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CONTENTS

EDITORIAL

Regular readers of *Human Movement* have certainly noted the changes in the journal editorial staff, which include a new Editor-in-Chief, Associate Editors and new members of the Editorial Board and Advisory Board. We do hope these changes will have a positive impact on *Human Movement* issues in the future. We truly believe that our journal will be constantly improving its scientific standards by publishing top quality research papers on various aspects of sports sciences. We are particularly interested in such areas as physical education, youth sport, recreational sport, high-performance sport and physiotherapy. We think *Human Movement* should respond to the modern challenges in the areas of motor development, motor learning, health and fitness, socialization in sport, function of sport in society and health in sport. We welcome contributors who represent the diverse sport sciences and different scientific approaches, especially those rarely covered in professional literature. Top quality papers on sport medicine, exercise physiology, sport biomechanics, sport psychology, sport pedagogy, sport sociology, sport philosophy, have always been regarded as valuable contributions to our journal. We are also looking forward to works from such nascent areas of sport sciences as computer science or sport information.

The present volume of *Human Movement* reveals the methodological diversity of modern sport research. New methods of observation, analysis, sensible justification and synthesis are constantly sought. There are, in fact, very few scientific disciplines which are not yet applied in sport research. Such scientific fields as sport economy, sport facilities and equipment, sport law and sport politics have been developing rapidly, challenging *Human Movement* editors to embrace these new contexts of sport and physical culture.

The first article in this volume is a study by Spanish authors concerning relationships between self-determined motivation and physical education. It is followed by a number of papers written by experts in natural sciences, in particular, by teams of bioengineers. They are concerned with the identification of factors and neurophysiological mechanisms that may determine a robust and very stable postural control in volleyball players; development of a mathematical model of javelin flight involving transverse elastic vibrations; and correlation between values of muscle torques with the level of development of tissue components in a group of young men. Another paper is devoted to the effects of cylindrical handle diameter and handle position on maximal grip force. The volume also includes an article with very practical aims, which shows that understanding aikido mechanics improves the performance of aikido techniques.

The papers in the current issue of *Human Movement* also touch upon the problems of physical development, motor development and physical fitness. Two other articles present the significance of social stratification factors in physical fitness development and a mathematical model of correlations between somatic traits and indoor rowing results.

The last two articles in the volume focus on entirely different aspects of sport. One of them is an interesting analysis of the phenomenon of Polish football hooligans; the other discusses the professional career paths of alumni of the Faculty of Physical Education of the University of West Bohemia in Pilsen, who graduated from this renowned institutions between 1998 and 2005.

Human Movement also reports on important scientific and scholarly events. The present volume is concluded with conference reports, the announcement of the annual competition for Prof. Bogdan Czabański's Award and an invitation to the International Conference "Rydzyna 2009".

Last but not least, we are especially grateful to our reviewers for their critical evaluation of the articles. Thanks to them *Human Movement* remains a top quality scientific journal.

SELF-DETERMINED MOTIVATION AND PHYSICAL EDUCATION IMPORTANCE

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ABSTRACT
It is widely accepted that when psychological needs for autonomy, competence and relatedness are encouraged in physical education classes, they can play a potentially important role in enhancing motivation and positive consequences. **Purpose.** The purpose of this study was to analyse the relations between self-determination theory and the importance and usefulness pupils give to physical education. **Basic procedures.** The sample consisted of 440 Spanish students, aged between 14 and 16, who were measured for psychological mediators (autonomy, competence and relatedness), motivation types (intrinsic motivation, extrinsic motivation and amotivation) and physical education importance (PEI). **Main findings.** The results showed that PEI was positively related to autonomy, competence, relatedness and self-determined motivation. Amotivation was negatively associated with PEI. **Conclusions.** The satisfaction of the three basic psychological needs and self-determined motivation develop a more positive attitude of the students towards physical education. The results are discussed with regard to enhancing participation rates and, potentially, physical activity levels.

Key words: physical education, motivation, self-determination

Introduction

Different studies have shown the impact that teachers' actions have on pupils' attitudes in physical education classes. Some aspects such as interest, satisfaction, the level of pupil's involvement in the class and motivation are variables that are influenced by the pupil's perception of the motivational climate generated by the teacher, with results demonstrating, among others, that environments favouring the pupils' autonomy and decision-making lead to greater satisfaction and interest in physical education [1–3].

Taking into account the postulates of the self-determination theory [4, 5], it is interesting to analyse pupils' perceptions of their autonomy, competence and relatedness, since they will have an influence on their motivation towards physical education and probably on how important and useful they think the subject is. According to this theory, self-determined behaviour can be described by distinct motivational types: (a) amotivation, a lack of motivation; (b) extrinsic motivation, or engaging for reasons that emanate from the outside of the self, such as rewards or coercion; and (c) intrinsic motivation, or engaging for reasons that emanate from within the self or within the activity itself. These motivational types can be ordered along a continuum on which amotivation and intrinsic motivation are at opposite ends. Movement along the continuum is partly governed by internalising motives for participating, so that those that were formerly extrinsic become intrinsic. In this shift along the continuum, it is suggested that one crosses a threshold of autonomy [6].

There are different types of regulation within extrinsic motivation depending on the level of self-determination: external, introjected, identified and integrated. In external regulation, students participate in class to attain external incentives, in introjected regulation, participation is determined by feelings of guilt, whilst in identified regulation, they participate because they think the activity is important, although it is not actually pleasurable. In integrated regulation, performing an activity is in congruence with the individual's different

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values, thoughts and ideas, although this type of motivation does not usually occur in adolescents [7]. Vallerand and collaborators [e.g. 8] also established the existence of three forms of intrinsic motivation: intrinsic motivation to know (participating actively in the class to enjoy learning things), intrinsic motivation to accomplish (participating to enjoy by improving skills) and intrinsic motivation to experience stimulation (participating to enjoy experiencing stimulating situations).

According to the self-determination theory, human behaviour is motivated by three primary and universal psychological needs: autonomy, competence and relatedness, which seem to be essential to facilitate optimum functioning of natural tendencies for growth and integration, as well as for social development and personal welfare [9, 10]. Students need to feel they have a certain freedom to act, that they can perform activities efficiently and relate positively with the people in their immediate environment. The three needs will influence motivation, to the extent that an increase in the perception of competence, autonomy and relatedness will create a type of intrinsic motivation, while frustrating these needs will be associated with less intrinsic motivation and more extrinsic motivation and amotivation [9]. The theory further proposes that as one's motivational state moves towards intrinsic motivation, increases in cognition (e.g. deeper understanding), behaviour (e.g. increased participation) and affect (e.g. attitude) will result. These postulates have been demonstrated in physical education classes by different research studies [e.g. 11–13]. High levels of intrinsic motivation in students are desirable because students will participate for reasons not limited to the influence of setting grades, the teacher, or forced participation. In other words, they are more likely to become physically active on their own.

As shown by the hierarchical model of intrinsic and extrinsic motivation and the different research conducted in this area [14], social factors have an important influence on the satisfaction of basic psychological needs and the development of self-determination. Furthermore, as mentioned above, the most self-determined motivation is linked with more positive consequences. Therefore, the climate created by physical education teachers can determine, to a large extent, whether their students feel competent, autonomous or integrated with their classmates. These feelings will lead them to participate in physical education for the enjoyment they obtain. Along these lines, it is interesting to analyse how this greater self-determination influences the development of a positive attitude towards physical education such as to be able to guide teachers' interventions.

Physical education is an excellent setting for developing favourable attitudes towards physical activity and sport at a stage as critical as adolescence. The fact that pupils consider physical education important and find it useful for their future is one of teachers' main objectives. Making adolescents appreciate physical education and sport is to be the first step in fostering active lifestyles. Bearing this in mind, and taking the self-determination theory for reference, the aim of this study was to analyse how the fulfilment of basic psychological needs and motivation can influence the pupils' view on how important or useful physical education is. We hypothesised that meeting the three basic psychological needs and the most self-determined forms of motivation would be related to recognising the importance and usefulness of physical education.

Material and methods

Participants

Our study's sample comprised 440 students, aged between 14 and 16 ($M = 14.8$, $SD = .81$), of which 229 were male and 211 female students, all members of physical education classes in schools in a large Spanish city. A sample of students in their final years of compulsory secondary education was used because adherence to sport tends to decrease after this stage [15].

Instruments

Contextual Self-determination. A modified version of the Sport Motivation Scale (SMS) [8] in Spanish [16] was used to measure motivation in physical education at the contextual level. This scale is composed of four items for each factor and so it has a total of 28 items with the question stem of "I participate and try hard when practising in physical education …" These items assess the constructs of amotivation, three types of extrinsic motivation (external, introjected and identified regulation) and three types of intrinsic motivation (to know, to accomplish, to experience stimulation). Students responded to 28 statements (four items on seven subscales) on a 7-point Likert scale where *does not describe me at all* – 1 and *describes me exactly* – 7. This scale is a contextual motivational measure, which assesses the motivational dispositions of students towards physical education in general. Recent studies (see [17], for a review) confirmed the factor structure of the scale and demonstrated a satisfactory level of internal consistency, as well as adequate test–retest reliability. In this study, Cronbach's alphas of the seven subscales ranged from .70 to .80. Subscales can be used separately or in combination to form a summary score called the self-determination index [18].

Psychological mediators. A modified version of The Basic Psychological Needs Scale in the work domain and the inter-personal relations domain was used to measure physical education. The Basic Need Satisfaction at Work Scale has been used most often [19, 20]. The original scale had 21 items concerning the three needs for competence (six items), autonomy (seven items) and relatedness (eight items). The version adapted to physical education [21] comprised three items for every one of the three factors: autonomy (e.g. "I express my ideas and opinions freely in the physical education class"), competence (e.g. "Most of the time I feel that I am talented at physical education") and relatedness (e.g. "I get on well with my peers in physical education classes"), which were answered using a 7-point Likert scale where *totally disagree* – 1 and *totally agree* – 7. The internal consistency of the instrument and every one of the factors was obtained by calculating Cronbach's alpha coefficient: autonomy (.64), competence (.67) and relatedness (.76).

Physical Education Importance (PEI). Three items were created in order to measure the importance and usefulness pupils give to physical education: "I think it is important to receive physical education classes", "Compared with the rest of the subjects, I think that physical education is one of the most important" and "I think the things I learn in physical education will be useful in my life". Students responded to three items on a 4-point Likert scale where *totally disagree* – 1 and *totally agree* – 4.

Procedures

Authorization to conduct the research was given by headteachers. The students were informed of the study's purpose and of their rights as study participants and were asked to sign a consent form. The instruments for measuring the different variables were administered in a classroom to the chosen subjects when the teacher was not present. Each participant took 10–20 min to complete the questionnaires and responses to the instrument were kept anonymous. The participants were told to ask for help if confused concerning either instructions or the clarity of particular items. No problems were encountered in completing either of the inventories or understanding the nature of the questions.

Data Analysis

First, we analysed the psychometric properties of the items created to measure how important the pupils think physical education is. Then we carried out a correlation analysis among the psychological mediators, motivation and the importance of physical education. Next an ANOVA was utilised to analyse the differences in the fulfilment of basic psychological needs and motivation based on how important the pupils rated physical education (low, medium or high). Finally, a regression analysis was undertaken in order to find out the prediction power of the psychological mediators on self-determined motivation and how important and useful the pupils think physical education is.

Results

Psychometric Properties of the Physical Education Importance

We carried out a factor analysis of principal components (see Tab. 1) in order to examine the factorial structure of the items. We then did a factor analysis of principal components with varimax rotation resulting from the analysis grouped into one factor (Physical Education Importance) with an eigenvalue of 2.01 and explaining a total variance of 67.15%. Cronbach's alpha reliability coefficient was .75.

Table 1. Psychometric properties of the Physical Education Importance

Items	Factor
1. I think it is important to receive physical education classes	.827
2. Compared with the rest of the subjects, I think that physical education is one of the most important	.814
3. I think the things I learn in physical education will be useful in my life	.818
Reliability	.75
Explained variance	67.15%

Means, Standard Deviation and Correlation Analysis

Tab. 2 shows that autonomy, competence and relatedness were related positively and significantly to all the variables except amotivation, which was related negatively. With respect to the PEI variable, there were positive and significant relations with all the variables, except amotivation, for which the relation was negative.

ANOVA

The dependent variables were the seven motivation factors (IM to know, IM to experience stimulation, IM to accomplish, identified regulation, introjected regulation, external regulation and amotivation) and the three psychological mediators (autonomy, competence and relatedness), and the independent variable was the PEI, which was recoded on three levels (not much importance: 1–1.99, average importance: 2–2.99 and a lot of importance: 3–4).

As observed in Tab. 3, significant differences are obtained in all the variables. In the three IM factors, the three EM factors and the autonomy, competence and relatedness factors, motivation increases when there is more PEI. As far as amotivation is concerned (F = 5.98, $p < .05$), it increases as PEI is less. In the *a posteriori* analysis test (Tukey's test), there were differences ($p < .01$) in all the variables and the differences in the amotivation variable were distinct ($p < .05$).

Hierarchical Multiple Regression

Two multiple regression analyses were conducted to examine how psychological mediators affect self-determination (SDI) and PEI (see Tab. 4). The SDI (Self-determination Index) was calculated using the scores of seven SMS subscales and the following formula: (2 × (IM to Know + IM to Accomplish + IM to Experience Stimulation)/3 + Identified Regulation) – ((Introjected Regulation + External Regulation)/2 + 2 × Amotivation) [18]. As Chantal, Vallerand, and Vallières [22] state, the justification for this type of computation is based on Guttman's [23] simplex structure patterns, such as the correlation matrix that emerges from the self-determination continuum. This type of matrix is characterised by strong positive correlations between subscales on the self-determination continuum and weaker correlations between subscales located at opposite ends. This type of index has been shown to be

Table 2. Means, standard deviation, alpha coefficient and correlations for all the variables

	M	SD	α	1	2	3	4	5	6	7	8	9	10	11
1. IM to know	5.17	1.44	.80	–	.78**	.75**	.72**	.73**	.49**	–.18**	.57**	.44**	.47**	.50**
2. IM to experience stimulation	5.09	1.35	.76	–	–	.77**	.78**	.73**	.57**	–.11*	.56**	.50**	.51**	.52**
3. IM to accomplish	5.29	1.33	.79	–	–	–	.74**	.73**	.51**	–.17**	.49**	.44**	.51**	.50**
4. EM Identified regulation	5.08	1.38	.78	–	–	–	–	.70**	.64**	–.04	.52**	.48**	.55**	.53**
5. EM Introjected regulation	5.19	1.27	.70	–	–	–	–	–	.53**	–.06	.51**	.43**	.46**	.47**
6. EM External regulation	4.44	1.42	.73	–	–	–	–	–	–	.18**	.36**	.44**	.35**	.37**
7. Amotivation	3.31	1.56	.70	–	–	–	–	–	–	–	–.13**	–.13**	–.13**	–.15**
8. Autonomy	4.90	1.40	.64	–	–	–	–	–	–	–	–	.45**	.47**	.40**
9. Competence	4.40	1.56	.67	–	–	–	–	–	–	–	–	–	.36**	.37**
10. Relatedness	5.67	1.28	.76	–	–	–	–	–	–	–	–	–	–	.38**
11. Physical Education Importance	3.02	0.74	.75	–	–	–	–	–	–	–	–	–	–	–

* $p < .05$, ** $p < .01$

Table 3. ANOVA by PEI

	Low PEI (n = 63)		Middle PEI (n = 156)		High PEI (n = 221)		Mean square	F	p
	M	SD	M	SD	M	SD			
IM to know	3.73	1.67	4.96	1.26	5.72	1.15	101.71	62.32	.000
IM to experience stimulation	3.63	1.56	4.87	1.15	5.66	1.03	106.91	78.64	.000
IM to accomplish	3.93	1.62	5.10	1.12	5.81	1.03	90.61	66.48	.000
EM Identified regulation	3.67	1.60	4.78	1.14	5.69	1.07	110.77	78.14	.000
EM Introjected regulation	4.01	1.62	5.03	1.13	5.65	.98	69.08	52.32	.000
EM External regulation	3.40	1.59	4.26	1.27	4.86	1.29	56.61	31.75	.000
Amotivation	3.75	1.42	3.48	1.44	3.08	1.64	14.29	5.98	.003
Autonomy	3.82	1.59	4.73	1.20	5.33	1.28	59.94	35.14	.000
Competence	3.18	1.57	4.23	1.32	4.88	1.50	74.53	35.34	.000
Relatedness	4.69	1.61	5.50	1.19	6.02	1.03	49.88	35.13	.000

Table 4. Summary of the multiple regression analysis for variables predicting importance and self-determination behaviour by mediators

	B	SEB	β	Adj. R^2
Physical Education Importance	1.35	.15		.23*
Autonomy	.11	.02	.21*	
Competence	.09	.02	.20*	
Relatedness	.12	.02	.21*	
Self-determined motivation	–7.30	.98		.26*
Autonomy	.86	.17	.24*	
Competence	.48	.14	.15*	
Relatedness	.93	.18	.24*	

* $p < .001$

a valid indicator of self-determination in studies on motivational issues [e.g. 24, 25]. The SDI provided a manipulation check [8, 26]. Possible total scores on the SDI range from –21 to +21. Scores in the present study ranged from –9.42 to +17.33 (M = 4.37, SD = 4.89). The internal consistency of the index was satisfactory (Cronbach's alpha = .89). In the regression analyses, the three factors (autonomy, competence and relatedness) predict PEI and self-determination by 23% and 26%, respectively, finding significant differences ($p < .001$) in them.

