activity. Accord-
According to some studies, BMI is not a reliable indicator of body adiposity in physically active persons because higher body mass may be caused by a greater amount of muscle tissue than fat tissue, and this is why these individuals may also be classified as obese. A study by Nevill et al. [21] observed no correlation between obesity and a higher value of BMI in 478 high-ranking athletes. Research by Witt and Bush [22] also confirms that fat tissue is responsible for being overweight only in 20% of women and 4% of men whose BMI exceeds 25 kg/m².

**Conclusions**

The obtained results concerning the declared level of physical activity among first-year students from Jozef Pilsudski University of Physical Education in Warsaw allowed to formulate the following conclusions:

1. Candidates for the degree course in sports should present a high level of physical fitness and activity. Consequently, setting a high level of physical activity as a requirement for the sports degree course is justified.

2. Women increase their level of physical activity and sometimes, they achieve results that rival or even surpass the results achieved by men, which may be indicated by the results of the present study in which women (in the category of augmented activity, as well as in the case of moderate energy expenditure and walking) displayed higher values.

3. First-year male students from the University of Physical Education in Warsaw prefer vigorous-intensity activities, while female students prefer both moderate-intensity efforts and walking.

4. There is a need for further research on being overweight based on the BMI in athletes and persons displaying HEPA, which may denote being overweight in terms of BMI values that, in fact, results from the proportion of body components, e.g. well-developed muscle tissue.

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**References**


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PHYSICAL ACTIVITY, SEX AND PLACE OF RESIDENCE AS DETERMINANTS OF SMOKING AND ALCOHOL DRINKING AMONG YOUTH BEFORE AND AFTER THE 1ST YEAR OF STUDY

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1 Faculty of Physical Education, Sport and Rehabilitation, Poznan University of Physical Education, Poland

Key words: youth, physical activity, cigarette smoking, alcohol drinking

Abstract

Aim. The aim of the study was to determine the significance of relationships between physical activity, selected demographic factors (gender and place of residence) and the frequency of cigarette smoking and alcohol drinking among youth before and after the first year of study.

Basic procedures. Youth beginning their education at Adam Mickiewicz University in Poznan (Poland) participated in the study. The study was conducted twice: before and after the first year of study. Physical activity was determined using the International Physical Activity Questionnaire (IPAQ - short version). Information about sex, place of residence, frequency of smoking cigarettes and drinking alcohol were collected using a questionnaire.

Results. After the first year of study, the percentage of smokers and drinkers did not change significantly. In both study periods, a significantly greater ($p<0.001$) percentage of men than women declared regular smoking and drinking alcohol. Physical activity did not significantly differentiate cigarette smoking and drinking alcohol. Place of residence was only significant in the case of women ($p<0.05$): a greater percentage of women living in larger cities regularly smoked cigarettes and drink alcohol.

Conclusions. The beginning of higher education and related lifestyle changes did not significantly differentiate the habits of young people in cigarette smoking and drinking alcohol after the first year of studies. Physical activity does not significantly differentiate the frequency of smoking cigarettes and drinking alcohol by men and women. Men more frequently declared regularly smoking cigarettes and drinking alcohol. A larger proportion of regular smokers and drinkers were found among women living in major cities.

Introduction

Physical activity is one of the most important components of pro-health behaviours and is one of the most effective ways of preventing chronic diseases. Without physical activity, no health strategy, its maintenance or improvement can be achieved, and in children and the youth, normal development [1].

Today, too frequent and excessive reaching for stimulants has become a problem not only for adults. Due to the very easy access to stimulants, young people do not have the problem of supplying themselves with ciga-
rettes or alcohol. Reaching for psychoactive substances becomes something „natural, synonymous with independence, adulthood and a laid-back lifestyle” for young people [2]. This problem was reflected in the operational objectives of the „National Health Program 2016-2020”, in which the need for preventive measures and problem solving related to the use of psychoactive substances was highlighted in the Operational Objective No. 2 [3].

According to the research conducted by CBOS [4] in Poland in 2012, 31% of adult Poles admit to cigarette smoking. Introducing the law prohibiting tobacco smoking in public does not seem to affect the prevalence of smoking. The Ministry of Health [5] reports that tobacco smoke contains more than 4,000 chemicals, including more than 40 known carcinogens and a number of toxic agents. Despite this, the number of smokers in Poland has remained at a similar level for several years [4]. Smoking has serious health consequences [6]. Smokers are particularly prone to: respiratory diseases (emphysema, chronic bronchitis, lung cancer, bronchial asthma or tuberculosis), cardiovascular disease (ischemic heart disease or hypertension) and other diseases such as gastric and duodenal ulcers. Majchrowska and Wszędyrówny [7] emphasize the importance of smoking prevention in junior-high and high schools. The authors report that men start smoking earlier than women, as early as in elementary school. On the other hand, women start smoking after college.

Research by the National Research Institute of Mother and Child [8] indicate that alcohol is the most commonly used stimulant by young people. Both with cigarettes and alcohol, young people start their adventure early in school, and the frequency and intensity of alcohol consumption significantly increases during adolescence. According to Wojnarowska and Mazur, the average age of alcoholic initiation in Poland in 2002 was 11.9 for boys, 12.8 for girls, and respectively, 11.7 and 12.9 regarding tobacco initiation. Regular alcohol consumption can cause many chronic diseases such as cancer and cardiovascular or central nervous system diseases [6].

Webb et al. [9] report that among British students, 61% of men and 48% of women abuse alcohol while studying, and only 11% do not use it at all. Wicki, Kuntsche and Gmel [10] also point to the favourable circumstances for drinking in the student environment. They believe that students freely abuse alcohol, mainly for social reasons and boosting their self-esteem. Among other risk factors to the healthy student life are smoking, poor eating habits, stress and lack of physical activity [11, 12].

Dishman, Sallis, and Orenstein [13], among the individual determinants of physical activity include, inter alia, drinking and smoking. However, in the comparison study results, these behaviors are not listed among the most important determinants of physical activity. We can find a lot of information in scientific publications about the significant relationships between the use of active substances and physical activity. Olchowski et al. [14] speaks of the negative relationship between smoking and students’ physical activity. He argues that students who smoke cigarettes are less engaged in physical exercise and moreover, they have an inferior perception of their health compared to non-smokers. Wilkinson et al. [15], while researching the youth, believes that boys smoke cigarettes more frequently and have more interest in physical activity than girls. Arazi, Hosseini and Rahimzadeh [16] argue that the important reason for cigarette smoking among male students is their close relationship with smoking friends and, as a result, less interest in physical activity than women. Musselman and Rutledge [17] argue that students who consume alcohol more often represent a higher level of physical activity. Also in other publications [18, 19, 20], attention is drawn to the higher level of physical activity among students who consume alcohol and the lower prevalence of cigarette smoking.

The main aim of the study was to assess the relationship between the level of physical activity and demographic characteristics (sex, place of residence) and the use of selected psychoactive substances (smoking and alcohol) in the group of academic students before and after their first year of study at Adam Mickiewicz University in Poznań.

The following research questions were formulated:

1. Does the percentage of people drinking alcohol and smoking cigarettes significantly change after their first year of study?
2. Are smoking and drinking alcohol significantly related to the physical activity of students before and after their first year of study?
3. Do gender and place of residence significantly differentiate smoking and alcohol drinking among students before and after their first year of study?

**Research materials and methods**

706 women and 232 men participated in the 1st term of the study, and 513 women and 120 men in the 2nd were first-time students taking first-degree courses at Adam Mickiewicz University in Poznań. The research was carried out twice: 1st term of the study - October 2014, 2nd term of the study - May 2015.