Discussion

This study has established connections between the self-determination theory and the importance students place on physical education. The results revealed that the fulfilment of the basic psychological needs of autonomy, competence and relatedness, intrinsic motivation and extrinsic motivation correlated positively with the physical education importance. The correlation was stronger with more self-determined forms of motivation. Furthermore, amotivation was connected negatively with the importance placed on physical education. It would appear that students feel physical education is more important as the teacher increases their perceptions of autonomy, competence and relatedness, giving rise to more self-determined motivation. In fact, the regression analysis showed the positive influence of the fulfilment of the three needs on self-determined motivation and the importance and usefulness students place on physical education classes.

In line with the postulates of the self-determination theory, this study shows that teachers need to encourage students to participate in class, to reach the objectives set and integrate in the group. This will result in students having a more positive motivation so that they will view the subject as something important and feel that they could use the knowledge acquired in their everyday lives. Previous studies showed that meeting basic psychological needs and self-determined motivation were connected with other similar positive consequences in physical education, such as effort and persistence [27, 28], satisfaction and task involvement [29], the intention to be physically active [11, 13], concentration, positive affect and the search for challenges [12, 30].

Managing to get pupils to value physical education more highly and to develop a more favourable attitude towards it could be a great help in increasing the probability of them doing physical activity and sport throughout their lives. We have to bear in mind that attitudes towards sport formed in adolescence may well have a great deal of influence at later stages of life [31]. This means that physical education is an ideal medium for fostering active lifestyles. This study has shown that pupils' basic psychological needs have to be met and their self-determined motivation cultivated in order to achieve a more positive attitude towards physical education. Therefore, creating autonomy-supportive activities and programmes for adolescents may be especially effective [26, 32]. In this regard, to make students feel competent, it would be interesting for physical education teachers to provide positive feedback, making them aware that their skill can always be improved with hard work and effort, to promote process-oriented goals (which are easier to attain), and to establish moderately difficult objectives. To promote this feeling of autonomy, teachers can allow students to choose from among different activities resulting in the same objective, encourage their students to participate in the process, make their opinion matter and motivate them to design exercise programmes and creative body compositions. Similarly, every activity's objective must always be explained so that students understand why it is important and do not feel that something is being imposed on them without any justification whatsoever. Teachers should also try to encourage interaction among the students, designing cooperative, reflective and group-building activities, with multiple and heterogeneous forms of grouping. It is important to treat all the students the same and not to establish normative comparison criteria in the assessment. If these guidelines are followed, then students' basic psychological needs would most likely be satisfied, their self-determination would increase [33], and, as this study demonstrates, this can have a positive influence on their appraisal of physical education. This could be a first step towards creating positive attitudes that encourage adherence to exercise.

The results call for the promotion of self-determined motivation in physical education to enhance participation rates and, potentially, physical activity levels. As shown by the hierarchical model of intrinsic and extrinsic motivation [14], physical education teachers (social factor) can influence students' self-determination by means of psychological mediators (autonomy, competence and relatedness). This motivation could have a positive effect on their attitude towards physical education and sport, encouraging a commitment to sport. The main limitation of this study is the use of a correlational design that does not allow cause and effect relations to be established. Nevertheless, it provides relevant descriptive information that may be a starting point in designing experimental studies that analyse how teachers can get students to recognise the importance and usefulness of physical education classes. Furthermore, it would be interesting to develop new theoretical models explaining self-determination and its consequences using the structural equation technique. Future investigations should be focused on the self-determination theory in the field of physical/sport activity, since this progress will help to discover more details about the most important variables en route to promoting physical/sport activity. In the light of the importance of motivated behaviour in human activities, the study of the determinants of motivation should be given high consideration in future research.

Conclusions

The satisfaction of the three basic psychological needs (autonomy, competence and relatedness) and self-determined motivation are related to a more positive attitude of the students towards physical education. These results could be of great help in enhancing participation rates and, potentially, physical activity levels.

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POSTURAL CONTROL IN QUIET STANCE IN THE SECOND LEAGUE MALE VOLLEYBALL PLAYERS

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ABSTRACT
Purpose. The aim of the present work was to identify factors and neurophysiological mechanisms that may determine a robust and very stable postural control in athletes. **Basic procedures.** Postural performance in quiet stance was compared in 23 volleyball players from the Polish second league with 24 age-matched healthy physically active male subjects (controls). All participants stood quietly for 20 s on a force plate with their eyes open, while the center of pressure (COP) was recorded with the sampling rate of 20 Hz in both: the anterior-posterior (AP) and medial-lateral (ML) planes. From the recorded signals the COP dispersion measures, postural frequency and stiffness were computed. **Main findings.** The players displayed lower COP variability in the ML plane ($p < 0.05$) and lower COP range than controls in both planes ($p < 0.01$). Their COP mean velocity was higher in the AP plane ($p < 0.0001$) and the ML plane ($p < 0.01$) than in controls. Together, these findings indicated the presence of an additional low-amplitude and high-frequency signal superimposed on the COP in athletes but not in controls. Superior body stability and different mode of automatic postural control observed in the players challenge recent views on the relationships between attention resources allocation and its consequences to the selection and implementation of postural strategies. **Conclusions.** The volleyball players have superior body stability and different mode of automatic postural control as compared with the control group. Postural strategies of athletes may result from slight muscular adjustments that adopt mechanisms similar to stochastic resonance to monitor an instantaneous body vertical with greater efficiently.

Key words: postural sway, body balance, volleyball, sports performance

Introduction

For most of their life people remain in an upright position. The vertical posture is the basis of bipedal locomotion and many other movements. While standing, humans can perform a variety of life activities. In everyday life and in sport versatile assessment of the vertical posture is absolutely necessary. Postural stability has been a subject of research in such sports as gymnastics, judo, rifle shooting or skiing [1–4]. Few researchers have focused on the question of postural sway in team games players, especially in volleyball, which has particular requirements to combine postural stability with control of the ball and the overall assessment of the situation in the field.

Volleyball is highly challenging to players as they must hit or pass the ball while being in highly dynamic and often unstable postures [5]. A technical element, which is particularly important, is the player's ability to adopt and maintain the so-called volleyball posture. It should ensure, at least instantaneously, appropriate body balance and allow body movements in all directions [6]. In all volleyball actions during which the player has contact with the floor, maintaining postural stability is crucial. Such actions include receiving a serve, defense, standing serve, setting and digging. The high effectiveness of these actions is determined by the player's ability to control his or her postural sway. High robustness to any disturbances of body balance is necessary as actions with the ball without postural stability are far less accurate. This is because the central nervous system aims first at restoring the body vertical [7].

The analysis of the world championship matches shows that success in present-day volleyball is largely determined by efficient individual actions. Thus, apart from perfecting the players' general and specific fitness, technical preparation, team and individual tactics,

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mental training, stimulation and experience, also some other factors should be sought. One of them could be the players' exceptional postural control skills which were identified in the Polish male team prior to the 2006 world championships [8]. We believe that if a similar postural performance is presented by the average second league athletes, this can provide evidence that postural control skills are an important training goal. Further, this would also demonstrate that studying the international level players, who are often beyond the reach of researchers, could be effectively substituted by the research on athletes of national ranking.

The purpose of this study was to compare postural control in quiet stance in second-league male volleyball players with the age-matched physically active male students. We hypothesized that the athletes would display better postural performance due to implementation of different and more effective postural strategies than the control group.

Material and methods

The subjects included 23 volleyball players (22.9 ± 4.7 years of age, body height 193.0 ± 5.4 cm, body weight 87.6 ± 6.4 kg) from sports clubs from the second league; and 24 physically active non-training students of the Opole University of Technology (22.9 ± 1.3 years of age; body height 180.9 ± 6.4 cm; body weight 77.9 ± 10.0 kg). All subjects were in good health and expressed their written consent to participate in the study which was approved by the local Ethics Committee.

During the test the subjects stood quietly for 20 s on a force plate with their eyes open; the center of pressure (COP) was recorded in the anterior-posterior (AP) and medial-lateral (ML) planes with the sampling rate of 20 Hz. From the recorded signals the COP variability and range were calculated. Further, using the second order autoregressive model [9] the frequency of the difference between the COP and the center of mass signals as well as the respective values of postural stiffness were computed.

The results from both groups were compared with Student's t-test for independent samples at $p < 0.05$.

Results

Tab 1. compares mean values (± SD) of computed parameters in both groups of subjects. The COP variability and range were 22–27% higher in the control group, with the exception of insignificant differences in variability in the ML plane. These results indicate superior postural stability in volleyball players. The COP mean velocity was 48% higher in the AP plane and 22% in the ML plane in the volleyball players than in the students. This points to an increased activity of the nervous system in postural control among the athletes. Postural frequency and stiffness were higher in the players than in the control group only in the AP plane, with the difference between the frequencies very close ($p < 0.07$) to the assumed level of statistical significance.

Discussion

Postural performance can be assessed using amplitude characteristics (variability and range), and lower values of these parameters are thought to account for better postural performance and stability. The amplitude characteristics are also good indices of coordination abilities of the equilibrium system [4]. Thus the volleyball players in this study exhibited superior postural stability and better motor coordination than their non-training peers. These results confirmed our hypothesis pointing to possible relationships between the inter-group differences and the specificity of volleyball training.

Comparison between the changes in the COP mean velocity may raise some doubts as the inter-group dif-

Table 1. COP parameters in quiet stance in the control and study groups (students and volleyball players)

	Anterior-posterior plane		Medial-lateral plane	
	Students	Volleyball players	Students	Volleyball players
Variability (mm)	4.6 ± 1.7	3.7 ± 0.8*	3.2 ± 1.0	2.9 ± 0.6
Range (mm)	22.8 ± 6.7	17.9 ± 3.8**	18.2 ± 4.8	14.4 ± 4.1**
Mean velocity (mm/s)	6.7 ± 2.0	9.9 ± 2.7***	5.9 ± 1.5	7.2 ± 1.9**
Frequency (Hz)	0.57 ± 0.12	0.65 ± 0.15	0.65 ± 0.14	0.63 ± 0.16
Stiffness (Nm/rad)	1255 ± 516	1803 ± 793**	1465 ± 495	1789 ± 786

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.0001$

ferences in signal variability are usually accompanied by similar differences in mean velocity. The results of the present study revealed an opposite trend: the group of athletes had lower COP variability and significantly higher COP mean velocity than the control group. Theoretically, a higher COP mean velocity could have been due to an increase in one or more of the three COP parameters: amplitude, useful frequency of the COP signal, and noise frequency. Our results suggest that a combination of the first two parameters could not have led to the observed velocity increase. Thus only the appearance of a low-amplitude noise with high frequency would explain the higher COP mean velocity in athletes as opposed to the subjects from the control group. However, since noise is usually associated with deteriorated information, and control engineers always try to eliminate it in order to improve the effectiveness of their devices, the above explanation seems at the first glance as being against common sense.

It appears that one plausible interpretation of these results in terms of positive impact of noise may be based on the concept of stochastic resonance [10, 11]. Stochastic resonance is probably the only known example of using noise to enhance the detection of weak information-carrying signals e.g. sensorimotor signals in biological systems [12, 13]. Priplata et al. [14] showed that artificial generation of a subsensory (90% of perceptual threshold) noise in the form of slight pressure on the sole of a standing subject led to a reduction in postural sway due to faster and/or more accurate detection of this sway from the vertical. It seems feasible that highly trained athletes, whose performance in competition may critically depend on their postural stability, have learnt to make use of this modality. A similar inverse relationship between the changes in the COP mean velocity has been found in the world class volleyball players [8], however the latter group presented even lower frequency of the correction signal and larger improvement in postural stability thus providing a more compelling evidence for the presence of the useful noise in their COP signals than in this study. This can indicate that the second league players were still in the developmental phase of adjusting their postural strategies and that these strategies may play crucial role during the competition

Our results raise a question regarding the odds that stochastic resonance is the actual reason for the observed discrepancies between the volleyball players and controls [15]. Had it been the only data providing this evidence, we would have to be extremely cautious in making neuromotor inferences. However, three other projects that are currently carried out by our team have also yielded similar results. These studies concerned 2006 volleyball world champions in comparison with the control group; subjects standing 1.5 m above the ground versus subjects standing on the floor; and subjects in light touch stance versus subjects in quiet stance. In all the cases a lower COP variability, which indicated better postural stability, was associated with a higher COP mean velocity. It is then highly probable that the central nervous system uses a mechanism similar to stochastic resonance in hazardous situations or situations requiring higher accuracy of action or resistance to perturbations.

Another problem concerns the scope of further research and its practical applications. Two important questions arise: What specific elements of volleyball training and competition can activate the mechanism of stochastic resonance? How to measure and discriminate between stochastic resonance and ordinary noise which can often occur during tests? The answer to the first one would make it possible to improve therapy of patients susceptible to falls by enhancing the existing rehabilitation procedures with specific sport exercises. It should be emphasized that the discussed regulatory mechanism of postural control in the volleyball players can be possibly found among other athletes representing different sports. The second question is more challenging. The existing computational methods are unable to effectively discriminate between the sources of slight noise in the signal, though the viscoelastic modeling provides certain means [16, 17] to cope with this problem, as we have shown here by analyzing the interplay between the COP mean velocity vs. COP variability and postural frequency. Some new possibilities can be offered by chaotic measures and fractal dimension of the COP signal [18] as well as by time-to-boundary measures of postural control [19]. It seems, however, that studying postural mechanisms in professional sport must lead to new methods of mathematical modeling and distinct experiments based on the specificity of individual sports.

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MATHEMATICAL MODELING AND NUMERICAL SIMULATIONS OF JAVELIN THROW

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ABSTRACT
A physical model of the human-javelin system has been developed together with a mathematical model of javelin flight including its transverse elastic vibrations. Three kinds of parametric identifications were distinguished: geometrical, mass and aerodynamic. Numerical calculations were made for different initial velocities and throwing angles. The results obtained have been presented graphically.

Key words: javelin throw, transverse vibrations, mathematical modeling, numerical simulations

Introduction

The javelin throw is one of the four track and field athletics throwing events. The other three include discus, shot put and hammer throw.

The rules of javelin throw specify the javelin shape, weight and construction, point of release, correct execution of throws and procedures of flight distance measurement [1–4]. Compliance with these rules is necessary to make a legal throw and score a point.

A javelin throw result depends on a number of factors: the thrower's somatic build, level of motor traits (strength and speed), physical preparation, proper motivation, attitude and psychical disposition. Other elements include the correct throwing technique, javelin type and quality, technical conditions of the javelin run-up area, weather conditions and the type and level of track and field competition.

The success in javelin throw is achieved when the thrower's physical, mental and technical capabilities are at the highest level during the top-level competitions. Providing a javelin competition takes place in good weather conditions (air temperature, wind speed and direction) and is properly organized (top-level athletes, referees, prizes, good quality of the run-up area), javelin throw records can be set.

A number of authors [1, 3, 4] studied the sport aspect of javelin throw, i.e. development of the throwing technique aimed at achieving the maximum javelin flight distance. Ernst [1] focused on the mechanics of javelin throw and flight. Golińska [2] developed a complete mathematical model of javelin elastic flight in her analysis of javelin flight dynamics, using analytical mechanics equations [5, 6].

Frames of reference, coordinates and kinematic relations

The following frames of reference [2, 5–7] were used in the description of javelin movement, according to the Polish aviation standards (Fig. 1):

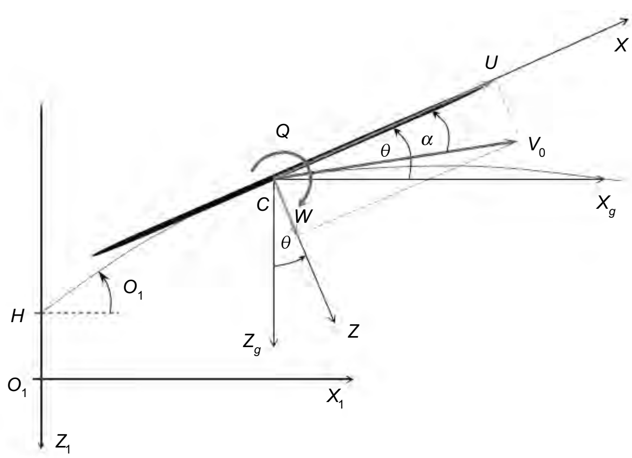

Figure 1. Frames of reference and coordinates of javelin throw

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$0_1x_1z_1$ – the Earth's reference frame (inertial),
Cx_gz_g – gravitational reference frame originating from the center of mass of the javelin *C*, parallel to the inertial frame of reference $0_1x_1z_1$,
Cxz – javelin reference frame originating from the center of mass of the javelin *C*, with the *x*-axis along the javelin axis, *y*-axis to the right and *z*-axis downwards.
V_0 – javelin center of mass velocity, tangent to the trajectory,
U, *W* – V_0 components relative to the *Cx* and *Cz* axis,
Q – downward pitching angular velocity,
θ – angle between the *Cx* axis and the Cx_g gravitational frame of reference,
α – angle of attack between the *Cx* javelin axis and the velocity vector,
m – javelin mass.

Fig. 1 demonstrates the following kinematic relations [2, 5, 6] for the javelin moving within the $0_1x_1z_1$ frame of reference.

Javelin linear velocity:

$$V_0{}^2 = U^2 + W^2 \tag{1}$$

$$\dot{x}_1 = U\cos\theta + W\sin\theta$$
$$\dot{z}_1 = -U\sin\theta + W\cos\theta \tag{2}$$

Angular velocity:

$$\dot{\theta} = Q \tag{3}$$

Angle of attack:

$$\alpha = arctan\,\frac{W}{U} \tag{4}$$

Density of air:

$$\rho = \rho_0\left(1 - \frac{H}{44300}\right)^{4,256} \tag{5}$$

$H = -z_1$ – height of javelin release above sea level,
ρ_0 – density of air at sea level.

Javelin elasticity

The flexural deformability of the javelin was taken into consideration using discretization by incorporating form I of free vibrations [2, 3, 8].

Deflection of the javelin element of mass:

$$z_g(t,x) = q(t)f(x) \tag{6}$$

Element of mass deflection velocity:

$$\dot{z}_g(t,x) = \dot{q}(t)f(x) \tag{7}$$

f(*x*) – deflection function,
m(*x*) – longitudinal javelin mass distribution,

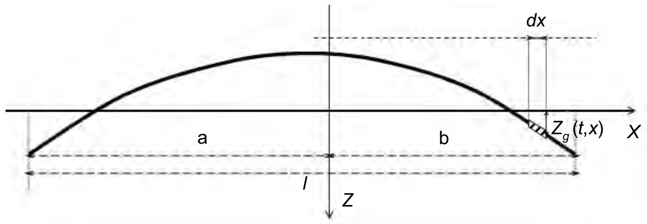

Figure 2. Flexural deformability of the javelin in form I of free vibrations

ω_g – frequency of transverse elastic vibrations of form I of free vibrations.

The following equations were obtained using derivations of Golińska [2] and Maryniak [6] (Fig. 2):

$$\int_0^l m(x)dx = m \qquad \int_0^l f^2(x)m(x)dx = a_1$$
$$\int_0^l x^2m(x)dx = J_y \qquad \int_0^l f(x)m(x)dx = a_2$$
$$\int_0^l xm(x)dx = S_x \qquad \int_0^l f(x)xm(x)dx = a_3 \tag{8}$$

Kinetic energy of the elastic javelin in quasi-velocities:

$$T^* = \tfrac{1}{2}U^2m + \tfrac{1}{2}W^2m + \tfrac{1}{2}Q^2J_{yc} -$$
$$WQS_x + \tfrac{1}{2}\dot{q}^2a_1 + W\dot{q}a_2 + Q\dot{q}a_3 \tag{9}$$

Potential energy of the javelin:

$$V_{zg} = \tfrac{1}{2}\omega_g^2q^2a_1 \tag{10}$$

General equations of javelin movement in the gravitational reference frame

The equations in the energy form included [2, 6, 8]:

$$\frac{d}{dt}\left(\frac{\partial T^*}{\partial U}\right) + \frac{\partial T^*}{\partial W}Q = Q_U^*$$
$$\frac{d}{dt}\left(\frac{\partial T^*}{\partial W}\right) + \frac{\partial T^*}{\partial U}Q = Q_w^*$$
$$\frac{d}{dt}\left(\frac{\partial T^*}{\partial Q}\right) + \frac{\partial T^*}{\partial U}W - \frac{\partial T^*}{\partial W}U = Q_Q^*$$
$$\frac{d}{dt}\left(\frac{\partial T^*}{\partial q}\right) - \frac{\partial T^*}{\partial q} + \frac{\partial V_{zg}}{\partial q}U = Q_q^* \tag{11}$$

Following the differentiation of kinetic (9) and potential (10) energy and matching them into the frame (11) the following system of differential equations was obtained:

$$m\dot{U} + mWQ - S_xQ^2 + a_2\dot{q}Q = Q_U^*$$
$$m\dot{W} + S_x\dot{Q} + a_2\ddot{q} - mUQ = Q_W^*$$
$$I_y\dot{Q} - S_x\dot{W} - a_3\ddot{q} + mUW + S_xUQ - a_2\dot{q}U = Q_Q^*$$
$$a_1\ddot{q} - a_2\dot{W} - a_3\dot{Q} + a_1q\omega_g^2 = Q_q^* \tag{12}$$

S_x – static moment (in the frame of the principal central axes $S_x = 0$);
J_y – moment of inertia [2, 8] (8).

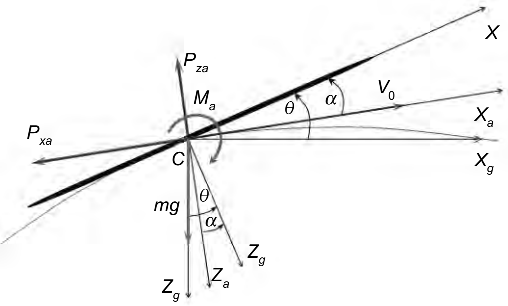

Figure 3. Distribution of forces affecting the javelin in flight

The right-hand sides of equations (11) were as follows [2, 8]:

$$Q_U^* = X_a + X_g + X_Q Q + X_{\dot q}\dot q$$
$$Q_W^* = Z_a + Z_g + Z_Q Q + Z_{\dot q}\dot q$$
$$Q_Q^* = M_a + M_g + M_Q Q + M_{\dot q}\dot q$$
$$Q_q^* = 0 \qquad (13)$$

X_a, Z_a, M_a – aerodynamic forces and moments,
X_g, Z_g, M_g – gravitational forces and moments,
X_Q, Z_Q, M_Q – aerodynamic derivatives of the downward pitching angular velocity Q [2, 5, 9],
X_q, Z_q, M_q – aerodynamic derivatives of elasticity [2, 6].

The following equations were obtained in consideration of relations of forces and moments of forces:

$$Q_U^* = -P_{xa}\cos\alpha + P_{za}\sin\alpha - mg\sin\theta -$$
$$-\frac{1}{2}\rho d V_0 Q \frac{\partial C_x}{\partial\alpha}\int_{-a}^{b} x dx + \frac{1}{2}\rho d V_0 \dot q \frac{\partial C_x}{\partial\alpha}\int_{-a}^{b} f(x)dx$$

$$Q_W^* = -P_{za}\cos\alpha - P_{xa}\sin\alpha + mg\sin\theta -$$
$$-\frac{1}{2}\rho d V_0 Q \frac{\partial C_z}{\partial\alpha}\int_{-a}^{b} x dx + \frac{1}{2}\rho d V_0 \dot q \frac{\partial C_z}{\partial\alpha}\int_{-a}^{b} f(x)dx$$

$$Q_Q^* = -x_A(P_{za}\cos\alpha + P_{xa}\sin\alpha) -$$
$$-\frac{1}{2}\rho d V_0 Q \frac{\partial C_z}{\partial\alpha}\int_{-a}^{b} x^2 dx + \frac{1}{2}\rho d V_0 \dot q \frac{\partial C_z}{\partial\alpha}\int_{-a}^{b} x f(x)dx \qquad (14)$$

After Golińska [2] and Maryniak [6] the aerodynamic forces took the following forms: (C_n = 1.15, C_t = 0.035):

$$P_{xa} = \frac{1}{2}\rho l d V^2 C_x = P_n \sin\alpha - P_t\cos\alpha =$$
$$= \frac{1}{2}\rho l d V^2 (C_n \sin^3\alpha + C_t\cos^3\alpha)$$
$$P_{za} = \frac{1}{2}\rho l d V^2 C_z = P_n \cos\alpha - P_t\sin\alpha =$$
$$= \frac{1}{2}\rho l d V^2 (C_n \sin^2\alpha\cos\alpha - C_t\sin\alpha\cos^2\alpha) \qquad (15)$$

d – maximum javelin diameter,
l – javelin length,
x_A – distance from the center of pressure to the center of mass of the javelin.

Numerical simulation of the javelin throw

The numerical simulation of javelin flight from the point of release to the point of landing was made for a thrower 1.8 m tall (athlete's body height with the throwing arm upwards) regardless of the athlete's sex. The javelin flight was assumed to be taking place in a windless environment of constant air density ρ = const.

The javelin was treated as a material system with four degrees of freedom: change of longitudinal velocity U, drift velocity W, downward pitching angle θ and form I of transverse elastic vibrations q.

The javelin must comply with the following requirements:

	Men	Women
Total weight (including the whipcord)	800 g	600 g
Minimum total length	260 cm	220 cm
Maximum total length	270 cm	230 cm
Minimum javelin head length	25 cm	25 cm
Maximum javelin head length	33 cm	33 cm
Javelin head weight	80 g	80 g
Minimum whipcord length	15 cm	14 cm
Maximum whipcord length	16 cm	15 cm
Minimum distance between the center of mass and the javelin point	90 cm	80 cm
Maximum distance between the center of mass and the javelin point	110 cm	95 cm
Minimum shaft diameter	25 mm	20 mm
Maximum shaft diameter	30 mm	25 mm

The dimensions of the selected javelin in the model were as follows:

Length l = 2.2 m
Mass m = 0.6 kg
Center of mass S_c = 0.95 m (measured from the head)

Maximum shaft diameter $d = 0.025$ m
Moments of inertia $J_z = 0.42$ kgm^2, $J_y = J_z = 0$

Fig. 4 presents the form of aerodynamic parameters of the javelin calculated following Maryniak's works [6, 8, 9].

Fig. 5 presents four javelin throws at a constant angle of 35 deg with different throwing velocities. The parameters of the first throw: throwing velocity $V_0 = 20$ m/s, flight distance $x = 43.98$ m, maximum flight height $H_{max} = 8.72$ m, landing time $t = 3.03$ s; second throw: $V_0 = 30$ m/s, $x = 90.21$ m, $H_{max} = 17.51$ m, $t = 4.27$ s; third throw: $V_0 = 35$ m/s, $x = 115.63$ m, $H_{max} = 22.91$ m, $t = 4.79$ s; fourth throw: $V_0 = 40$ m/s, $x = 139.88$ m, $H_{max} = 28.75$ m, $t = 3.63$ s.

Fig. 6 presents four throws with the throwing velocity of 25 m/s at different angles θ_0. For $\theta_0 = 20$ deg the flight distance was $x = 49.82$ m, maximum flight height $H_{max} = 5.3$ m, and landing time $t = 2.27$ s; for $\theta_0 = 25$ deg: $x = 57.56$ m, $H_{max} = 7.68$ m, $t = 2.78$ s; for $\theta_0 = 30$ deg: $x = 63.02$ m, $H_{max} = 10.09$ m, $t = 3.25$ s; for $\theta_0 = 35$ deg: $x = 67.1$ m, $H_{max} = 12.73$ m, $t = 3.69$ s.

Fig. 7 presents four throws with the throwing velocity of 30 m/s at different angles θ_0. For $\theta_0 = 20$ deg the flight distance was $x = 68.91$ m, maximum flight height $H_{max} = 7.29$ m, and landing time $t = 2.66$ s; for $\theta_0 = 25$ deg: $x = 78.9$ m, $H_{max} = 10.3$ m, $t = 3.23$ s; for $\theta_0 = 30$ deg: $x = 86.08$ m, $H_{max} = 13.76$ m, $t = 3.77$ s; for $\theta_0 = 35$ deg: $x = 90.35$ m, $H_{max} = 17.51$ m, $t = 4.28$ s.

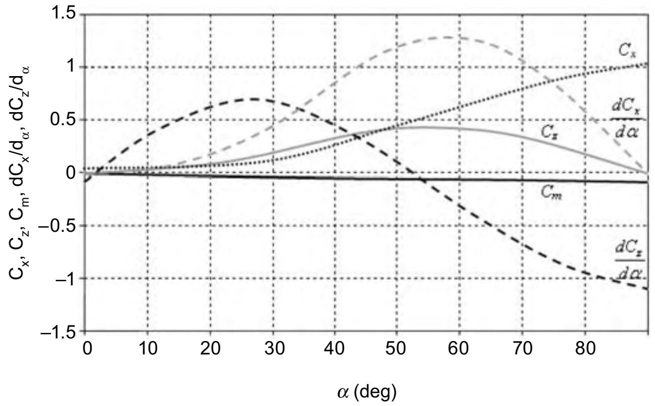

Figure 4. Non-dimensional aerodynamic parameters: drag C_x, lift C_z, downward pitching moment C_m, drag derivative $\frac{dC_x}{d\alpha}$ and lift derivative $\frac{dC_z}{d\alpha}$

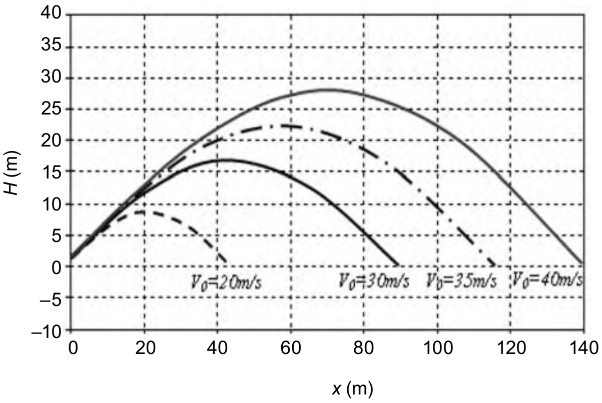

Figure 5. The height of javelin throw as a function of at velocity $\theta_0 = 35$ deg

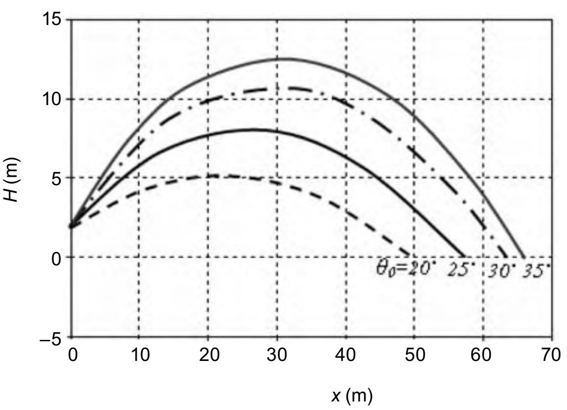

Figure 6. The height of javelin throw as a function of distance at a velocity of 25 m/s

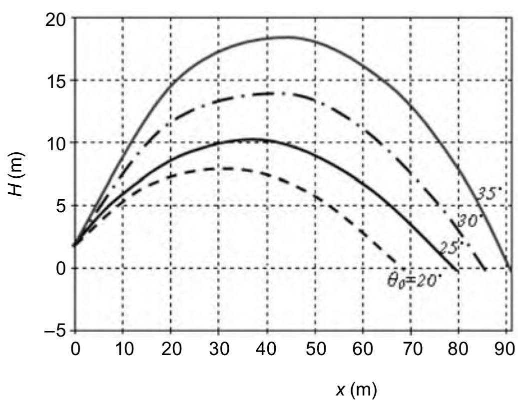

Figure 7. The height of javelin throw as a function of distance at a velocity of 30 m/s

Conclusions

The throwing angle significantly determined the javelin flight distance. There is an optimal range of javelin release angles depending on the initial velocity of the javelin, throwing force and wind direction, which ensures the attainment of optimal results. Throwing outside the optimal range reduces the javelin flight distance.