The research group was composed of students from 14 faculties (English, Biology, Chemistry, Polish and Classical Philology, Physics, History, Mathematics and Computer Science, Geographical and Geographical Sciences, Political Science and Journalism, Social Sciences, Neo-Philology, Law and Administration, Educational and Theological Studies) of Adam Mickie-
Physical activity, sex and place of residence as determinants...

wicz University in Poznań. The study was conducted at Adam Mickiewicz Physical Education and Sport College in Poznań, where students participated in compulsory physical education classes. The tests were of personal nature (the questionnaires were appropriately coded), which made it possible to reach the same persons on the 2nd term of the study.

Physical activity was examined using a short version of the International Physical Activity Questionnaire (IPAQ) [21]. The short version of the International Physical Activity Questionnaire contained 7 questions about all types of physical activity related to daily life, work and leisure. In the study, we only used information on the sum (MET-min/week) of physical activity.

Information about the gender, place of residence, frequency of using psychoactive substances (smoking and drinking alcohol) was collected using the author’s personally designed questionnaire. In the first study, information about the respondent’s place of residence regarded the time before beginning their studies. During the second term, the respondents identified the place of residence during their studies.

Statistical analysis of the research results consisted in determining the frequency (%) of responses to the questions in the questionnaire. Data analysis was performed using the STATISTICA 12 programme. The Chi-Square Test of Independence ($\chi^2$) and Kruskal-Wallis one-way analysis of variance (ANOVA) were used to determine the significance of the differences, due to the lack of normal distribution of values illustrating the level of physical activity. In further analysis, Dunn’s post-hoc test was used. The level of statistical significance was assumed to be $p<0.05$.

**Research results**

The frequency of cigarette smoking (Fig. 1) and alcohol consumption (Fig. 2) were determined with respect to gender differences and study dates. In the first study, significant differences were observed between the groups of women and men, both in the case of smoking ($\chi^2=18.57, p<0.001$) and alcohol consumption ($\chi^2=48.93, p<0.001$). A greater proportion of men than women declared regular use of both psychoactive substances. A similar image was obtained during the second term of the study and the differences, although statistically significant, were lower for cigarette smoking ($\chi^2=8.47, p<0.05$) and alcohol consumption ($\chi^2=17.87, p<0.01$). Thus, the slightly increasing in the proportion of women, and the decreasing percentage of men declaring regular and occasional use of psychoactive substances between the two study dates should be noted.

The above-mentioned changes were, however, insignificant compared to the differentiation between cigarette smoking and alcohol drinking for the two study dates. The percentage of cigarette-smoking (Fig. 1) women ($\chi^2=4.58; ns$) and men ($\chi^2=0.56; ns$) did not change significantly after the first year of study. The same situation occurred in the case of alcohol consumption (Fig. 2) in the group of women ($\chi^2=2.42; ns$) and men ($\chi^2=0.03; ns$).

![Figure 1. The frequency of cigarette smoking before and after the first year of study](image-url)
In the conducted analysis, physical activity (Tab. 1) did not significantly differentiate the use of stimulants among women at both study dates. Among men, statistically significant differentiation ($p<0.05$) in smoking frequency was observed depending on physical activity after the 1st year of study (2nd term). Further

Table 1. ANOVA test values defining the differentiation in smoking cigarettes and drinking alcohol depending on the level of physical activity before and after the first year of study

<table>
<thead>
<tr>
<th>IPAQ</th>
<th>Sex</th>
<th>Smoking cigarettes (1st term)</th>
<th>Smoking cigarettes (2nd term)</th>
<th>Drinking alcohol (1st term)</th>
<th>Drinking alcohol (2nd term)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sum (MET-min/week)</td>
<td>women</td>
<td>H=5.37 ns</td>
<td>H=1.27 ns</td>
<td>H=4.05 ns</td>
<td>H=0.57 ns</td>
</tr>
<tr>
<td></td>
<td>men</td>
<td>H=2.32 ns</td>
<td>H=7.27 $p&lt;0.05$</td>
<td>H=2.11 ns</td>
<td>H=0.57 ns</td>
</tr>
</tbody>
</table>

ns – statistically non-significant differentiation

Table 2. The structure of place of residence before and during the first year of study

<table>
<thead>
<tr>
<th>Place of residence</th>
<th>Women (%)</th>
<th>Men (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before studies – 1st term</td>
<td></td>
<td></td>
</tr>
<tr>
<td>country</td>
<td>35</td>
<td>21</td>
</tr>
<tr>
<td>city less than 20,000 residents</td>
<td>18</td>
<td>17</td>
</tr>
<tr>
<td>city 20,000-100,000. residents</td>
<td>23</td>
<td>28</td>
</tr>
<tr>
<td>city more than 100,000 residents</td>
<td>24</td>
<td>33</td>
</tr>
<tr>
<td>During studies – 2nd term</td>
<td></td>
<td></td>
</tr>
<tr>
<td>family home</td>
<td>23</td>
<td>28</td>
</tr>
<tr>
<td>rented flat</td>
<td>46</td>
<td>43</td>
</tr>
<tr>
<td>rented room</td>
<td>23</td>
<td>18</td>
</tr>
<tr>
<td>dormitory</td>
<td>8</td>
<td>11</td>
</tr>
</tbody>
</table>
analysis did not show any general regularity in this regard. In other cases, physical activity did not significantly differentiate smoking or alcohol consumption frequency for both study dates.

Tab. 2 shows the structure of students’ place of residence during the 1st and 2nd terms of the study. At the end of the study, statistically significant differences ($\chi^2=24.95; p<0.001$) were observed in the percentage of the subjects according to gender. A significantly higher percentage of women lived in rural areas, and more men came from cities with more than 100,000 residents. Gender turned out to be a factor that did not significantly differentiate ($\chi^2=3.18; ns$) students’ residence during studies (2nd term). It can be seen that nearly half of the women and men preferred to rent an apartment. The least number of students lived in dormitories.

The place of residence (Tab. 3) at the time of the study significantly differentiated ($p<0.05$) both the frequency of smoking cigarettes and alcohol consumption among women. In both cases, the greater proportion of women living in large cities declared regular smoking and alcohol drinking. In the group of men, the place of residence did not significantly differentiate smoking cigarettes and alcohol consumption on both study dates.

### Discussion

The conducted research shows that taking up studies is not significantly associated with a change in the incidence of cigarette smoking and alcohol consumption among adolescents. However, there is a slight tendency to increase the proportion of women regularly and occasionally smoking cigarettes and drinking alcohol. It is important to note that over 60% of men and women do not smoke at all, and more than 95% of women and 85% of men declare only occasional alcohol consumption at most. It seems that the results do not put the studied youth in a bad light. The results show a higher proportion of men declaring regular cigarette smoking. Similar results were obtained by Jopkiewicz [22], but Majchrowska and Wszędryówna did not confirm this regularity in their studies [7], indicating that more women than men smoked cigarettes while studying.

The above mentioned opinion was not confirmed in the research conducted by Lisicki and Wilk [23], who believe smoking and alcohol drinking among higher education first-year students of Trójmiasto is widespread and alarming. Gacek [24] also considers that the vast majority of female-students (86%) and all the first-year AWF (University School of Physical Education) students in Kraków declare contact with alcoholic beverages. Similarly, Patok [25], when studying the anti-health behaviour of students at the University of Gdańsk, found that students are more likely to consume alcohol than smoke cigarettes. Molina et al. [26] report that 78.3% of students drink alcohol and 31.7% smoke cigarettes, which is associated with low levels of physical activity (about 22.7% declare sufficient physical activity with a declining trend in women).