The mathematical simulation revealed that the optimal javelin throw was at the throwing angle of 35 deg and initial velocity of 40 m/s, which resulted in the flight distance of 141.88 m (Fig. 5). In practice, javelin throwers are often unable to achieve the initial velocity higher than 30–35 m/s, therefore the model presented remains only a theoretical optimum. Two throw cases revealed attainable javelin throw results:

1. Flight distance of 49.82–66.06 m at the initial velocity of 25 m/s and throwing angle between 20 and 35 deg (Fig. 6).
2. Flight distance of 68.91–90.35 m at the initial velocity of 35 m/s and throwing angle between 20 and 35 deg (Fig. 7).

The above results correspond to the results achieved by champion-level javelin throwers.

The impact of aerodynamic drag depends on the velocity of the moving javelin and its position in mid-flight. Thanks to its shape the javelin has specific aerodynamic properties, and the proper positioning of the javelin in mid-air can be useful in extending its flight distance. The javelin elastic vibrations are fairly insignificant and do not visibly affect the javelin trajectory and flight distance. In general, the throwing angle should be reduced in throws against the wind, since due to its aerodynamic properties the javelin reaches then a greater flight height. The position of the javelin in mid-flight is also significant. It should reduce the drag so the javelin can glide lightly with the optimal use of aerodynamic forces.

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RELATIONSHIP BETWEEN KNEE JOINT FLEXOR AND EXTENSOR TORQUES AND TISSUE COMPONENTS IN YOUNG MEN

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ABSTRACT
Purpose. The purpose of this work was to assess the relationship between muscle torques in the knee joint area and components of tissue composition by means of the bioelectrical impedance method. **Basic procedures.** 31 male subjects, aged 22–23, participated in the study. Basic morphological parameters, namely: body height (BH), body mass (BM) and somatotype were measured by the usage of Sheldon method modified by Heath and Carter. The body composition was examined using an BIA 101S apparatus by Akern. Torques of the knee joint extensors and flexors of both limbs were measured for joint angles 75° and 30°, respectively. In the statistical report cluster analysis was applied (k-means). Step regression was applied in order to evaluate the relationship between muscle torques and tissue components. **Main findings.** A significant correlation ($r = 0.42$ for $p \leq 0.01$) between the torques of the knee joint extensors and the entire content of lean body, its metabolically active components (BCM) and muscle mass was observed. Also, a high value of correlation coefficient between extensors and fat mass was noticed. Significant correlations between flexor torque and muscle mass, cell mass and lean body were observed. **Conclusions.** The results obtained enable us to conclude that the values of muscle torques are significantly connected with the level of development of the tissue components, thus its estimation may be based on the measurement of body components.

Key words: muscle torques, knee joint, body composition, students

Introduction

Force abilities are one of the indicators of men's functional abilities. From the biomechanical point of view force abilities in the best way describe measurements of muscle torques. Such parameters measured in the static or isokinetic conditions are frequently used for the needs of sports training [1–4] or in order to formulate norms for specific populations [5]. Taking measurements of torques requires a complex apparatus and can be carried out only in laboratory. Therefore, it seems appropriate to seek more available methods which allow these biomechanical parameters to be estimated, for example, in the screening of large populations. The relationship between the value of muscle torques and body mass, its components and somatotype were observed by many authors [6–8]. However, the published data concerning the relations mentioned above consider only some of the tissue components. What is more, the results obtained are based on group diversity in respect of physical activity.

The purpose of this work was to assess the relationship between muscle torques in the knee joint area and components of tissue composition. Those components were determined with the use of the BIA (bioelectrical impedance analysis) method which applies to four-element model of body composition.

Material and methods

31 male subjects, aged 22–23, participated in the study. The subjects were students of the Karkonosze College in Jelenia Góra. Basic morphological parameters, namely: body height (BH), body mass (BM) and somatotype were measured by the usage of Sheldon method modified by Heath and Carter. This method enables us to assess the level of development of three components: endomorphy, mesomorphy and ectomorphy. Endomorphy expresses fat deposition. Mesomorphy describes the development of muscles and bone massiveness. Ectomorphy considers body leanness. The body

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composition was examined by means of BIA 101S apparatus by Akern. The person being examined lied on his back. On the distal segments of the upper and lower extremities 4 disposable surface electrodes were placed. This method makes it possible to assess the amount of fat (FM) and fat-free body mass (FFM) and its components: body cell mass (BCM) and extra-cellular mass (ECM). Also, information on the amount of total body water (TBW) and its intra-cellular (ICW) and extra-cellular (ECW) fraction can be obtained. Additional software enables the muscle mass (MM) to be assessed.

The measurement of static torque of muscle was performed on a special measurement stand by OPIW. The subject was sitting on a special armchair. That position enabled the trunk and the tights to be stabilized. The knee joint extensor and flexor torques of both limbs (T_{exR}, T_{exL}, T_{flR}, T_{flL}) were measured for joint angles 75º and 30º, respectively. The measurement range was within 500 Nm, and the frequency of signal sampling was 500 Hz. The mean value of the right and left limb extensor torques ($T_{(exL + exR)/2}$) and flexor torques ($T_{(flL + flR)/2}$) was computed on the basis of measured values. The measured torques were added. The relative torques for the knee joints in relation to body mass were computed on the basis of the following formula: ($T_{flL} + T_{flR} + T_{exL} + T_{exR}$ /BM).

For all the parameters tested basic statistical values were assessed. In the statistical report cluster analysis was applied (k-means). The independent variables were torques of knee joint flexors and extensors. Intergroup diversity was determined by the usage of Student's t-test. Step regression was applied in order to evaluate the relationship between torques and tissue components. We used Pearson's correlation as a measure of the relationship between the variables of interest.

Results

Compared to the entire population, the subjects under examination are characterized by an average body height, with low intergroup variability of this feature. A slightly greater variability can be observed in relation to the body mass (Tab. 1) which results from heterogeneous specificity of this parameter. The greatest variability in the body mass components is observed in fat mass, which can be the result of poor genetic conditioning. The relative amount of fat slightly exceeds the range typical of male. The percentage amount of lean body develops at an average level, yet the amount of metabolically active cell mass relative to muscle mass is very high. The somatotype of the subjects being examined corresponds to mesomorphic type, with a balanced lower amount of ectomorphy and endomorphy.

The biomechanical parameters examined display quite visible intergroup differentiation, which results from the genetic and environmental conditioning. In order to create relatively consistent groups as regards the values of generated moments of force, k-clustering method was applied. It enabled us to distinguish two groups which significantly differ in these biomechanical parameters: I – stronger group, II – weaker group. In the case of the somatic structure, particularly, the tissue composition, intergroup differences are also visible. No significant differences are observed with reference to the body height, however, body mass reveals significantly greater values in the stronger group of men (I). Similarly, the comparison of absolute and relative contents of fat, lean body and water shows significant domination in the range of those features in the stronger group of subjects.

Considering the components of body build, a significant difference was observed only with reference to ectomorphy.

A significant correlation between the torques of the knee joint extensors and the entire content of lean body, its metabolically active components (BCM) and muscle mass was observed. Also, the value of correlation coefficient between extensors and fat mass was significant. Significant correlations between flexor torques and muscle mass, cell mass and lean body were observed (Fig. 1, Tab. 2).

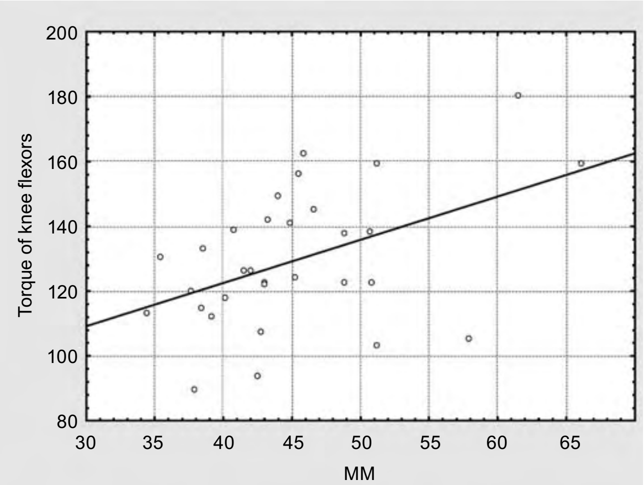

Figure 1. Correlation between muscle mass (MM) and knee joint flexor torques

Table 1. Statistical characteristics of the parameters examined in the entire group and in groups I and II

Variable	Entire group		Group I		Group II		Student's t-test
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	
BH (cm)	178.33	5.20	179.16	5.61	176.83	4.19	1.20
BM (kg)	74.79	8.42	77.58	8.11	69.73	6.62	**2.73**
FFM (kg)	59.94	5.05	61.28	5.00	57.52	4.37	**2.08**
TBW (kg)	43.88	3.70	44.85	3.67	42.12	3.20	**2.06**
ECW (kg)	15.83	1.91	15.99	1.86	15.55	2.05	0.61
BCM (kg)	37.69	6.49	38.63	6.69	36.00	6.03	1.08
FM (kg)	14.84	4.21	16.30	4.03	12.21	3.23	**2.88**
FM (%)	19.6	3.68	20.8	3.33	17.3	3.32	**2.77**
FFM (%)	80.4	3.68	79.2	3.33	82.7	3.32	**–2.77**
TBW (%)	58.9	2.69	58.0	2.43	60.5	2.43	**–2.75**
ECW (%)	36.1	3.51	35.7	3.54	36.9	3.49	–0.91
ICW (%)	63.9	3.51	64.3	3.54	63.1	3.49	0.91
BCM (%)	62.9	9.49	63.0	9.41	62.7	10.09	0.09
MM (kg)	45.20	7.23	46.29	7.45	43.21	6.68	1.13
MM (%)	60.8	9.21	59.9	8.94	62.3	9.93	–0.69
Endomorphy	2.32	0.92	2.52	0.95	1.97	0.78	1.63
Mezomorphy	4.31	0.84	4.38	0.87	4.19	0.82	0.58
Ectomorphy	2.47	0.81	2.24	0.83	2.90	0.59	**–2.30**
T_{exL} (Nm)	304.16	56.20	332.35	33.77	252.90	53.19	**5.09**
T_{exR} (Nm)	307.32	37.90	325.45	30.47	274.36	26.35	**4.67**
T_{flL} (Nm)	125.00	21.08	134.50	14.41	107.73	20.73	**4.22**
T_{flR} (Nm)	133.87	27.24	140.65	27.59	121.55	22.81	1.95
$T_{flL} + T_{flR} + T_{exL} + T_{exR}$ /BM (Nm/kg)	11.70	1.4	12.11	1.27	10.94	1.35	**2.40**
$T_{(exL + exR)/2}$ (Nm)	305.74	40.81	328.90	26.61	263.64	25.06	**6.66**
$T_{(flL + flR)/2}$ (Nm)	129.43	20.96	137.57	17.19	114.64	19.58	**3.38**
$T_{ex + fl}$ (Nm)	435.17	56.35	466.47	38.71	378.27	34.04	**6.32**

BH – body height, BM – body mass, FFM – fat-free body mass, TBW – total body water, ECW – extra-cellular body water, BCM – body cell mass, FM – fat mass, ICW – intra-cellular body water, MM – muscle mass, T_{exL} – torque of left limb extensors, T_{exR} – torque of right limb extensors, T_{flL} – torque of left limb flexors, T_{flR} – torque of right limb flexors, $T_{flL} + T_{flR} + T_{exL} + T_{exR}$ /BM – the relative torques for the knee joints in relation to body mass, $T_{(exL + exR)/2}$ – mean value of the torques of the left and right limb extensors, $T_{(flL + flR)/2}$ – mean value of the torques of the left and right limb flexors, $T_{ex + fl}$ – knee joint extensor and flexor torques

Table 2. Values of the correlation coefficient between body components and the torques of the knee joint flexors and extensors

	FFM	TBW	ECW	BCM	FM	MM
FFM	1.0000					
TBW	0.9999	1.0000				
ECW	0.5657	0.5661	1.0000			
BCM	0.4139	0.4136	–0.4856	1.0000		
FM	0.6467	0.6438	0.4222	0.1239	1.0000	
MM	0.4422	0.4419	–0.4569	0.9994	0.1422	1.0000
T_{ex}	0.4035	0.4006	–0.0380	0.4130	0.4184	0.4195
T_{fl}	0.2951	0.2920	–0.1471	0.4566	0.1656	0.4599

FFM – fat-free body mass, TBW – total body water, ECW – extra-cellular body water, BCM – body cell mass, FM – fat mass, MM – muscle mass, T_{ex} – torques of the knee joint extensors, T_{fl} – torques of the knee joint flexors

Step regression was conducted, as a result of which to the equation reflecting values of flexor torques only one variable was added, i.e. the muscle mass. The correlation coefficient for this equation is $r = 0.4599$, confidence level $p < 0.00923$, and the error of estimation equals 18.936. The equation is

$$T_{fl} = 69.19750 + 1.33270*MM$$

In the case of extensors, the regression comprises two steps, so the fat mass has been added to the equation. The correlation coefficient is $r = 0.5544$, $p < 0.00585$, and the error of estimation equals 35.157. The equation is

$$T_{ex} = 159.4149 + 2.0728*MM + 3.5451*FM.$$

Discussion

The comparison of torques of lower limb extensors and flexors leads to a conclusion that human muscles are partly shaped by the gravity field [9]. This manifests itself in the greater values of the knee joint flexor and extensor torques which function against the gravity field and over twice as small the value of the knee flexor torques. The results concerning the mutual relationships between the torques of these muscle groups confirm the conclusions reached by many authors [10–12]. However, the level of the torques developed in the students of the Karkonosze College is slightly lower compared to the values presented by other researchers [1, 13].

In the group under examination, there are students training various sport disciplines and this fact may justify this result (a topography of torques varies in different sport disciplines) [13, 14]. There was a great similarity in the values of body height and mass of students from the two groups compared, and therefore, the differences in the biomechanical parameters may be the effect of differentiation in the body composition of the persons examined. The students from the College were characterized by a significant content of fat (19.6%), which slightly exceeded values typical of males, particularly, sport groups [15, 16].

Using the k-means method, the students were divided into two groups with different torques, which allowed the authors to characterize the specificity of body build and composition in both groups. The first group (students with higher muscle torques) obviously dominates as regards absolute values of the tissue elements, because males from that group had significantly bigger body mass. However, the relative values of those components were really interesting. An unexpected difference in favour of group II regarding the content of lean body was observed. No significant intergroup differentiation with reference to relative cell mass was noticed, however, those components show slightly higher values in the group with lower values of torques. This means that the influence on the values of the biomechanical parameters of interest is due to the absolute amount of those tissues. In the range of the body build components, significant differences were observed with reference to ectomorphy. The value of this component is significantly higher in group II. Consequently, a thesis may be put forward that body leanness is not in favour of obtaining high values of torques, which fact was confirmed by Madej et al. [8].

The correlation coefficients between the amount of tissue elements and torques in flexors as well as extensors attain positive values. However, there should be noticed stronger relations of fat mass and lean body mass with extensor torques than with flexors. Probably, this may be justified by the function of extensors as the antigravity muscles, the main aim of which is to control an upright posture. The bigger the body weight, the higher the torque of the knee joint flexor must be released.

Applying the regression analysis allows us to estimate the influence of the tissue components examined on the value of the torques released. The muscle mass was chosen as the only significant parameter in the regression equation. The correlation coefficient for this equation is significant at $p = 0.01$. Similar results were obtained by Pietraszewska and Pietraszewski [17] during examination of football players. In the case of extensors, the fat mass is an additional variable. This result may seem quite surprising, however, it can be explained by the intercorrelations in the area of body components. A significant value of correlation coefficient between fat mass and lean mass was observed, which proves the coexistence of active tissue and fat in the students being examined.