The relationship between stimulant usage and physical activity was also the topic of studies by other authors. Mantilla-Toloza et al. [27], investigating students at the age of 20, state that there was no significant relationship between physical activity and smoking or alcohol consumption. The results of our own research also confirm this thesis. Dunn and Wang [18] conducted a study among 18-23-year-olds who found that recreational physical activity was associated with higher rates of alcohol use and a lower rate of smoking in both men and women. Similarly, Buscemi et al. [28] indicated a positive relationship between physical activity and alcohol consumption, but only in men aged 17-38. Seo et al. [29] argued that cigarette smokers are more engaged in intense physical activity than peers who did not smoke. On the other hand, in the case of moderate physical activity, no such a connection could be observed.

Jopkiewicz [22] believes that place of residence is a factor that significantly differentiates not only physical

<table>
<thead>
<tr>
<th>Place of residence</th>
<th>Sex</th>
<th>Smoking cigarettes</th>
<th>Drinking alcohol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before beginning studies (1st term)</td>
<td>women</td>
<td>$\chi^2=13.67$</td>
<td>$\chi^2=14.59$</td>
</tr>
<tr>
<td></td>
<td>men</td>
<td>$\chi^2=9.14$</td>
<td>$\chi^2=7.01$</td>
</tr>
<tr>
<td>After studies (2nd term)</td>
<td>women</td>
<td>$\chi^2=7.19$</td>
<td>$\chi^2=6.66$</td>
</tr>
<tr>
<td></td>
<td>men</td>
<td>$\chi^2=6.19$</td>
<td>$\chi^2=4.59$</td>
</tr>
</tbody>
</table>

ns – statistically non-significant differentiation
activity but also smoking and drinking. A larger proportion of students living in the city declared daily smoking. An analogous situation occurred in the case of alcohol consumption. The above conclusions were confirmed in our own research but only for women.

Conclusions
1. Undertaking higher education and the associated alteration in lifestyle do not significantly change the youth’s habits with regard to smoking or alcohol consumption after the first year of studies.
2. Physical activity does not significantly differentiate the frequency of cigarette smoking or alcohol consumption among men and women.
3. Regular cigarette smoking and alcohol drinking are more often reported by men. The higher percentage of regular cigarette smokers and alcohol drinkers were found in women living in larger cities.

References
Physical activity, sex and place of residence as determinants...


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SELECTED NUTRITIONAL BEHAVIOURS OF JUNIOR-HIGH SCHOOL STUDENTS WITH DIFFERENT BODY MASS FROM THE BIALSKI SCHOOL DISTRICT

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Key words: body mass index BMI, youth, nutritional behaviours

Abstract

Aim. The aim of the study was to examine the selected nutritional behaviours of junior-high school students with different body mass from the Bialski school district.

Basic procedures. Based on international standards for the subjects’ BMI, they were divided into three groups: underweight, norm, and overweight or obese. We used our own personally designed questionnaire to evaluate nutrition behaviours.

Results. Body Mass Index (BMI) for most of the subjects, both girls (69.84%) and boys (79.9%) was within the norms. The most commonly noted source of knowledge about health was the media, and the least popular – teachers. Overweight and obese youth declared abiding the principles of maintaining a healthy lifestyle less frequently than the rest. More than 65% of the subjects consumed 3 to 5 meals a day. The most common mistakes in eating habits are: irregular eating, snacking in-between meals, frequently eating fast-food meals.

Conclusions. The studied youth declared that they adhere to the principles of a healthy lifestyle, however, abnormal nutritional behaviours were observed related to, among others: lack of regularity in eating meals, snacking in-between meals and frequent consumption of fast-food meals. The results of the study indicate the need for education about maintaining a healthy lifestyle and its impact on health.

Introduction

One of the determinants of health is proper nutrition. Easy access to semi-finished products or ready-made food that only needs to be warmed up makes us increasingly reluctant to prepare wholesome meals and reach for such foods. Due to lack of time or out of convenience, parents use them without realizing that this is the way they shape their child’s abnormal eating behaviour. Ensuring proper nutritional behaviours in children results in good health and reduced susceptibility to malnutrition. Regular consumption of wholesome meals, especially by children and adolescents, is essential for their proper physical and mental development [1-4].

During adolescence, i.e. between the age of 12-14 and 18-21, the youth is particularly susceptible to changes, and that is when a number of experimental behaviours regarding health occur. Frequently, the attitudes and health behaviours that have been shaped over the years tend to completely transform under the influence of the changes taking place in the body as well as under the pressure of the environment and the desire to please others. On the one hand, raging hormones, intense physical development, on the other, increased interest in one’s
own appearance, and most often its critical assessment, cause the occurrence of nutritional disorders [5].

The aim of this study was to examine selected nutritional behaviours of junior-high school students with differing body mass from the Bialski school district.

**Material and methods**

The study was conducted among 13-15-year-old junior-high school students, in randomly selected schools from the Bialski District (Janów Podlaski, Konstantynów, Terespol). The study was possible after gaining approval from the school administrators and the parents of the studied children. Overall, 89% of the students from these schools (393 students) were studied, the remaining 11% were students absent on the day of the study or whose parents did not agree to their child’s participation in the study. The study was conducted during the students’ homeroom classes in October 2014. Prior to the study, the students were informed about the purpose of the research and were instructed on how to complete the questionnaire.

The study was conducted with a diagnostic survey using our own personally designed questionnaire consisting of closed questions with the option of single choice. The questions concerned, among others, sources of knowledge about health, dietary behaviours, physical activity and personal hygiene. The questionnaire enquired about the child’s date of birth in order to determine the child’s calendar age, which was calculated by subtracting the date of the test from the date of birth, converting months and days to decimal values [6].

In order to calculate the BMI of the subjects, body height and body mass measurements were conducted according to Martin and Saller’s technique [7], using an anthropometer to measure body height (B-v), with an accuracy of 0.1 cm, and body mass was measured with an accuracy of 0.1 kg on an electronic scale (measurement error up to 100 g).

Based on the international standards for BMI developed by Cole et al. [8,9], the subjects were divided into three groups: underweight, norm, and overweight or obese. The girls whose BMI was less than 16.89 kg/m² were qualified into the first group and those with a BMI above 23.3 kg/m², into the last. Analogously among the boys: the first group - BMI below 16.4 kg/m²; the last group - BMI above 22.6 kg/m² (Tab. 1).

The obtained results were subjected to statistical analysis using the \( \chi^2 \) test, with the assumed level of significance at \( p \leq 0.05 \).