Conclusions

The results obtained enable us to conclude that the values of torques are significantly connected with the level of development of some tissue components. Since the measurement apparatus applied to assess tissue components was less advanced and considering great mobility of such devices, the way of forecasting the knee joint torques developed based on the impedance method seems to be useful for preliminary assessment of the aforementioned biomechanical parameters, however, it may be connected with a substantial estimation error.

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MAXIMAL GRIP FORCE DURING HOLDING A CYLINDRICAL HANDLE WITH DIFFERENT DIAMETERS

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ABSTRACT
Purpose. The purpose of the study was to estimate the effects of cylindrical handle diameter and handle position on maximal grip force in young males and females. **Basic procedures.** The maximal voluntary grip force perpendicular to the surface of the handle was estimated using a glove with 320 sensors (Tekscan, USA – GripTM System). Individual digit and palm forces were studied. Different handle diameters (20, 30, 40 and 50 mm) and handle positions (vertical, natural – vertical handle with 12 deg of ulnar deviation of the hand, and horizontal) were applied during measurement. **Main findings.** Using handles and hand tools frequently leads to the feeling of discomfort in daily life. In a longer term, using improper handles and hand tools may also cause musculoskeletal disorders. Poor wrist positioning and handle diameter can diminish grip strength. The ideal diameter and wrist position during holding a tool handle was determined for males and females using maximal grip strength measurements. The obtained results showed that a tool handle diameter of 20 to 30 mm is optimal for the general population. Further research should be carried out to estimate the impact of wrist positioning in the elderly. **Conclusions.** The handle positioning is not a significant factor influencing hand grip force capabilities for young men and women. The grip force of three digits did not significantly vary for different handle positions used in the study. The optimal handle diameter for maximal grip force was estimated to be between 20 and 30 mm, and the diameter was larger for men. On the basis of results for individual digits the 30 mm diameter was chosen as optimal for both sexes.

Key words: hand, grip force, cylindrical handle, finger force

Introduction

The human hand plays a crucial role in the process of interaction with the outside world. The hand develops strength in contact with objects and stabilizes them in space [1]. In 1962 Landsmeer [2] made a distinction between power grip and precision grip, indicating differences in the hand functions resulting from the areas of the hand involved in prehensile movements. He observed that the basic difference between the two types of grips lies in the positioning of fingertips against the thumb and the palm: in the precision grip the fingertips are positioned opposite the thumb, and in power grip opposite the palm. Both types of grip were later compared numerous times from the standpoint of hand biomechanics. Chao et al. [3] and Cooney and Chao [4] showed that a strong pincer grip overloads forearm tendons more that a power grip. On the other hand, Armstrong [5] revealed a correlation between the tension of long sinews of fingers and the hand grip diameter. A greater tension was noted during gripping handles of both large and small diameters. Therefore, optimization of the handle diameter becomes important to minimize the tension in the tendons. The results of numerous studies show that elderly people with weakened hand function due to degenerative joint disease, decreased strength of finger flexors and tendon elasticity have problems with opening bottles and cardboard boxes [6–8]. Peebles and Norris [9] noted that grip force in all age groups can be affected by the handle diameter, position and movement direction. The aim of this study was to determine the maximal strength capabilities of the hand, regarding the grip handle diameter and position, among young men and women. The results of the study will be regarded as future reference frames in research of elderly subjects by the Institute of Industrial Design in Warsaw.

Material and methods

The study sample consisted of 48 men and 46 women aged 21–24 years. The subjects' mean body weight and

* Corresponding author.

height values are presented in Tab. 1. Before the measurements each subject gave his or her written consent to participate in the examination. The study was given approval of the Ethics Committee of the Józef Piłsudski University of Physical Education in Warsaw.

Table 1. Mean values (± SD) of subjects' basic anthropometric indices

Sex	Age (years)	Body weight (kg)	Body height (cm)
Women	21.3 ± 0.2	56.5 ± 3.3	163.4 ± 2.7
Men	21.5 ± 0.1	79.5 ± 2.4	182.5 ± 2.7

Figure 1. Tekscan 4255N grip measurement system before (A) and after (B) mounting on a glove

The Tekscan grip measurement system (Fig. 1) was used to assess the force of palm and fingers. The multiple sensing areas of the system could be individually positioned on different parts of the hand. The total hand grip force was measured by 320 resistive sensors located in twenty 2 × 2 cm sensing regions of the glove. Thirteen sensing areas were placed on the phalanges of the hand, and the remaining ones on the palm (Fig. 1).

Before the measurements the measurement chain of each new glove was scaled and calibrated. The glove was also recalibrated before each new measurement. Each subject was then properly positioned and the elements of the measurement system were placed. Each subject was sitting with the glove arm perpendicular to the ground placed on the armrest. The subject's glove (Fig. 1) was connected to a terminal which transferred the signal to a PC data card. The maximal voluntary grip force on the cylindrical handle was estimated. The handle was set in three positions and two planes: A – hand perpendicular to the ground and the forearm, in the sagittal plane; B – hand at the natural angle from the forearm (estimated with anthropological tests of hand strength) in the sagittal plane; C – hand at the natural angle from the forearm in the transverse plane.

For each handle position grip measurements were carried out for handles with four different diameters: 50, 40, 30 and 20 mm. The signal from the sensors was sampled with the frequency of 500 Hz within five seconds. After three minutes, a handle with a different diameter was used. The measurements were repeated in the same way for all four handle diameters. The grip force measured at each sensor was recorded in real time (time function), with the force direction perpendicular to the area of contact between the hand and the sensor. The maximal grip force was recorded as a total of values registered by the 320 sensors. Then the values of grip forces of the fingers and the palm were analyzed. To eliminate the impact of other forces tangent to the handle surface the handles were mounted in such a way as to allow translation and rotation along the handle axis. This way the accuracy of the measuring gloves was greatly improved. For the measurement chain the error of the grip system with sensors was set.

With the use of ordinary least squares the actual processing properties of the measurement chain were determined. The sensors were loaded with a standard load of ascending and descending value. The error of the measurement chain was lower than 2%. To set the error of measurement method a series of grip force tests were performed on the grip system using different cylindrical handles. The results revealed the measurement error between 10 and 20%, mostly due to the specificity of the human nervous system.

Results

The mean values of total hand grip force are presented in Tab. 2. In both sex groups grip force was strongly correlated with the handle diameter and in both groups significantly lower values were obtained with handles of 40 and 50 mm in diameter than with a handle of 20 mm in diameter (Tab. 2). For the diameter of 30 mm the observed differences were not clear. Among the women the grip force values for the diameter of 30 mm were 4.2% (maximally) lower than the values with the smallest handle, and were not correlated with the handle position. Only in the group of men did the handle position affect the grip force. In two cases the grip force values for the 30 mm handle were higher than the results for the smallest handle diameter (Fig. 2).

The obtained results were analyzed statistically with the use of ANOVA with regard to three main factors: subject's sex, handle position (A, B, C) and handle di-

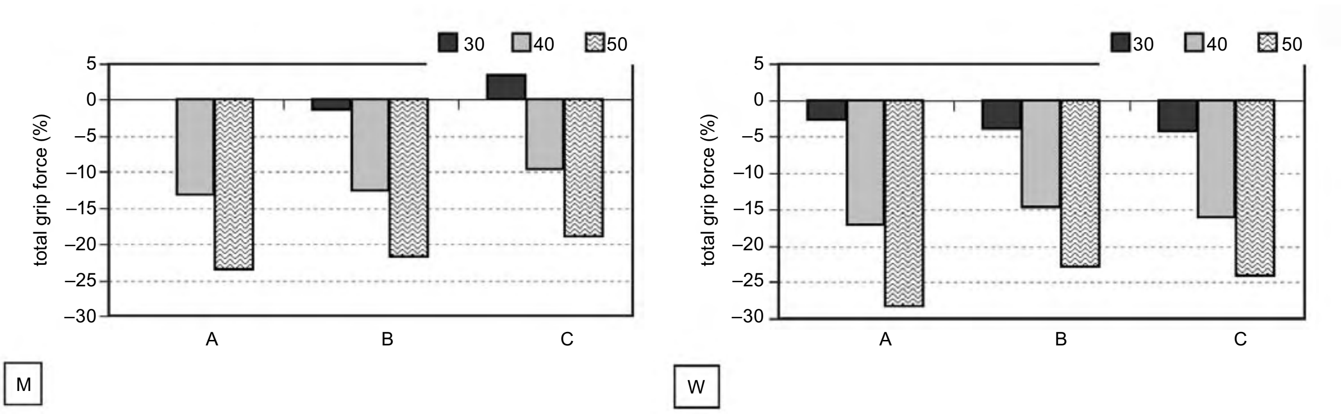

Figure 2. Percentage differences between total grip force for diameters of 30, 40 and 50 mm and grip force for handle diameter of 20 mm for three handle positions (A, B, C) in the group of women (W) and men (M)

Table 2. Mean, standard deviation (SD), minimal (Min.) and maximal (Max.) grip force during holding a cylindrical handle regarding the handle position (A, B, C) and diameter (20, 30, 40 and 50 mm)

Sex	Position	Diameter (mm)	Mean (*n*)	SD (*n*)	Min. (*n*)	Max. (*n*)
Men	A	20	117.00	26.44	81.03	214.07
	A	30	117.05	26.16	72.33	209.05
	A	40	101.60[a]	22.48	62.05	165.12
	A	50	89.48[b]	19.23	52.25	144.83
	B	20	113.79	28.94	72.72	223.46
	B	30	112.20	29.31	60.84	212.69
	B	40	99.56[c]	25.75	57.34	171.30
	B	50	89.04[d]	22.79	49.19	153.62
	C	20	104.42	20.32	69.54	170.10
	C	30	108.02	28.09	62.34	197.64
	C	40	94.45[e]	24.88	45.40	151.98
	C	50	84.71[f]	21.73	48.47	141.20
Women	A	20	99.41	22.01	62.11	165.28
	A	30	96.78	21.03	51.93	157.20
	A	40	82.36[g]	18.81	46.92	149.60
	A	50	71.37[h]	19.40	34.19	136.73
	B	20	97.05	22.10	54.97	150.56
	B	30	93.30	21.39	51.32	144.72
	B	40	82.76[i]	19.76	40.05	137.04
	B	50	74.90[j]	18.88	40.94	138.75
	C	20	95.65	21.55	60.05	161.33
	C	30	91.55	20.74	52.87	148.79
	C	40	80.28[k]	19.27	42.99	140.86
	C	50	72.56[l]	18.39	40.06	119.00

The level of statistical significance for force values higher than values for the smallest handle diameter: [a] $p < 0.02$, [b] $p < 0.001$, [c] $p < 0.02$, [d] $p < 0.001$, [e] $p < 0.05$, [f] $p < 0.001$, [g] $p < 0.02$, [h] $p < 0.001$, [i] $p < 0.05$, [j] $p < 0.001$, [k] $p < 0.05$, [l] $p < 0.001$

ameter (20, 30, 40 and 50 mm). The effects of each main factor on grip force was confirmed (sex – F = 138.67, p = 0.001; handle position – F = 5.56, p = 0.002; handle diameter – F = 70.23, p = 0.001). No significant correlations between the factors were revealed.

The results obtained by men and women turned out to be statistically related only to the factor of handle diameter.

The grip measurement system allowed identification and analysis of the grip force of the palm and its individual fingers. Tab. 3 presents percent differences of grip forces while holding a cylindrical handle with reference to the smallest handle diameter. In the case of three fingers: the thumb, index finger and middle finger, no significant correlation between the handle position and grip force results was noted. No significant correlation between the subject's sex and the thumb force was revealed either. The thumb was the only hand part to display an inverse correlation of grip force and the handle diameter. Regardless of the handle position angle and subject's sex the highest results of the thumb grip force were attained for the handle diameter of 50 mm.

Discussion

The human hand grip force is commonly assessed using hydraulic or tensometric hand dynamometers, and is typical of double-handled tools such as a pair of tongs. The existing data fail to indicate an optimal handle diameter generating the maximal hand grip force. In studies using hand dynamometers the greatest force was obtained for the handle diameter of 6.03 cm [10] and 4.76 cm [11]. In the case of cylindrical grip the handle diameter is much smaller. Edgren et al. [5] obtained the highest grip force values for the handle diameter of 3.8 cm. It must, however, be noted that the measured total grip force consisted of two components perpendicular to each other. The results of Edgren et al. [5] also show that the tangent component of force reduces the total force most significantly for small handle diameters (2.5 cm and 3.8 cm). The perpendicular component of force was more significantly correlated with the handle diameter. However, a non-significant difference was revealed between the handle diameters of 2.5 cm and 3.8 cm. In the present study similar observations were made for handle diameters of 2 and 3 cm. Like in

Table 3. Percentage grip force differences for handle diameters of 30, 40 and 50 mm for individual fingers with reference to the results for the handle diameter of 20 mm

		Men			Women		
		Handle position			Handle position		
Finger	Handle diameter	A	B	C	A	B	C
Hand	30	–3.8	–4.6	–2.9	–6.1	–6.7	–9.6
	40	–19.6	–16.4	–20.3	–25.1	–25.6	–27.5
	50	–34.3	–31.1	–32.4	–41.6	–36.0	–38.8
Thumb	30	27.9	15.3	9.0	32.1	17.7	–0.3
	40	31.3	15.7	0	44.5	31.6	–0.5
	50	65.6	52.2	26.8	82.8	69.7	26.4
Index finger	30	3.8	–0.1	9.7	–1.6	–5.0	–1.3
	40	–10.6	–16.6	–4.5	–16.4	–17.0	–12.7
	50	–24.5	–26.4	–18.4	–26.8	–26.1	–22.7
Middle finger	30	1.1	–1.4	4.6	–0.9	–2.4	–2.4
	40	–9.6	–9.6	–6.8	–14.4	–12.2	–11.2
	50	–20.5	–21.2	–15.6	–28.3	–24.1	–21.4
Ring finger	30	–0.2	4.3	12.2	–4.5	–4.9	1.9
	40	–11.1	–4.3	2.8	–17.5	–16.0	–6.4
	50	–24.4	–16.8	–7.8	–34.1	–26.1	–19.7
Little finger	30	–17.0	–19.7	–12.5	–21.9	–21.3	–17.7
	40	–35.1	–32.9	–28.2	–40.9	–36.4	–32.8
	50	–50.0	–43.5	–40.3	–57.4	–48.1	–40.5

Edgren et al. [5] a significant reduction of the grip force for handle diameters larger than 4 cm was observed. Sancho-Bru et al. [12] using their hand model indicated a handle diameter of 3.3 cm as optimal for both sexes. Irwin and Radwin [13] in their study of hand grip force for handle diameters of 2.54, 3.81, 5.08, 6.35 and 7.62 cm used a simple biomechanical model to determine the tension of tendons of long finger muscles. Their simulation revealed a 130% increase in tendon tension and 36% of decrease of grip force between the smallest and the largest handle diameters.

Conclusions

The handle position does not affect the hand grip force in men and women. In the case of three fingers the handle position had no significant effect on the grip force. An optimal handle diameter to develop the maximal hand grip force is between 20 and 30 cm and is larger for men. The measurement results of grip force of individual fingers point to the diameter of 30 mm as optimal for both sexes. The obtained results with the optimal handle diameter for the index finger, middle finger and ring finger are the highest in men and 5% lower in women.

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THE USE OF BIOMECHANICS IN TEACHING AIKIDO

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ABSTRACT
Purpose. This paper aims to examine how the knowledge of biomechanics, specifically of mechanics principles used in teaching aikido techniques, affects the precision of aikido movements execution. It also aims to answer the question whether secondary-school teaching of solid-state mechanics, using examples from aikido and other sports, improves the learning outcomes. **Basic procedures.** The experiment involved 60 second- and third-form secondary-school students, divided into two groups: F (n = 27) and E (n = 33). The research on the understanding of mechanics principles was based on the results of a written test. Group F (experimental group) had been taught the principles of rotation mechanics, using examples from aikido and other sports, as opposed to group E (control group). Surprise tests were applied to assess the understanding of mechanics rather than retrieving of definitions learned by heart. The experimental group took a written test to assess their understanding of aikido mechanics. Over the period of one month the students in this group had been taught four selected aikido techniques. Using a ten-point grading scale the precision of execution of aikido techniques was evaluated. **Main findings.** Student's t-test and regression analysis were used for statistical analysis. A statistically significant difference was found between the aikido-enhanced and the conventional ways of teaching solid-state mechanics: the experimental group attained much higher test results than the control group. There was a strong correlation between understanding aikido mechanics and the performance of aikido techniques. **Conclusions.** Understanding aikido mechanics improves the performance of aikido techniques. Teaching solid-state mechanics, using examples from aikido and other sports, is more effective than teaching physics in the conventional way.