**Results**

In this report, analysis of the study results is given regarding the sources of obtaining knowledge about health and selected dietary habits of the youth. The results showed that the BMI in the majority of boys (79.9%) and girls (69.84%) was normal. In both of the extreme groups, the amount of underweight and overweight/obesity was lower.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Level of BMI</th>
<th>Boys</th>
<th></th>
<th></th>
<th>Girls</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>underweight</td>
<td>N</td>
<td>%</td>
<td>N</td>
<td>%</td>
<td>N</td>
<td>%</td>
</tr>
<tr>
<td>From the Internet</td>
<td></td>
<td>17</td>
<td>43.59</td>
<td>133</td>
<td>45.08</td>
<td>26</td>
<td>44.07</td>
</tr>
<tr>
<td>From friends</td>
<td></td>
<td>4</td>
<td>10.26</td>
<td>11</td>
<td>3.73</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>From parents</td>
<td></td>
<td>9</td>
<td>23.08</td>
<td>88</td>
<td>29.83</td>
<td>18</td>
<td>30.51</td>
</tr>
<tr>
<td>From T.V./the radio</td>
<td></td>
<td>9</td>
<td>23.08</td>
<td>38</td>
<td>12.88</td>
<td>10</td>
<td>16.95</td>
</tr>
<tr>
<td>From teachers</td>
<td></td>
<td>0</td>
<td>0.00</td>
<td>25</td>
<td>8.47</td>
<td>5</td>
<td>8.47</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Variable</th>
<th>underweight</th>
<th>norm</th>
<th>overweight/obesity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N %</td>
<td>N %</td>
<td>N %</td>
</tr>
<tr>
<td>From the Internet</td>
<td>17 43.59</td>
<td>133 45.08</td>
<td>26 44.07</td>
</tr>
<tr>
<td>From friends</td>
<td>4 10.26</td>
<td>11 3.73</td>
<td>0 0.00</td>
</tr>
<tr>
<td>From parents</td>
<td>9 23.08</td>
<td>88 29.83</td>
<td>18 30.51</td>
</tr>
<tr>
<td>From T.V./the radio</td>
<td>9 23.08</td>
<td>38 12.88</td>
<td>10 16.95</td>
</tr>
<tr>
<td>From teachers</td>
<td>0 0.00</td>
<td>25 8.47</td>
<td>5 8.47</td>
</tr>
</tbody>
</table>
groups, the majority were girls, being underweight was reported in 12.7% of girls and 7.35% of boys, and being overweight or obese, respectively: 17.46% and 12.75% (Tab. 1).

Analyzing the sources from which the youth obtain knowledge about health did not show any statistically significant differences ($\chi^2 = 12.8; p = 0.098$). Nonetheless, it is worth noting that the most frequently indicated source was the media (Internet, radio, television); teachers were the least often source of information regarding health (Tab. 2).

Knowing the principles of a healthy lifestyle and adhering to them in daily life allows to stay healthy for as long as possible. Analysis of the study results showed statistically significant differences between the BMIs in obeying the principles of a healthy lifestyle ($\chi^2 = 16.9; p = 0.005$) (Tab. 3). The overweight and obese youth declared compliance with the principles of healthy living less frequently than the others (57%-79.66% and 71.79%). An indifferent attitude towards the principles of maintaining a healthy lifestyle was most often manifested by the overweight and obese students (27.12%), and the least by those with normal body mass (11.86%). In the studied group, individuals with knowledge on a healthy lifestyle could be found.

Regular consumption of meals, especially by growing and developing individuals, has significant impact on proper, biological and mental development. However, in present times, it is increasingly observed that attention is not paid to the regular consumption of meals. The results of this study showed that the vast majority of the studied youth, in all the specified BMI groups, did not eat regularly (Tab. 4). The Chi-squared independence analysis test showed no statistically significant differences between the groups ($\chi^2 = 0.25; p = 0.881$).

Analyzing the obtained data regarding the number of meals consumed by the respondents during the day, it was found that the vast majority of them consumed from 3 to 5 meals a day (Tab. 5). A smaller number of meals during the day is consumed by the underweight pupils (17.95%) than those overweight or obese (15.25%). More than 5 meals a day are more commonly consumed by the overweight and obese students. The differences in the number of meals consumed by the subjects, taking into account BMI, were not statistically significant ($\chi^2 = 0.18, p = 0.913$).

The majority of the studied junior-high school students snacked in-between meals (Tab. 6). In all the groups, sweets were the most commonly consumed (45.76%), and least often among young people was drinking water or juice in-between meals (5.08%). Fruits and vegetables were more commonly consumed by overweight and obese students (20.34%) than the rest, while the students whose BMI was normal most commonly consumed sandwiches (28.81%). Not eating in-between meals or doing this only sporadically, much more frequently than the rest (both groups 1.69% each), was declared by those underweight (23.08%). The ob-

### Table 3. The respondents’ attitudes towards the principles of a healthy lifestyle

<table>
<thead>
<tr>
<th>Variable</th>
<th>Level of BMI</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>underweight</td>
<td>norm</td>
<td>overweight/obesity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I try to abide</td>
<td>28  71.79</td>
<td>235 79.66</td>
<td>34 57.63</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I do not abide</td>
<td>2  5.13</td>
<td>22 7.46</td>
<td>6 10.17</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neutral attitude towards principles of a healthy lifestyle</td>
<td>8 20.51</td>
<td>35 11.86</td>
<td>16 27.12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I do not know what a healthy lifestyle is</td>
<td>1  2.56</td>
<td>3 1.02</td>
<td>3 5.08</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 4. Regularity in consuming meals by respondents

<table>
<thead>
<tr>
<th>Variable</th>
<th>Level of BMI</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>underweight</td>
<td>norm</td>
<td>overweight/obesity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>14 35.90</td>
<td>110 37.29</td>
<td>20 33.90</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>25 64.10</td>
<td>185 62.71</td>
<td>39 66.10</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
served differences between the groups of underweight students and the norm, and those overweight and obese were statistically significant ($\chi^2 = 25.66; p = 0.001$).

The analysis of the frequency of fast-food meal consumption did not show any statistically significant differences between the groups with differentiated BMIs ($\chi^2 = 0.67; p = 0.715$) (Tab. 7). Nearly half of the students in the groups with normal body mass and those overweight or obese declared eating fast-food meals once a month (47.80% and 47.46%). In the group of students consuming fast-food 2-3 times a week, most were underweight; next, the students with a normal BMI and the last were overweight and obese (35.90%; 29.49%; 27.12 %). Among the respondents, subjects who declared not eating fast-food were noted. Most commonly, not consuming such meals was reported by underweight students, and least commonly by those overweight or obese (5.13% and 1.69% respectively).

**Discussion**

Knowledge on the topic of healthy eating and its application in daily life are factors that determine good health. In our times, in the age of the Internet and access
to various media, the ability to choose information, including that related to healthy eating, is extremely important. The high number of unhealthy food advertisements, and at the same time, the propagated slim figure and too little time spent on school health education means that young people lack adequate systematic knowledge regarding healthy eating habits.

The information ‘muddle’ and unrestricted access to all sorts of information make young people independently seek and complement knowledge. However, often the inability to select information makes young people copy the anti-healthy behaviours or inaccurate information presented in the media [10]. The results of this study have shown that for junior-high school students, the main source of health knowledge is the media (Internet, T.V./radio) and not teachers or parents (Tab. 2). More than half of the studied girls (50.79%) and 39.22% of boys obtain their knowledge regarding health from the Internet, television and the radio - 12.7% of girls and 16.18% of boys. However, school, which in its essence should educate, also on the knowledge of health, did not gain the recognition of the studied students.

Teachers as the main source of health knowledge were pointed to by 6.35% of girls and 8.82% of boys. The results of our study were confirmed by the research of A. L. Sosinska et al. [11] conducted among post-junior-high adolescents, in which 68% of the respondents gained knowledge on the principles of healthy eating from the Internet and 48% from T.V. programmes. In her research, A.E. Chmielewska [12] has shown the influence of the Internet on dietary habits among junior-high school girls. On the other hand, in the study by D. Ponczek and I. Olszowy [13], the students indicated parents (26.5%) as the main source of health knowledge. The Internet was slightly less indicated (25.9%).

The noted mistakes in nutritional habits of the pupils from selected junior-high schools in the Bialski District do not differ from those described in the literature. One such mistake is the irregularity of eating. In the present study, the vast majority of students in all BMI groups did not eat regularly (Tab. 4). Similar results were obtained by E. Međrela-Kuder [14], showing a slightly more than 40% regularity of food intake by junior-high school students. Similar results were obtained by A. Grochowska, M. Schlegel-Zawadzka [15], in which 44.5% consumed meals “rather regularly” and “definitely regularly” - 7.9%. Irregular meal consumption by the youth has been shown in the studies [16, 17, 18, 19, 20]. B. Całyniuk et al. [21] showed a high level of regularity in eating behaviours among children from schools with a sports profile (83.9%). For sure, increased physical activity of the sports school students and greater awareness of the importance of proper nutrition for athletic performance influenced such a high percentage of consuming meals regularly.

Children and teenagers should consume from 3 to 5 meals a day [2]. Our research shows that most students (over 66%), regardless of BMI, consume the recommended number of meals (Tab. 5). The high frequency of food intake among high-school students (83.6%) was observed by D. Ponczek, I. Olszowy [13], however, M. Nawrocka et al. [22], who noted a correlation between the number of meals consumed and the location of the school in research conducted among post-primary-school students - 3 or more meals a day was declared by 37% of students from the municipal school, 78% - district, and 36% - urban. In studies by other authors, we can find that most young people consume the correct number of meals [5, 11, 16, 17, 23].

Snacking in-between meals is a very common phenomenon, both among children, adolescents and adults. This phenomenon can be considered pro-health, provided that the consumed snacks are recommended products such as vegetables, fruits, kephirs [11]. Unfortunately, a large number of studies show that the most commonly eaten snacks are sweets, crisps and sweetened or carbonated beverages. In such a case, snacking is definitely not healthy. The results of this study showed that the youth from the Bialski District is no different from the image presented in the literature and also most often consists of the consumption of sweets (Tab. 6). Sweet snacks were most commonly eaten by students with a BMI indicating that they are overweight (45.76%), and the least – by those underweight (33.33%). Excessive consumption of sweets by junior-high school students (nearly 46%) was demonstrated by P.F. Nowak, P. Barcicka [24], T. Wołoski, M. Janowska [19] - over 50%, B. Kurc-Darak, P. Chrustowska [25] - over 30%. Fruits and vegetables were much less commonly eaten in-between meals, and it was noted that the lower the BMI, the lower their intake. B. Całyniuk et al. [21] noted the statistically significant relationship between BMI and fruit and vegetable consumption among girls.

The results of the presented studies show that underweight individuals snack in-between meals less often, which is of statistical significance. However, B. Całyniuk et al. [21] showed the opposite situation, in which individuals with higher BMI values were less likely to snack in-between meals. J. Ambrozý et al. (26) demonstrated the higher consumption of vegetables and fruits than sweets (respectively, 41.7% urban children, 52.1% rural children, 16.3% urban children, 8.6% rural children).

We have become accustomed to the presence of fast-food, nonetheless, it is disturbing that more and more children and young people replace main meals with this type of food or eat it every day. The results of this study showed that more than 30% of students eat fast food 2-3 times a week, more often by young people with low BMIs (Tab. 7). Consuming fast-food...
meals several times a month was declared by more than 40%, about 3% of the junior-high students did not eat it at all. Similar results were obtained by Wanat et al. [23]. The studied junior-high school students consumed fast-food meals several times a week (33%), several times a month (60%) or less frequently (7%). I. Batyk [27], analyzing the nutritional habits of adolescents aged 13-18, obtained different results. Most of the studied students consumed fast-food meals every day (56.3%), several times a day - 7.5%, several times a month - 3.7%, and none of the study participants reported not consuming such products. Research on the frequency and quantity of fast-food consumption was also conducted by other authors [17, 20, 28].

The results of the analyzed nutritional behaviours of junior-high school students clearly indicate the need to extend education on healthy eating. The bad eating habits formed in adolescence will surely contribute to the development of diet-dependent diseases, among others, being overweight, obesity, type 2 diabetes. Such a situation can be prevented by early implementation of education related to pro-healthy lifestyle habits, and continuing it throughout the whole process of school education.

Conclusions

1. The media are the main source of the youth’s knowledge about health.
2. Irregularities in the dietary habits of young people were observed, consisting of a lack of regularity in consuming meals, eating in-between meals, frequently eating fast-food.
3. There were statistically significant differences between students enrolled in different BMI groups and the type of snack consumed.

References

Selected nutritional behaviours of junior-high school students...


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A SCIENTIFIC EVENING WITH L. VON BERTALANFFY, P. BLASER, E. LOOSCH AND J.M. MORAWSKI

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Key words: system theory, motor operation, information processing, Loosch’s bow tie

Abstract

The author takes the diagram by E. Loosch, concerning information processing during a motor operation, as a “starting point” for scientific considerations. The author termed it “Loosch’s bow tie.” His study shows an apparent paradox in this diagram and he analyses it from the system-theoretical perspective. In this respect, the achievements by L. von Bertalanffy and J.M. Morawski are highly instructive, who created the strong systemic perspective for scientific investigations. Mathematics, a very effective instrument in the non-living world (e.g., in physics), turned out to be hardly applicable in biology, psychology and motor control. Hence, the system-theoretical perspective seems to be promising.

In the multilevel and multimodal structure of a system, the nonlinearity is very significant. Just the nonlinear relations between particular levels of a system are probably “responsible” for the most precious product of a system, i.e., a qualitatively new, emergent system effect. As a result, the information processing chunks, involved in motor operation creation, residing at various levels of the movement construction system, differ qualitatively from each other. The author presents an attempt at ordering particular classes of motor operations according to the information processing nature, which underlies them.

Finally, the author points to the fact that especially in the development of motor control, the part of theoretical considerations is by far greater than that of experimental research.

Systems thinking plays a dominant role in a wide range of fields from industrial enterprise and armaments to esoteric topics of pure science.

Ludwig von Bertalanffy

Moreover, the quantitative relations I perceive as a specific kind of structural ones, and mathematics itself – as an earlier developed because of other reasons, branch of general science on organization. This is why it has such a gigantic power as a tool for life organization [5].

Bogdanov argued also that:

The system may be termed organized not in general, versatile, but only in respect to specific activities, challenges or energies. Therefore, against the others it may bring about disorganization, and still against others, it may be neutral [5].
Half a century later von Bertalanffy claimed:

… systems theory is a broad view which far transcends technological problems and demands, a reorientation that has become necessary in science in general and in the gamut of disciplines from physics and biology to the behavioural and social sciences and to philosophy [6].

The same – essentially – idea has been expressed by J.M. Morawski, who stated:

… the borders between particular layers are absolutely relative. Their demarcation depends on the goal of research, experiment results and scientist's practice. By division into system layers, the boundaries between them are to be seen not in morphological sense, but in some categorical caesurae [7].

These statements delimit the intellectual space of considerations presented in this paper.

The first of quotations from Bogdanov and von Bertalanffy may make up a basis for establishing the role of mathematics in contemporary science. It works nearly perfectly in sciences related to the non-living world. Mathematics "distils" the relations between the items it deals with, and not their essence. R. Penrose stated:

There are two other words I do not understand – awareness and intelligence. Well, why am I talking about things when I do not know what they really mean? It is probably because I am a mathematician and mathematicians do not mind so much about that sort of thing. They do not need precise definitions of the things they are talking about, provided they can say something about the connections between them [8].

Accordingly, mathematics focuses on relations, and not on explanation and description of the nature of what it describes. Such reasoning may work properly in the non-living world, where the items do not have their own “personalities”, which may influence their behaviour. Here, one only has to deal with stimulus and reaction – predictable and thus, mathematically describable. However, in biology and, even more, in psychology and motor control, between stimulus and response – no longer a sheer reaction! – there appears a new, quite capricious element: information. It is shaped by both evolutionary and individual factors, so linking the adjoining elements is quite ambiguous and predictable (if any) only with some probability.