Key words: biomechanics, teaching, aikido

Introduction

The following article is a continuation of my earlier studies concerning combining knowledge from PE classes and teaching physics [1]. The results obtained had pointed to a significant improvement of the secondary school students' understanding of the principles of mechanics taught during physics classes when using examples from PE classes. The observations of mechanical movement performance of students during their PE classes were used in teaching physics. For example, a shot putting exercise was used to demonstrate that students who understood the mechanics of the particular sport, significantly increased their putting range, after having changed their putting technique. It was also observed that understanding the principles of mechanics could be very useful in extracurricular forms of physical activity. The research conducted showed that teaching aikido techniques was more effective if their dynamics was explained using principles of mechanics [1, 2]. The aim of the following study was to assess whether the level of knowledge about principles of mechanics in aikido affects the precision of execution of aikido techniques. The other research question was whether teaching solid-state mechanics using examples from aikido and other sports could increase teaching effectiveness.

Material and methods

The samples for the study consisted of two groups of secondary school students from the city of Koło. All subjects had participated in similar studies in the school year 2000/2001, when they were in the first grade [1]. The two study groups were in fact two school classes E and F. Group E (control group) comprised 33 students, and group F (experimental group) included 27 students. In the first semester of the school year 2001/2002 group F (second secondary school grade) practiced aikido one hour a week. Solid-state mechanics is part of physics curriculum in the third grade of secondary-school, after students acquire sufficient mathematical skills in their lower grades. Before the commencement of the mechanics course in the school year 2002/2003 students had to pass a physics revision test covering material from the first grade, i.e. translational mechanics (Test 1). Solid-state mechanics was taught in class E in the traditional way, whereas students from class F used their experiences and examples from aikido and other sports, e.g. by analyzing mechanical movements during diving, sports gymnastics, dancing, figure skating, etc. Both groups then took a final test to assess their learning outcomes. Both tests (1 and 2) were surprise tests and were carried out some time after the last class to ensure assessment of students' understanding of the mechanics principles, and not merely their memorizing skills.

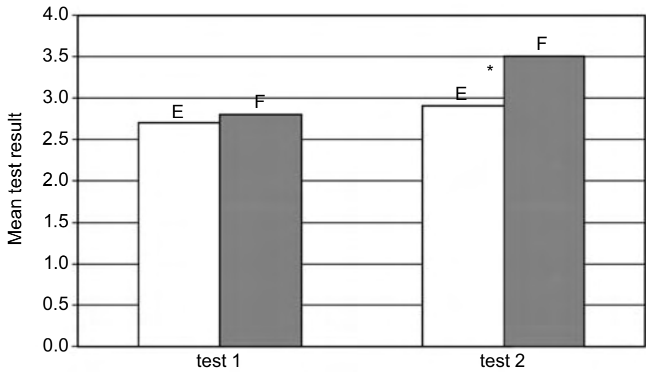
In the experimental group the dynamics of aikido techniques was taught using principles of biomechanics, i.e. mechanics principles of human movement. In the description of human movement the human body is divided into 14 parts treated as solids [3]. The classes focused mostly on the solid-state rotational mechanics. The basic principles of mechanics in aikido techniques were the subject of my earlier study [2]. The students taking the mechanics classes were informed about the advantages of reducing the radius of performed movements, the distance between the arms and the axis of rotation, or of lowering or optimal shifting the body's center of gravity. The principles of aikido such as "yield to win", "turn around if you're pushed" or "move forward if you're pulled" were explained to the students using the law of momentum conservation, second law of motion for angular motion, centrifugal force and composition of resultant forces and moments of force [2, 4].

The students' knowledge of biomechanics for aikido was tested in an essay form. After writing their essays the students got acquainted with four selected aikido techniques during one month. Then the precision of performance of each technique was assessed using a ten-point scale. Each subject could score up to 40 points. The method of evaluation of aikido technique performance was taken from the Koichi Tohei aikido school[1]. As sports rivalry does not apply in aikido practitioners are evaluated on their performance of *taigi*, i.e. sets of techniques executed in response to a particular attack [4, 5]. Both the precision and speed of movements are evaluated. During the study only the precision of movement sequences performed by a practitioner was assessed. The precision criteria included an appropriate reduction of the radius of motion, assuming proper body posture, arms movement and shifting the body's center of gravity at a given movement.

Before learning the selected techniques the students taking part in the test had already acquired basic aikido skills, i.e. safe falls [6], body turns and rotations. The assumed method of instruction was "from the general to the specific" [4]. First, general rules of technique execution were explained, followed by a detailed analysis of particular movement sequences in a given technique. Student's t-test for independent variables and regression analysis were used in statistical analysis.

Results

The effects of the mean results of the written tests in both groups were assessed using Student's t-test for independent variables. No statistically significant differences were observed between group E and group F in test 1, but not in test 2 ($p < 0.05$) (Fig. 1), where group F attained a much higher mean result than group E.



* statistically significant difference between the groups in test 2, at $p < 0.05$

Figure 1. The mean results of mechanics tests taken by students from group E (taught in the conventional way) ($n = 33$) and from group F (taught using examples from aikido and other sports) ($n = 27$)

The obtained Student's t-test results were confirmed by results of non-parametric U-Mann Whitney test. The analysis of regression was used to examine the correlation between the correctness of biomechanics test answers and precision of performance of aikido techniques. A strong correlation was noted between the two at $r = 0.9$.

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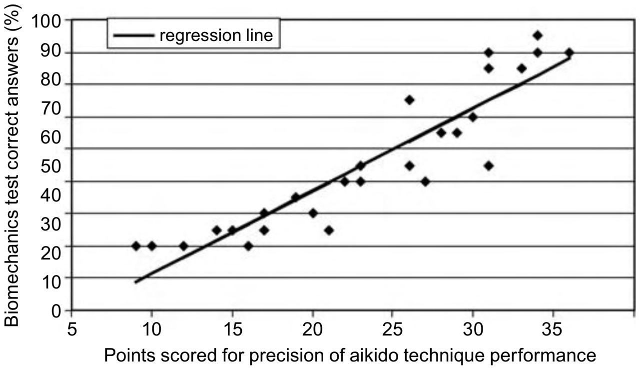

Figure 2. Correlation between results of the biomechanics tests and points for precision of performance of aikido techniques in group F (n = 27). Equation of the regression line: $y = -4.10 + 2.56\ x$, $r = 0.9$

Discussion

There was no statistically significant difference between the two groups of students (E and F) in terms of their results of mechanics tests in the school year 2000/2001 [1]. This was confirmed by the results of the written test taken by the students before the start of the solid-state mechanics course (test 1). It shows that both groups had similar conditions for learning the mechanics material. A new method of teaching solid-state mechanics significantly affected the differences between the results of solid-state mechanics learning attained by both groups of students. In a traditional physics class the teacher demonstrates first the mathematical equation of a law of physics and then carries out an experiment illustrating the theory. In the author's opinion the main factor affecting the results in group F was students' participation in aikido classes, during which aikido techniques were explained using the principles of mechanics. The students' participation in aikido classes could facilitate their understanding of mechanics principles, following the educational rule of affecting as many student's senses as possible [7]. The PE classes as well as other forms of extraschool physical activity allowed more active contribution of other senses – including somatic ones – to the learning process, than hearing and sight only. The results obtained correspond to my earlier conclusions that learning the laws of mechanics by school students could be greatly facilitated by the use of examples from sport and other extracurricular physical activities [1].

The results confirm that the knowledge of biomechanics in teaching aikido techniques affects the precision of performance of a given technique (Fig. 2). The term "aikido technique" must, however, be precisely defined. There are multiple definitions of "sport technique" in professional literature. Bober [8] in his analysis of definitions of sports technique follows Zatsiorsky [9], who thinks sport technique is a term which can be described rather than defined. In my opinion the term aikido technique refers to a way of neutralizing a specific attack and simultaneous execution of a specific motor task. Neutralizing can be made by (1) locking, (2) throwing or (3) a combination of both [10]. The neutralizing technique differs with regard to the type of attack. The study revealed a strong correlation between the learnt knowledge of biomechanics and the number of points scored for execution of aikido techniques. Similar results had been attained during teaching shot putting techniques [1]. The putting distance increased in students who had learnt about the mechanics of this particular field event.

The study can be confirmed by Bober and Zawadzki [11], who observed that the concepts of motor learning refer to the learner's task awareness and understanding during learning a specific motor pattern. Not only then does reproduction of motor patterns practiced earlier become easier, but also creation of new ones. The examples of applying knowledge of the principles of mechanics in aikido or shot put training point to the need to use biomechanical knowledge in teaching all sports or physical recreation. In my opinion this knowledge is not always effectively used by physical education teachers. Carrying out a thorough biomechanical analysis of sports techniques during PE classes, rather than giving mere instructions to students seems reasonable. Teaching an infinite number of movement sequences requires the knowledge of laws of translation and rotation [2]. The teacher's role is to know these laws as they can be very useful in students' learning of specific motor tasks.

Conclusions

1. Understanding the principles of mechanics during execution of aikido techniques increases the precision of their performance.

2. Teaching solid-state mechanics using examples from aikido and other sports is more effective than the conventional methods of physics teaching.

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THE SIGNIFICANCE OF ENVIRONMENTAL FACTORS FOR PHYSICAL DEVELOPMENT OF ADOLESCENTS*

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ABSTRACT
Purpose. The aim of the study was to determine the influence of environmental factors on the physical development of girls and boys at puberty. **Basic procedure.** The sample of adolescents of both sexes was studied using comprehensive measuring data and information from surveys. To examine correlations between quantitative and qualitative data the factor analysis was used (one-dimensional test F for every variable). **Main findings.** The biological indices of social stratification of adolescents under study were the results of medicine ball throw test and maximal anaerobic power (MAP). The MAP was calculated using results of the standing broad jump test. The highest level of physical development was noted among the group of students with the best environmental conditions. The majority of subjects with a high level of physical development came from families with a single child and with monthly net income per person from 301 to 500 PLN and more. Their parents had at least a secondary education and were either white-collar or blue-collar workers. **Conclusions.** To enhance physical fitness of young people the pre-pubescence period should be used better. During the pubescence period children should have every opportunity to take part in various extra curricular classes during the school year. In addition, appropriate conditions for active leisure pursuits (during summer or winter holidays) should be created for children to develop their physical recreation interests.

Key words: environmental differences, puberty, motor abilities

Introduction

Social diversification has been widely accepted as a factor determining the children's and adolescents' level and speed of development by a number of anthropologists in Poland and abroad [1–3]. The factors affecting physical development include nutrition, migrations, place of residence, socio-economic status and lifestyle. The current, often dynamic, social, economic and cultural transformations have a great impact on the kinetics and dynamics of biological development and health state of different human communities.

The motor development of children and youth depends to a large degree on the processes of growth and pubescence [4, 5]. It is assumed that differences in terms of the pace of development of basic somatic parameters generate significant differences in the levels of development of motor skills. It has been well-known that the development of somatic traits takes place in a specific order and is correlated with puberty. A number of studies show that the basic motor skills are developed in sequence as well. Most children reach the optimal level of their skills at pubescence [6–8].

Polish authors have commonly sought the causes of diversification of physical development in the socio-economic situation of young people's families and, in particular, in their lifestyle. According to Drabik [9] and Sławińska [10] one of the major environmental stimulators of physical development is physical activity regarded as an important lifestyle component. In modern times, nature and ecological values of rural areas themselves fail to make a serious improvement of life quality, and are not regarded anymore as significant positive indicators of health and population development.

The aim of the study was to determine the significance of socio-economic status and family lifestyle for physical development of adolescents at puberty. The effects of the environment are multidirectional, depending, for instance, on the range of the body's response, i.e. its genetically determined sensitivity to environmental factors. According to Wolański [11] faster development can cause an easier divergence from the former course of de-

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velopment, i.e. children may become less alike their parents. Thus the question remains: what is the gradation of environmental variables in view of their different influences on rural and urban adolescents?

Material and methods

The study was carried out in the spring of 2001 in primary and middle schools of the Przeworsk District in the Podkarpackie Province of Poland. There are 45 cities and 2.166 villages in the Province, divided into 21 districts, 160 communes and 1.532 seats of village council chair (the smallest administrative units in Poland) [12]. The subjects were boys aged 12–15 years and girls aged 11–14 attending different primary and middle school grades. The subjects were selected at random from specific schools. The measurements took place in the morning.

The results of 30.7% of adolescent population from the Przeworsk district were used in the analysis. The sample was divided into two groups: urban and rural (Tab. 1). The tests of the urban population of students were conducted in chosen schools in the towns of Przeworsk, Kańczuga and Sieniawa; all the urban students lived with their parents. The examination of the rural population was carried out in twelve schools in rural areas of the district.

Table 1. Number of subjects from urban and rural areas

Area of residence	Sex	Age (years)					
		11	12	13	14	15	Total
Urban	♂	–	146	112	66	76	400
	♀	115	117	141	77	–	450
Rural	♂	–	159	119	164	194	636
	♀	162	127	128	148	–	565
							2051

To ensure the most optimal evaluation of subjects' physical development 17 somatic traits were measured and nine common fitness tests were carried out. The choice of tests was made in consideration of facilities available in different schools. The flamingo balance tests and plate tapping tests were modified following the simplified measuring procedures introduced by Szopa [13], included in the Żak test of relative assessment of physical fitness. The fitness tests were performed in the following sequence:

1. *Flamingo balance test* – (static balance) on the preferred foot, maintaining balance on a 4 × 3 × 50 cm beam; the best result out of five attempts was recorded with the accuracy of 0.1 s.
2. *Plate tapping test* (speed of arm movement) – measuring the time of 15 cycles in two attempts.
3. *Sit and reach test* (flexibility) – following EUROFIT guidelines [14].
4. *Standing broad jump* (explosive strength of legs) – following EUROFIT guidelines; using the body weight and the result of the jump test the maximal anaerobic power (MAP) was calculated for each subject, according to the formula:

$$\text{MAP} = m \cdot h \cdot g$$

m – body weight (kg),
h – standing broad jump test result (m),
g – gravitational acceleration (J).

The MAP is, according to Januszewski [15], more useful for general assessment of physical development than the absolute score of the jump test.

5. *Hand grip test* (static strength of forearms) using DRP 30 and DRP 90 hand dynamometers, following EUROFIT guidelines, in arbitrary units per kilogram of lean body mass.
6. *Sit-ups* (abdominal muscular endurance), maximum number of sit-ups achievable in 30 s.
7. *Overhead medicine ball (2kg) throw backward* (explosive strength of arms and trunk), the best score in two attempts.
8. *10 × 5 m shuttle run* (running speed, agility) – following EUROFIT guidelines.
9. *Burpee test* (speed endurance) – a cycle of repetitions, each consisting of four stages: standing erect, clapping hands overhead – start measuring the time – squat position, thrusting the legs back, returning to the squat position, returning to the standing position. The subjects performed as many repetitions in 30 s as possible. The choice of the Burpee test rather than a regular running test for evaluation of endurance may seem disputable, but it was relatively easy to apply in different schools.

The measurements were completed with data on the subjects' living conditions. The students' parents received anonymous questionnaires on the family's socio-economic situation and lifestyle[1]. The questionnaire

[1] The questionnaire used in the present study was developed after consultations with the faculty of the Chair of Anthropology and Anatomy of the University School of Physical Education in Cracow and gaining approval by the Faculty Council.

contained 14 items: parents' age at their child's birth, parents' place of birth and residence until 18 years of age, education, occupation, farmstead size, number of children in the family, number of family members per one working person, number of people living in one room, net income per person, interests, health state, physical activity, child's active leisure pursuits and others.

The obtained questionnaire data was used to set up categories of socio-economic status and family lifestyle. The scores of fitness tests were presented according to the subjects' sex and place of residence in the selected categories of environmental factors. Factor analysis was used for interpretation of correlations between qualitative and quantitative data. The results of univariant F-test for each variable became the basis for further interpretation.

Results

The mean scores of medicine ball throw tests assessing the explosive strength of the arms and trunk, revealed the most numerous significant correlations with the indices of family's socio-economic status and lifestyle (Tab. 2, 3). Fewer such correlations were noted for the MAP, flexibility and abdominal muscular endurance tests. Additionally, significant correlations were found between the flamingo test and shuttle run test results and the environmental variables under study, in urban boys. In urban girls, the shuttle run, Burpee and plate tapping scores were frequently correlated with the indices of socio-economic status and family lifestyle; whereas in rural girls such correlations were only found between the environmental factors and the flamingo balance test results.

Table 2. One-dimensional F-test values representing correlations between selected motor abilities and environmental factors in boys

Environmental variable		Static strength	Explosive strength	Muscle mobilization	MAP	Strength endurance	Speed endurance	Static balance	Speed of movements	Spinal flexibility
Urban environment										
Father's education		0.25	1.01	0.93	1.17	0.32	0.62	1.57	0.36	0.14
Mother's education		0.36	**3.31**	**3.62**	**2.92**	**3.48**	**3.27**	2.64	0.29	**3.07**
Father's occupation		0.84	**2.95**	0.93	**3.94**	**3.04**	1.25	1.07	0.25	0.52
Mother's occupation		1.45	1.53	**2.95**	0.16	0.57	1.4	0.2	0.39	**2.93**
Number of children in family		0.05	0.12	**3.73**	**3.65**	0.95	0.19	**3.88**	0.34	0.17
Number of people in family per working person		0.38	0.13	1.03	0.38	1.39	1.05	0.44	**2.99**	0.02
Number of people in family living in one room		**2.87**	**3.56**	1.48	0.08	0.42	0.02	**3.73**	**2.83**	0.45
Income per person		0.41	**3.24**	**2.99**	0.78	0.52	0.45	**3.02**	0.67	**2.95**
Physical activity	child	**3.55**	**2.95**	**3.49**	**3.73**	**3.19**	**2.97**	0.27	2.77	0.69
	father	**2.83**	**2.84**	0.11	**3.71**	**3.41**	1.01	**2.97**	0.29	0,41
	mother	1.71	**2.89**	0.83	1.02	0.61	0.56	**4.54**	1.16	**3.15**
Child's leisure		0.18	1.15	0.31	1.38	**2.97**	0.14	**3.38**	**3.88**	0.02
Rural environment										
Father's education		0.22	**3.39**	1.84	1.63	0.24	0.86	0.32	**3.13**	**4.91**
Mother's education		0.36	**3.81**	**3.21**	**8.47**	0.1	**3.03**	0.81	0.45	**3.26**
Father's occupation		0.16	0.91	0.69	2.27	**2.98**	0.35	0.11	0.91	0.89
Mother's occupation		0.68	**2.76**	0.72	**4.95**	**3.85**	**3.21**	1.09	1.0	**3.17**
Number of children in family		0.73	**8.23**	**2.91**	**5.17**	0.95	**3.15**	0.08	1.86	**4.65**
Number of people in family per working person		**3.29**	**7.71**	0.93	**10.77**	0.02	1.85	**3.35**	0.21	**4.49**
Number of people in family living in one room		0.37	**4.66**	0.51	2.19	2.04	1.91	0.15	1.06	0.14
Income per person		1.39	**6.96**	0.35	**11.42**	**2.97**	1.43	0.47	1.0	**4.29**
Physical activity	child	0.33	**2.89**	0.89	**2.91**	0.78	0.89	**2.97**	**2.87**	**5.13**
	father	0.21	0.85	1.82	0.16	0.12	0.28	0.52	0.57	1.74
	mother	1.05	1.25	1.29	2.37	0.04	0.71	0.58	0.45	1.77
Child's leisure		**2.93**	**2.87**	1.17	**8.34**	0.82	0.47	**2.96**	1.8	0.17

F values at $\alpha \leq 0.05$ marked in bold

Table 3. One-dimensional F-test values representing correlations between selected motor abilities and environmental factors in girls

Environmental variable		Static strength	Explosive strength	Muscle mobilization	MAP	Strength endurance	Speed endurance	Static balance	Speed of movements	Spinal flexibility
Urban environment										
Father's education		2.78	2.46	**4.42**	**4.05**	0.93	0.82	**5.04**	0.21	0.44
Mother's education		**3.13**	**3.27**	**3.66**	**4.31**	1.41	0.17	**3.17**	0.27	**3.18**
Father's occupation		0.41	**2.99**	**3.07**	**2.96**	**3.17**	**3.38**	1.37	**3.57**	0.41
Mother's occupation		1.61	**5.09**	**3.52**	0.64	**3.78**	**3.85**	**3.67**	**3.51**	**3.17**
Number of children in family		0.31	**3.01**	**3.02**	**2.94**	1.28	0.62	0.15	**3.85**	**2.97**
Number of people in family per working person		0.48	0.47	0.41	0.71	0.41	0.08	0.15	0.58	1.16
Number of people in family living in one room		**3.05**	1.08	0.35	**3.29**	0.1	0.52	0.04	0.34	0.82
Income per person		0.39	**5.57**	**3.23**	**3.48**	**3.21**	0.41	0.54	**3.14**	1.64
Physical activity	child	**3.08**	**3.52**	2.31	2.61	2.04	**3.44**	1.95	0.31	2.37
	father	1.17	**3.58**	1.75	2.51	2.11	0.05	0.86	0.88	2.17
	mother	0.65	0.79	1.69	0.77	1.99	**3.09**	0.67	0.01	1.47
Child's leisure		1.18	0.04	0.07	1.69	0.31	**3.07**	0.93	**3.44**	0.65
Rural environment										
Father's education		0.45	1.41	0.46	**3.09**	0.4	**3.21**	**3.54**	0.57	2.21
Mother's education		0.28	**3.92**	0.76	0.65	**2.96**	0.45	**3.21**	0.86	**2.91**
Father's occupation		0.47	1.64	2.16	0.94	0.98	1.63	0.14	0.18	0.05
Mother's occupation		**3.69**	**3.91**	**3.67**	**2.97**	**3.21**	**3.36**	1.36	0.47	**3.27**
Number of children in family		**3.39**	**4.65**	**2.99**	0.86	**3.47**	0.71	0.1	**3.15**	**2.97**
Number of people in family per working person		0.82	0.03	1.26	0.32	**3.48**	2.14	**2.99**	0.57	**3.66**
Number of people in family living in one room		1.21	1.25	0.93	1.11	0.63	0.01	1.27	0.45	1.51
Income per person		0.13	**4.67**	0.57	**3.72**	**3.58**	0.25	0.43	**2.89**	**3.21**
Physical activity	child	**3.41**	**2.95**	**3.21**	**3.48**	**3.25**	**3.13**	2.73	**3.17**	**3.04**
	father	0.31	0.45	1.21	1.04	0.3	2.57	0.19	0.16	0.13
	mother	0.78	0.77	1.35	0.04	0.57	0.31	1.58	0.07	0.42
Child's leisure		0.59	**2.96**	0.84	**4.59**	**3.24**	1.12	**2.92**	0.57	**3.06**

F values at $\alpha \leq 0.05$ marked in bold

As the body's functionality was considered secondary to its structure, the mean scores of motor tests in the categories of environmental factors under study were then compared. The multivariant F-test results comparing the medicine ball throw scores with the number of children in the family, number of people living in one room and child's motor activity indicate a certain social gradient: the better the living conditions and level of physical activity, the greater the explosive strength of the arms and trunk (Fig. 1b, 1c, 1e). Students from sport-practicing families with a single child and good living conditions tended to achieve far better results. Students from families with many children with relatively worse living conditions and low level of physical activity achieved results below the study sample average. Other factors which significantly affected the mean medicine ball throw scores revealed some environmental diversification. For instance, urban boys and rural girls, whose parents had a secondary or vocational education, attained the highest medicine ball throw scores (Fig. 1a). On the other hand, these results were higher in rural boys and lower in urban girls, whose mothers had a higher education.

The correlations with variable "net income per person" also revealed some interesting results. The explosive strength was, for example, the highest in boys from

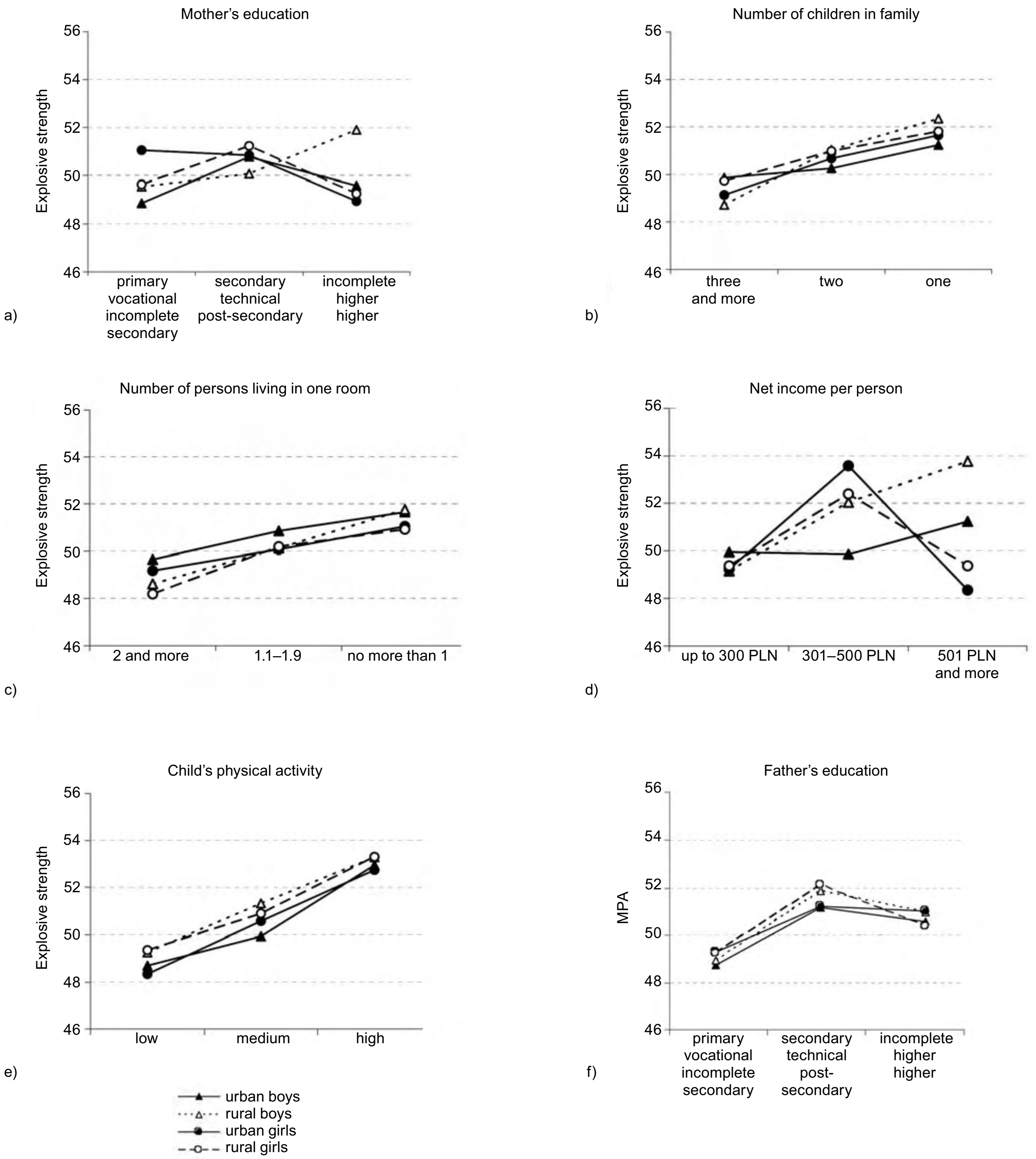

Figure 1. Mean explosive strength and MAP values in both sex and environmental groups correlated with selected environmental factors on a T-score (a score of 50 represents the population mean)

families with the highest income, but only in rural boys the distribution of the test results was monotonic. In girls, the mean results of explosive strength displayed some degree of conformity, and the highest score was within the second range, i.e. income per person between 301 to 500 PLN (Fig. 1d).

The results of the tests assessing the explosive strength of the arms and trunk in combination with the

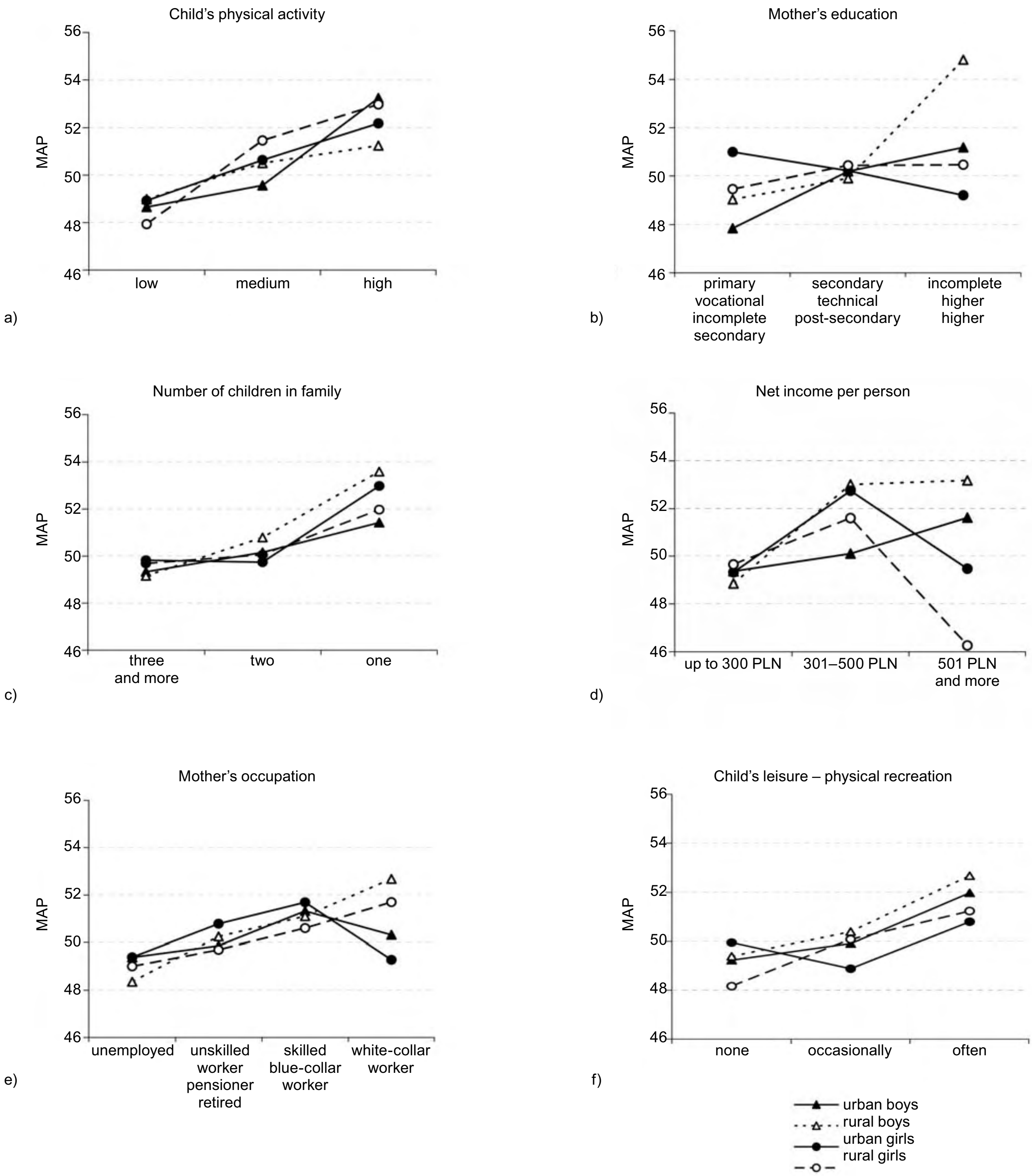

Figure 2. Mean maximal anaerobic power in both sex and environmental groups correlated with selected environmental factors on a T-score (a score of 50 represents the population mean)

subjects' body height were affected by the subjects' living conditions and physical activity. Students from families with fewer children, with good living conditions, high income, mother's secondary education and practicing organized sports tended to score higher.