Mathematics is objective; the reality has to be adjusted to its image of the world. It is completely indifferent to the “nature” or “soul” of items which it describes. For example, according to L. Prandtl, the same differential equation describes deformation of elastic membrane and tension in a twisted rod [9]. Accordingly, while seen from purely mathematical perspective, the nature of phenomena and processes is insignificant: the equation is important. Technological constructions arise at first as drawings and calculations and only later as “tangible” artefacts, functioning of which is (nearly) fully predictable. On the other hand, human mind has to be subjective. Its product has to be adjusted to highly variable reality.

By the way: In the last paragraph symptomatic is the word “calculations”. Mathematics as such is not useful in technology. To become an attribute of usefulness (and reliability), it has to be deprived of all fantasy and reduced to the level of plain and boring, yet intellectually “hard” and unquestionable calculations.

In some limited fields of abstract knowledge and observable external world, mathematics coincides with reality. M. Heller names such a phenomenon “resonance” [10].

In the “field of full resonance” the mathematical description so tightly “adjoins” the “personalityless” reality that many physical structures were invented as mathematical models – e.g., quants (M. Planck), Higgs boson (P. Higgs), or gravitational waves (A. Einstein) – and only then discovered in reality. Nevertheless, despite of such a resonance, the capricious information between stimulus and response makes the biological and psychological systems hardly liable to mathematical description. Thus, “the earlier developed branch of science on organization” – mathematics – cannot be equally efficient (if at all) in biology and psychology as it is in physics, no matter how seductive its intellectual charm may seem to be. Biologist J. Cohen and mathematician I. Stewart wrote:

Mathematics wallows in emergent phenomena. It also came to terms, long ago, with something that often puzzles nonmathematicians. By definition, mathematical statements are tautologies. Their conclusions are logical consequences of their hypotheses. The hypotheses already “contain” the information in the conclusions. The conclusions add nothing to what was implicitly known already. Mathematics tells you nothing new [11].

This clearly shows the advantage of systems theory over mathematics. The former is able to produce an unpredictable, qualitatively new system effect. One might imagine that the “free nonlinearity” of inter-level transformations in a system produces new system effects at each of the levels of a system. Furthermore, such system effects make together not a sheer sum, but a new system, which in the sphere of reasoning makes up the human brilliance. The term “free nonlinearity” means that it is not pre-programmed in advance, but dynamically adjusts to a current situation. Therefore, it is hardly mathematically describable. One might put forward the hypothesis that only the “free nonlinearity” is responsible for Bernstein’s “repetitions without repetitions” [12 - 14] and, as a consequence, for both the evolution of species and the learning of individuals. Moreover, the “free nonlinearity” may be regarded as a close cousin of deterministic chaos, underlying the contemporary theory of chaos.
Hence, while using Bogdanov’s poetry, the application of systemic ordering of human knowledge while creating science – i.e., the later developed branches of general science on organization – is necessary [15].

“Loosch’s bow tie”

E. Loosch graphically presented the track of information processing during a motor operation in living beings, especially in humans [16]. It has a specific shape, so it may be termed “Loosch’s bow tie” (Fig. 1).

It is worth noting that already in 1986, R. Pöhlmann described this phenomenon, though he uses another, not so illustrative graphic depiction [17].

While analysing “Loosch’s bow tie”, one might ask, where did the bits of information between “Input” and “Conscious processing” disappear, and how did they reappear between “Conscious processing” and “Output”? Even in much simpler physics, the phenomena of annihilation and creation consist in a specific interplay between mass and energy; it happens “thanks to” A. Einstein’s famous “E = mc²” equation. Therefore, in physics, in the case of annihilation and creation, one may speak not of disappearing and reappearing, but of specific mass-energy transformations.

Here arises the question: how can such an “intellectual black hole” be avoided, where the disappearing and reappearing of information bits in “Loosch’s bow tie” take place?

According to Pavlov, each motor operation may have been composed of pure reflexes, of the same nature, i.e., using the same information processing modality. Alike the bits in “Loosch’s bow tie”. In such a case, the marvellous disappearing and reappearing of information before and after the “bow tie knot” would be unavoidable. Thus, the Pavlovian philosophy in this model is evidently inappropriate.

Incidentally: such unexplainable phenomena, reflecting the scientist’s childish longing for fairy-tales, are even present in contemporary science. They may be exemplified by the “black box” or “self-organization.” Both mysteriously endow a given phenomenon or process, which cannot be explained rationally, with the attribute of commonly acknowledged, though not genuine, scientificity. Nevertheless, the role of such fairy-tales in science is fundamental: just they make an engine of science development and (sometimes) progress; just they pave the way of reasoning for the most productive component of intellect in science, the intuition.

However contradictory it may sound, Bernstein’s concept may underlie a modification saving the rationality of Pavlov’s theory. Bernstein’s neurophysiological “brain skyscraper” [12, 13], as well as its “functional shadow”, the modalities ladder [15], consist of at least five “floors.” Each of them uses a different information processing modality.

Parenthetically: “at least five floors,” because Bernstein divided the C-level into two sub-levels, C1 and C2.

Moreover, he wrote:

“In this book (“On Construction of Movements” – WP), we shall not touch on those factors proving the existence of at least one more cortical level (E) in our brain... because it is unrelated to the main topic, dexterity [14].

It is merely the modality that determines both “information capacity” and “information processing potentiali-
ties” of a single chunk. Accordingly, a “high-level chunk” may include information equivalent (yet not identical) to many “low-level chunks.” Hence, while going from lower to higher levels of a system, it is possible to lower the information chunk’s number – according to the idea of degrees of freedom reduction – but retain the general volume of information. Consequently, while replacing the term “bit” with the term “chunk” in “Loosch’s bow tie”, its rationality becomes obvious. At the same time, the whole model transforms from Pavlovian intellectually passive (yet very important in the history of science!), focused on the present, reflexive model of movements’ control, into active, directed towards future, Bernsteinian systemic theory.

As I learned from I.M. Feigenberg, in fact, Bernstein regarded the E-level as tightly related to dexterity. However, proclaiming such a view would be dangerous for him in the Soviet Union of that time, because it was not consistent with Pavlov’s theory, officially declared as being the “only right one.”

The “backbone” of Bernstein’s brain skyscraper structure is a systemic way of thinking. In fact, it is consistent with both Bogdanov’s and von Bertalanffy’s inventions. Moreover, the main “intellectual DNA transformation” of Bernstein’s concept, while comparing it to that of Pavlov, is the premise that the information may be not homogenous (Pavlov, reflex approach), but it may be of various modalities (Bernstein, systemic approach). Sadly, juxtaposition of both these great concepts was an “achievement” of Pavlov’s followers of and not Pavlov’s himself. Therefore, it was possible to interpret Bernstein’s concepts as continuation and development of Pavlov’s achievements – significant indeed, but in 1904 (Nobel Prize for Pavlov – for research into physiological mechanisms of digestion and the “seeds” of psychological theory of reflexes), and not in 1947 (Stalin Prize for Bernstein for “On Construction of Movements”). Unfortunately, shortly afterwards Bernstein was heralded by Pavlov’s followers as a “cosmopolitan” and banned from the scientific society of the Soviet Union [18, 19].

The specificity of a system

The process of lowering the number of information chunks may take place at the same level, by “melting together” primarily separate operations. This may be exemplified by R.A. Schmidt’s “gearshift analogy” [20]. At first, the process consists of seven separate operations: clutch down – gas up – lever forward – lever to the right – lever forward – gas down – clutch up. Then it transforms into three operation processes: clutch down-gas up – lever forward-to the right-forward – gas down-clutch up. Finally, all these sub-operations melt into one fluent operation, being controlled by a single chunk of information.

In this case, one has to do with the transformations at the same, contactceptive B-level. However, the more intensive “concentration” of information requires a more complex process, i.e., the change of information processing modality. While “translating” it into the “language” of the brain skyscraper or modalities ladder, this means transition from one level of a system to a higher one. This is a process of specifically systemic nature. In this respect, the two following statements by J.M. Morawski are very important:

In afferent direction (from lower to higher levels), there occurs the reduction of information, from its detailed, phenomenological form to a synthetic, averaged, statistic one. Conversely, along the efferent paths (from higher to lower levels) more general, global information has been written out to a form (language) specific to lower levels [21].

This imposes a special responsibility on a scientist. Creation of theory, which makes the very essence of science, needs precise thinking and concluding, and not only following – sometimes nearly mechanically – a commonly accepted methodology, as at the empirical stage of science building. In short, it needs abduction, and not merely induction [3, 15]. While climbing up the abstraction scale (abduction slope of the IAD [3, 15]) in science creation, the share of “elusive” concluding becomes greater, and that of “tangible” experiments – smaller. Typical for empirical methodology inductive thinking – which may be regarded as an equivalent of life experience in everyday life – is nowadays no longer productive enough in the creation of science. At the borders between particular levels, the transformations are, generally, of nonlinear nature, hence, the modalities of information processing at each of them have their specific kind of logic. Reasoning effective at one level may turn out to be non-effective at another one. This makes the usefulness of empirical data in building highly abstract theories small or even extremely small. Their only function is to produce premises. All the further stages of science creation are completely detached from the reality and observable facts, and base on more and more abstract, nonlinearly transformed representations of the empirical data. Such a process has been very illus-
tively and instructively described by mathematician I. Stewart and biologist J. Cohen [22].

At this point, let me mention my personal experience, which I regard as highly instructive in this respect. During the conference in 2009 in Chalkidiki, Greece, Professor P. Blaser asked me about nonlinearity. Although I am an educated engineer and at the time, had been working as a physicist for 7 years, at first I did not understand the question. Nonlinearity was so distant to my image of motor control and the question was so unexpected that I was not able to immediately grasp what Professor Blaser was asking me about. Only when he repeated this question in German did I understand it. Then, because application of Abraham Lincoln’s wise suggestion (“better to remain silent and be thought a fool than to speak out and remove all doubt”) was not possible, I speak out and remove all doubt (cause application of Abraham Lincoln’s wise suggestion this question in German did I understand it. Then, beessor Blaser was asking me about. Only when he repeated that I was not able to immediately grasp what Professor Blaser was asking me about. Only when he repeated this question in German did I understand it. Then, because application of Abraham Lincoln’s wise suggestion (“better to remain silent and be thought a fool than to speak out and remove all doubt”) was not possible, I answered that – in my opinion – if we observe in biology or, all the more, in psychology any linear relations, then most probably, either our measuring devices or our interpretations are not precise enough. At that time, I did not realize how significant this apparently simple question was for my understanding of the matter of motor control. Only later, while considering Blaser’s query, did I realize that it is only the “freely nonlinear” fluctuations – which may be exemplified with Bernstein’s “repetitions without repetitions” [12 - 14] – that make up the essence of any information transformations in living creatures. They force a living being to reduce the degrees of freedom slightly differently each time, which opens the way towards purposefulness and inventiveness, for the evolution of species and the learning of individuals. This mechanism has been termed by M. Heller “logic of loops” or “nonlinear logic” [23]. It may also be associated with D.R. Hofstadter’s “strange loops” [24, 25].

To be brief, “mathematical nonlinearity” may be associated with “stiff determinism”, whereas “free nonlinearity” – with “flexible determinism” in the case of learning, and “plastic determinism” in the case of evolution. Stiff nonlinearity may be associated with biological purposefulness, the fully shapable flexible nonlinearity – with psychological learning, and shapable, yet relatively stable plastic nonlinearity – with performing already mastered motor skills. All the more, probably just freeing the system reasoning from mathematical formalism and mathematical tautologies – what, roughly, might be termed the “dictatorship of equal sign” – enables creation of the most precious product of system thinking, i.e., the unpredictable, QUALITATIVELY NEW system effect.

The anatomy of a system

The “anatomy” of a system has been illustratively and instructively described by J.M. Morawski [7]. Unlike Bogdanov [5], who was a physician, economist and philosopher, von Bertalanffy [6], who was a biologist, Morawski is an engineer and biomechanist. In this case, a typically technical way of thinking, which consists in possibly unambiguous and clear ordering of knowledge, greatly contributes to the general understanding of the nature of a system.

Morawski formulated three basic system creation axioms:
1. Layer hierarchy axiom; in a system there is a “chief” layer, and the other ones are auxiliary to it.
2. Layer autonomy axiom; each layer performs sub-tasks assigned to it without any additional information.
3. Scale conformity axiom; each layer uses its own code of information processing which determines modality of such processing (most important: its depth and swiftness) [7].

The latter may also be termed “layer identity rule”, because it is the modality of information processing that determines the character of a given layer of a system. Metaphorically, it may be compared to a cellular membrane in biology.

In fact, Bernstein’s five-level movements construction system is fully consistent with Morawski’s axioms. The “daughter” of Bernstein’s “brain skyscraper”, the modalities ladder [15], consists of the proprioceptive A-level, contactceptive B-level, teleceptive C-level, verbal D-level and symbolic E-level. However, in the Bernstein’s concept – and, consequently, in the modalities ladder – one might trace still another tenet:
4. Lower level development rule; the creation of a higher level does not suppress but develop the potentialities of a lower one [12 - 14].

For example, while driving a car, a human with fully developed “visual” C, “common sense” D, and “fantasy” E levels is able to perform all the “haptic” B-level operations (pedals, gear stick), but the creatures which do not dispose of D and E levels are not, although their B-level is usually also highly developed. Such a phenomenon is sometimes termed “muscle memory” [26]. In this case, one might state that a purely “executive part” of those motor operations resides at the B-level, but a “sense-giving part” – at higher levels, not even fully developed in apes.

Admitting that while going from one level to another, the information transformation is of nonlinear nature, it is possible to formulate one more principle:
5. Adjacent level translatability rule (ALT); only the modalities of adjacent levels are – to some extent – translatable into each other [15].

For example, it is not possible to verbally explain (D-level) how to keep balance while cycling (B-level). More generally, the “very heart” of this principle is the nonlinearity.
By the way: The ALT may be regarded as a “cousin” of the correspondence principle by N. Bohr [27], the very essence of which is in fact the nonlinearity. Symptomatically, M. Jammer described the correspondence principle as follows:

There was rarely in the history of physics a comprehensive theory which owed so much to one principle as quantum mechanics owed to Bohr’s correspondence principle [28].

Let us be reminded that physics deals with by far simpler matter than that of psychology and motor control. Therefore, some universal regularities may be easily discernible in physics, but they – may be – are valid also in motor control. In Bohr’s principle the correspondence bridges the gap between quantum and classical physics. In Bernstein’s brain skyscraper (and the modalities ladder as well) there are at least four such “gaps”: between A-B, B-C, C-D and D-E levels.

The anatomy of a motor operation

At first, let us term an intentional, goal-aimed motor action “motor operation.” If the whole operation starts with reception of an extrinsic stimulus, then it is termed “motor response.” One might discern the following links in the cause-effect chain of information processing in a motor response:
1. Physical stimulus reception and physiological sensory inputs production.
2. Perception – retrieving from one’s own memory the psychological information joined with the just produced physiological sensory input.
3. Attention – evaluation of the information on the basis of “condensed” previous experiences (emotions).
4. Motivation – assessment, whether the information needs a response or not.
5. Intellect – consisting of three cooperating instruments: instinct, intuition and intelligence; it works out the pattern of a motor response.
7. Decision – assessment whether the response should be executed or not.
8. Skills – retrieving already mastered sub-operations from one’s own memory.
9. Efferent copies – recording in one’s memory the pattern of the operation just being executed; they enable differentiation, which events in the environment result from one’s own operation and which are independent of it; moreover, they make up “frames of reference” for possible, future improvement of the operation.
10. Physical execution of the psychologically invented motor operation [15].

Such a cause-effect chain may take place at each of the levels of the “brain skyscraper”, though at D and E levels, which do not have their “own” sensory organs, the part of stimuli is being played by engrams (hunches).

Figure 2. General pattern of information processing during a motor response. Black circles – environment, physics; light grey circles – physiology; white circles – psychology.
Accordingly, even within the same level (and, consequently, the same information processing modality), particular “links” may be placed at various sub-levels of abstraction (Fig. 2).

For the sake of simplicity, the particular links may be – roughly – compared to technological devices (in brackets). The abbreviations in Fig. 2 mean:

- **E1** – Environment, stimuli creation;
- **R** – Transducer: stimuli reception and sensory inputs production;
- **P** – Detector: perception;
- **A** – Input filter: attention;
- **M** – Input on-off switch and pre-amplifier: motivation;
- **I** – Processor: intellect;
- **F** – Output filter: foresight;
- **D** – Output on-off switch and final amplifier: decision;
- **S** – Controller: skills;
- **EC** – Recorder: efferent copies;
- **MC** – Actuator: motor commands, muscles;
- **E2** – Environment, motor operation execution.

Such a model of information processing enables a specific interpretation of “Loosch’s bow tie” [16]. While “ascending” from stimulus reception to intellect, one observes reduction in the number of information chunks and an increase in their complexity. With intellect, the “stimuli path” (“left leg” of the diagram in Fig. 2) ends and the “engram path” starts (“right leg” of the diagram). Thus, the multiplication of information chunks in the “right wing” of “Loosch’s bow tie” is rooted in the memory and not in the environment. In such a model the reduction (“left leg”) and multiplication (“right leg”) of information chunks is fully coherent with the already cited statement by J.M. Morawski [21].

Incidentally: the left leg of the diagram shown in Fig. 2 might be associated with what R. Cattell [29] termed “fluid intelligence,” whereas the right leg – with “crystallized intelligence.” Inverted commas are significant here, because in the system-theoretical approach, the meaning of the term “intelligence” differs from that used by Cattell.

While admitting that motor activity is the only way of manifesting any mental processes, the idea presented in Fig. 2 may underlie a more general reflection. Cattell joined “fluid intelligence” with the young, and “crystallized intelligence” – with those more matured individuals. Accordingly, one might suppose that along with the passage of time in an individual’s life, the share of “left leg” shown in Fig. 2 diminishes, whereas the “right leg” gains more and more importance. While analyzing the human perception of the world, W. James has stated that “the intellectual life of man consists almost wholly in his substitution of a conceptual order for the perceptual order in which his experience originally comes” [30]. Therefore, if along with time passing, the “conceptual order” is beginning to outweigh the “perceptual order”, it may produce serious consequences in seniors, e.g., while car driving.

### The categorization of motor operations

The higher „rung“ of modalities ladder, the more complex the motor operations are taking place. However, „more complex“ means also „more time consuming.” The particular motor operation categories and their internal patterns (in brackets) are shown in Fig. 3.

The circles “A”, “B”, and “C” are marked in light grey. One might term the levels corresponding to them as “sensory levels.” Although, while looking at Fig. 2., one may learn that the final motor operation originates in intellect, i.e., in engrams, and not in stimuli, but at those sensory levels the whole information processing chain may start in reality, just with the reception and perception of a stimulus. The dark grey D and E levels have no “own” sensory organs, hence, the only possibility of any motor or mental activity (in the case of E-level, only the latter is possible, because fantasy cannot control any motor operations in reality) inevitably starts in the sphere of engrams.

Such a process is also possible in the “sensory levels.” A dog has no developed D-level, but each owner of this animal has for sure observed that his or her sleeping pet suddenly starts to nuzzle and its legs slightly vibrate, as if it were running. The same mechanism discovered by W. Carpenter termed “ideomotor phenomenon” [31] underlies mental training in competitive sports.

This phenomenon unveils a very important “ability” of the engrams, especially at both “purely mental” D and E levels. The sensory ones (A, B, and C) may work “here and now”, in real time. In “sensory levels”, only at C-level is it possible to extend the temporal perspective of a motor operation controlled by it to the limits of timing, including the short portion of the time axis adjoining the moment, which may be addressed as “here and now.” On the other hand, the D-level enables extending the time axis of the phenomena and processes just being analysed far into the past and the future. Inevitable price, which has to be paid for this, is complete detaching the information processing from “here and now”, i.e., from current stimuli. However, at D-level, the time axis is “stiff”, i.e., the phenomena have to be adjusted to it. On the other hand, at the E-level, the time axis gains some “topological” flexibility and enables creation of purely fantastic images, sometimes even completely detached from reality. This may make up a basis for unlimited inventiveness, not constrained by common sense.

In the history of science – especially in physics – such a “moonshine” way of thinking turned out to be especially effective. This is symptomatic. Physics is very
strongly embedded in reality, but even in this discipline, the apparently nonsense fantasy turned out to be especially significant. Such way of thinking is, all the more, important in motor control, the issue of which is by nature, much more abstract than that of physics.

Conclusion

In the history of physics, the apparently marginal phenomenon of the black body radiation [32], while analysed in detail by M. Planck – not without the “moonshine” way of thinking – gave rise to the creation of quantum physics. Therefore, there are no “marginal phenomena”; if something, even seemingly unimportant, does not match the already existing knowledge, than it should be categorized as a paradox. In addition, according to N. Bohr, “How wonderful that we have met with a paradox. Now we have some hope of making progress” [33]. Therefore, just the paradoxes and “fairy-tale” creation of the image of future make the very “engine” of science development. Hence, even the apparently trifling diagram by E. Loosch, while analysed deeply, unveils a paradox – the disappearance and reappearance of bits of information. This paradox may start a chain of conclusions leading far beyond – probably – Loosch’s intentions.

In the 1970s, one of my mentors at the Technical University in Wrocław, Professor R. Haimann, used to say that he is able to examine a student using only two questions. It does not matter what the first one is. How-
ever, the next one is “Why?” Then anew – why, why, why… This question may be addressed as a “paradox killer.” Therefore, it seems that just such a “paradox killer” may pave the abductive way towards understanding and its most noble product – the theory – in motor control. Anyhow, the simple question “why” would be by far more effective than collecting, often nearly mechanically, “new, original, experimental data.”

It is worth noting that systems theory is a sheer theory, as any other one. Consequently, it draws its strength from the fact that it has a limited field of applicability [4]. J. Cohen and I. Stewart argued that “a Theory of Everything would have the whole universe wrapped up; and that’s precisely what would make it useless” [11]. Therefore, without doubt, there exist such regions of human knowledge where the systems theory would not be efficient. While seen from a general perspective, this phenomenon may be regarded as an important component of science’s immune system. Thanks to such a modular, “Lego bricks” structure, if only one theory falls out from the whole edifice of human knowledge, then such an event does not ruin the whole structure of science. And the process of its development continues!

The same concerns the people of science. Let this paper be my humble homage to Professor Eberhard Loosch, who passed away on 13th October 2016 at age of only 62. He was a honest scientist and a good man. We will miss him. Moreover, without him, building motor control (and movement science, and Bewegungslehre as well) will be much more difficult… However, the show must go on! Just this will endow the achievements of Professor Eberhard Loosch with a scientific sense. Just this will make them lively and fruitful.

References


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Kind regards,

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