The mean values of the MAP index altered significantly alongside such variables as parents' education, mother's occupation, number of children in the family, income per person and child's physical activity and leisure pursuits (Tab. 2, 3). The subjects' test results in the categories: number of children in the family and child's physical activity and leisure revealed an improvement of anaerobic efficiency forming a sort of social gradient (Fig. 2c, 2a, 2f). Students whose fathers had a second-

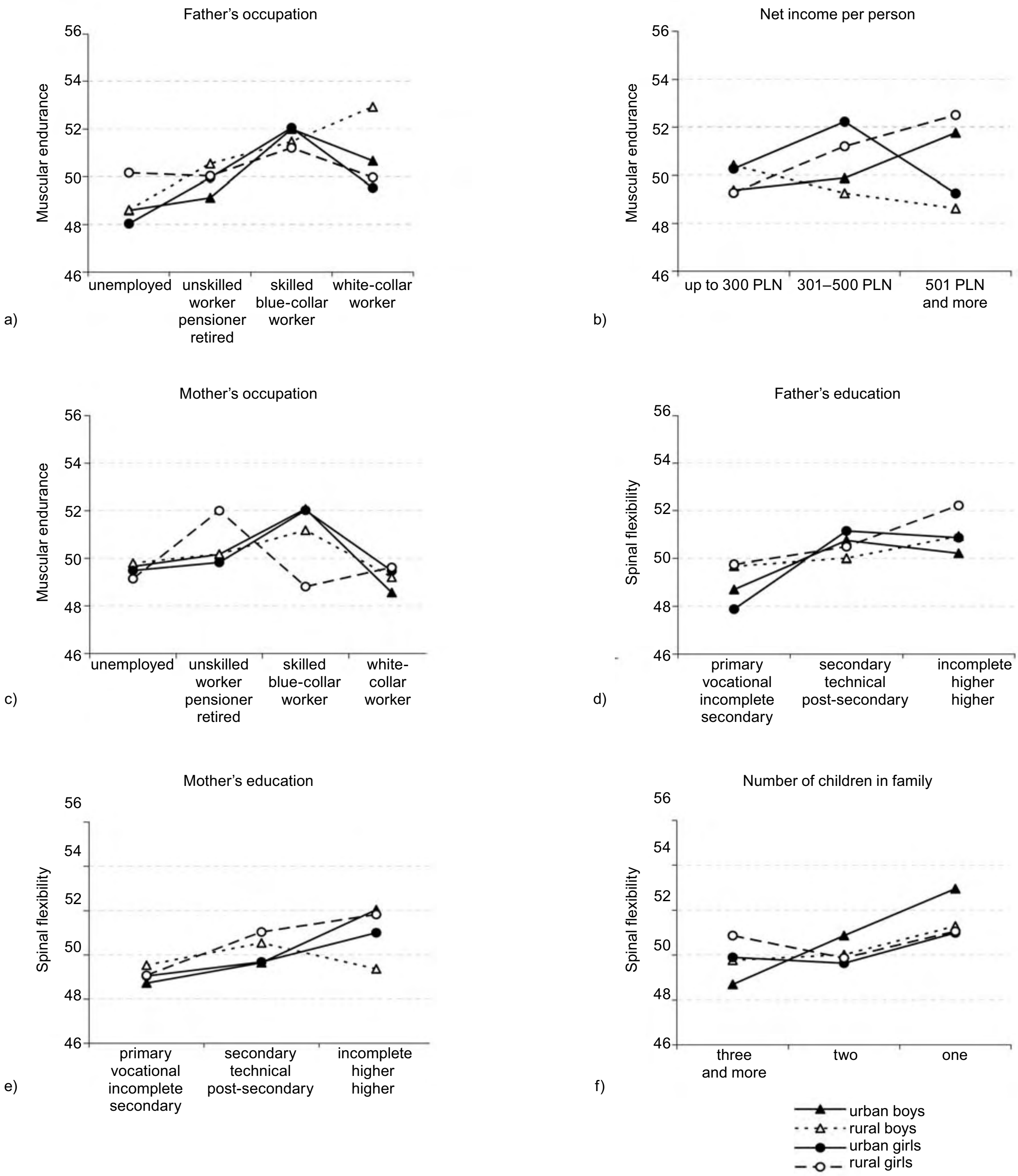

Figure 3. Mean muscular endurance and spinal flexibility in both sex and environmental groups correlated with selected environmental factors on a T-score (a score of 50 represents the population mean)

ary or vocational education attained the highest MAP, in the rural environment, in particular (Fig. 1f). In terms of mother's education, the higher education level had a positive impact on the MAP results, but only in boys (in rural areas, in particular). It should be noted that in the category of mother's education the MAP values of their daughters were very similar (Fig. 2b).

The MAP values changed significantly in correlation with the mother's occupation, only in the rural environment: the higher mothers' professional status, the better the maximal anaerobic power of their children (Fig. 2e). The MAP index values also revealed correlations with the income per person (Fig. 2d). A significant improvement of test results was observed in the second

Figure 4. Mean spinal flexibility in both sex and environmental groups correlated with selected environmental factors on a T-score (a score of 50 represents the population mean)

range of the net income category, i.e. from 301 to 500 PLN per person in the family. In the other cases, i.e. outside the second range, both urban and rural students attained the lowest MAP results.

Another test featuring a great variability of scores was the sit-ups test assessing abdominal muscular endurance. The children of non-working parents and office workers scored the lowest in the sit-ups, while children of skilled laborers attained higher than average results. The exceptions were rural boys whose muscular endurance increased monotonically alongside their fathers' professional advancement, and rural girls whose mothers were unskilled laborers or pensioners. The sit-ups test results varied in the category of income per person in the family. In rural girls and urban boys the mean sit-ups scores formed a sort of gradient as their family income grew; whereas it was inversely proportional in rural boys. In the group of urban girls the highest scores were noted in the second range of the income factor, i.e. from 301 to 500 PLN per person in the family (Fig. 3b).

A statistically significant variability of scores of the sit and reach test was observed in correlation with the mother's education and occupation (Tab. 2, 3). A visible improvement of test results was noted in the groups of urban boys and girls and rural girls as the mothers' education level was higher (Fig. 3e). On the other hand, the rural boys whose mothers had a secondary education displayed the highest level of spinal and pelvic flexibility. Significantly varied flexibility test results were reached by the students in ranges of the category of mother's occupation (Fig. 4a). Higher (above the sample average) scores were attained by the students whose mothers were skilled laborers. Students whose mothers were in other ranges of the occupation category scored lower (below the sample average). Similar correlations were noted between the results of all motor tests and mother's education.

Significant changes in the flexibility test results were also noted in the category: income per person. The rural girls scored better in the sit and reach test, directly proportionally to higher income, unlike the other groups of subjects where the test results were the highest in the category range between 301 and 500 PLN per person (Fig. 4b).

Discussion

According to some researchers the time and intensity of the pubertal growth spurt are interconnected; the earlier the spurt occurs the more intensive it is. The pubertal spurt determines all morphological traits and many physiological ones. The pattern of fitness test scores of boys from Nowa Huta [16] corresponds to the observations of Tanner [17] and Milicerowa [18] concerning the increase of dynamics of motor development during the spurted growth of somatic traits (shoulder width, chest circumference). Żak [19] revealed a hugely significant role of the factor of biological age affecting results of static strength tests by subjects at puberty. Burdukiewicz et al. [20] showed that girls at puberty featured a higher dynamics of somatic development with accelerated development of hand grip strength.

Welon and Bielicki [21] in their study of correlations between body height and general fitness and two social variables (father's education in big urban, town and rural areas), showed them to be of secondary character: the greater the body height, the stronger the correlation. Significant coefficients of correlation between the body height and fitness test results in all age groups of boys and girls were noted by Szklarska [22]. She also revealed that regardless of the impact of body height on fitness tests scores, the differences in the level of fitness remain significant.

In the present study the majority of the analyzed environmental factors are variables which affect the children's physical development in an indirect and multifaceted way. The correlations observed between selected environmental variables and the level of subjects' physical development were not that clear as with somatic traits [23]. This might have been caused by, first of all, the accuracy of the fitness tests and the lability of some results of motor tests; and, second, by the fact that the discriminant function of the socio-economic variables regarding motor effects is not so high as in the case of somatic traits. A similar problem was noted earlier by Szopa [24], Orlicz [25], Cieśla [26] and Mleczko and Ozimek [27].

Mleczko and Ozimek [27, p. 45] in their research of the Cracow population in the 1990s showed that "such factors as the number of children in the family, parents' education, school type, and goodness index of the environment did not significantly affect the existence of social gradients". Their sample revealed a very slight superiority of groups of higher social status in terms of their physical development.

The results of the present study correspond only to some extent to those of Charazewski and Przewęda [28], who noted a weak correlation between the father's level of education and fitness of rural boys; whereas sons of fathers with a secondary and higher education in urban areas attained the highest level of physical fitness. On the other hand, Orlicz [25, p. 9] in his study of girls noted that "the correlation between parents' education and subjects' general physical fitness forms a gradient descending with lower education levels", but not in the rural areas.

In a study of physical development of children from Lower Silesia Sławińska [10, p. 91] came up with slightly different results, noting the weakest correlation between the explosive strength of legs and social and family factors. Only the mother's education and occupation did have a significant influence on the test scores; however, "better results were attained by children of office working mothers with at least a secondary education".

Szklarska [22] in her research of adolescents from selected schools in Poland, showed a significant positive correlation between the parents' education level and their children's broad jump, medicine ball throw and short run results in all age categories. This relationship was particularly strong between the boys and their parents. As for the sit and reach test, measuring pelvic and spinal flexibility, the number of children in the family affected the results in the opposite manner: students from families with many children attained generally worse results than families with a single child. Only among the urban boys was the trend opposite. These results contradict to some extent Szklarska' reports by showing "better sit and reach test results achieved by boys from families with many children in the youngest and oldest age categories, than their peers from families with a single child or two children. The factor 'number of children in the family' is a greater differentiating factor among the boys than the girls, and the biggest difference between families with a single child and families with many children was noted in boys aged 11–15 years" [22, p. 20].

The range and direction of differences in the physical development of children under study in relation to environmental factors can also be regarded as a reflection of the impact of physical activity: more active subjects engage more frequently in sports activity. Much worse motor test results were noted among boys and girls who were moderately or merely involved in physical activity. Similar conclusions were reached by Żak [19, 29], Sławińska, Ignasiak [30] and Ambroży [31]. Regarding the importance of the differentiating impact of child's physical activity on physical test results, the problem of greater and more effective physical stimulation of children's and adolescents' development becomes highly significant.

Extracurricular organized activities and active leisure pursuits during holidays, often under professional coaching supervision, require some extra expenses from the family budget, for example, transportation costs or subscription cards to sports facilities (swimming pool, tennis court). Dutkiewicz's [32] study of Kielce population showed that for more than 50% of rural children from the region the only form of organized sport are PE classes at school. The compulsory four PE classes a week in the school curriculum do not, however, meet the child's needs. Their spontaneous physical activities are the only remaining alternative, but it is not enough either. Nowocień [33, quoted after 10] claims that household chores take up 78.3% of rural children's free time, followed by meetings with friends, watching television, taking care of one's looks and religious practices. Physical activity was ranked rather low alongside reading and collecting hobbies.

Conclusions

The statistical analysis of results points to a few conclusions, which apart from their cognitive value, can serve as useful hints for parents and teachers in directing children's and adolescents' physical development.

1. Family income, mother's education and occupation, and the number of children in the family are key elements of the family's socio-economic situation, as they significantly affect the functional development of boys and girls at puberty. Among the so-called "lifestyle" factors – related to the family economic situation, but exerting a more direct influence on the subjects' physical development than socio-economic factors – the most significant is the child's physical activity. The other correlations revealed certain differences between children from rural and urban environments. For instance, father's occupation significantly affected the physical development of urban adolescents, while the number of persons per one working person in the family and child's active leisure pursuits had a greater impact on the rural youth. The boys' bodies responded more often to the impact of environmental factors than the girls'.
2. The biological "indices" of social diversification of adolescents include medicine ball throw test (measuring the explosive strength of the legs and trunk) and maximal anaerobic power (MAP) calculated with a standing broad jump. The differences between the family's socio-economic and lifestyle factors revealed a relatively smaller influence on the results of the sit and reach test (measuring flexibility) and sit-ups (measuring muscular endurance).
3. The socio-economic variables and family lifestyle exert an indirect impact on adolescents' motor development, but in any uniform way in all sex and age groups. In terms of family's socio-economic situation the results are similar to those obtained in populations from other regions of Poland, i.e. they form a social gradient with the highest level of physical development in subjects with the best socio-economic conditions. In the majority of cases children from families with a single child, with net income between 301 and 500 PLN per person and more, whose parents had at least a secondary education and were working obtained much better fitness test results than their peers with the lowest levels of the environmental factors. Adolescents with low and medium levels of physical activity attained much worse results.
4. Physically active leisure pursuits or practicing sports are not common among the sample under study. This worrying situation has its cultural and economic background. Considering the effects of this variable the issue of increasing application of movement stimulation becomes highly significant in the process of children's physical development. Thus the phase preceding the pubertal spurt should be taken advantage of to the maximum. During pubescence children should have access to as many extracurricular activities as possible, and conditions should be made to enable them to engage in physical recreation and sports during holidays.

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MEASUREMENT OF MOTOR FITNESS OF STUDENTS USING THE ROWING ERGOMETER

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ABSTRACT
Purpose. The aim of the study was to develop a mathematical model to determine correlations between selected somatic traits and indoor rowing test results over a distance of 500 m as well as differences in the level of motor fitness of students of the University of Warmia and Mazury in Olsztyn. **Material and methods.** The research was carried out on a group of 274 full-time UWM students with the aid of Concept II Indoor Rower. The analysis concerned the effects of students' body weight and body height, year of study and the time required to cover the distance of 500 m during an indoor rowing test. Analysis of variance and regression analysis with stepwise elimination of the polynomial degree and form were used. **Results.** Only 15 subjects (5.5% of the sample) achieved the highest level of motor fitness, i.e. covered the distance under 92.7 s. A mathematical model describing the effects of decisive variables on the dependent variable was a model of regression of multiple variables of the 2nd degree. The exogenous variables were subjects' body height and body weight. **Conclusions.** The proposed mathematical model of regression of multiple variables of the 2nd degree can be useful for selection of individuals with predispositions to practice rowing at the academic and recreational levels. The proposed method of mathematical model development should be regarded as an algorithm for other, more versatile models involving additional variables.

Key words: motor fitness, ergometer, body height, body weight, students, mathematical model

Introduction

The diversity of morphological predispositions [1] is a decisive factor affecting the process of selection for particular sports [2–4]. It has been subject to numerous research studies focusing on athletes' body build and sports results [5–8]. Body height is often taken into consideration in selection for such sports as basketball, jumping events, judo, canoeing, air sports or rowing. Long arms and legs as well as big feet and hands are equally important. Limb length proportions and the body height/body weight ratio are significant factors affecting achievement of results in the vast majority of sports [9].

One of methods of assessment of motor fitness is the measurement of time required to cover a simulated distance with the aid of a rowing ergometer. Ergometer tests on large, representative samples can be carried out, for example, during various sports competitions held at the academic level [10, 11]. The measurements of students' motor fitness have been, first of all related to their health, as they have been commonly regarded as a determinant of good health and capacity to successfully perform different motor tasks [12]. In this context motor fitness can determine the body's adaptability to the motor challenges of the surrounding environment. The selection of the sample for the study can be important for choosing a university team representing the UWM in Olszyn at the annual academic indoor rowing championships in Poland.

In 2004 the 1st 500 m Indoor Rowing Championships of the University of Warmia and Mazury were held by the University Study Center for Physical Education and Sport. The results of the ergometer tests became the basis of the following analysis.

The following research hypothesis was formulated: the mean time required to cover a simulated distance of 500 m on a rowing ergometer is correlated with the students' year of study, body height and body weight. The research also aimed to determine the impact of selected factors (independent variables) on the dependent varia-

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ble: time required to cover the simulated distance of 500 m. The independent variables included students' body weight and height and the index *w*, i.e. body height/body weight ratio; and students' year of study.

Material and methods

The sample consisted of full-time students of the UWM in Olsztyn, who attended their PE classes at the time of the indoor rowing championships and volunteered to take part in them. The sample included 274 male students who only attended the mandatory PE classes for two hours a week and did not practice any other sport. The sample was divided according to the participants' years of study (Tab. 1).

Table 1. Number and percentage of students participating in ergometer fitness tests with regard to their year of study

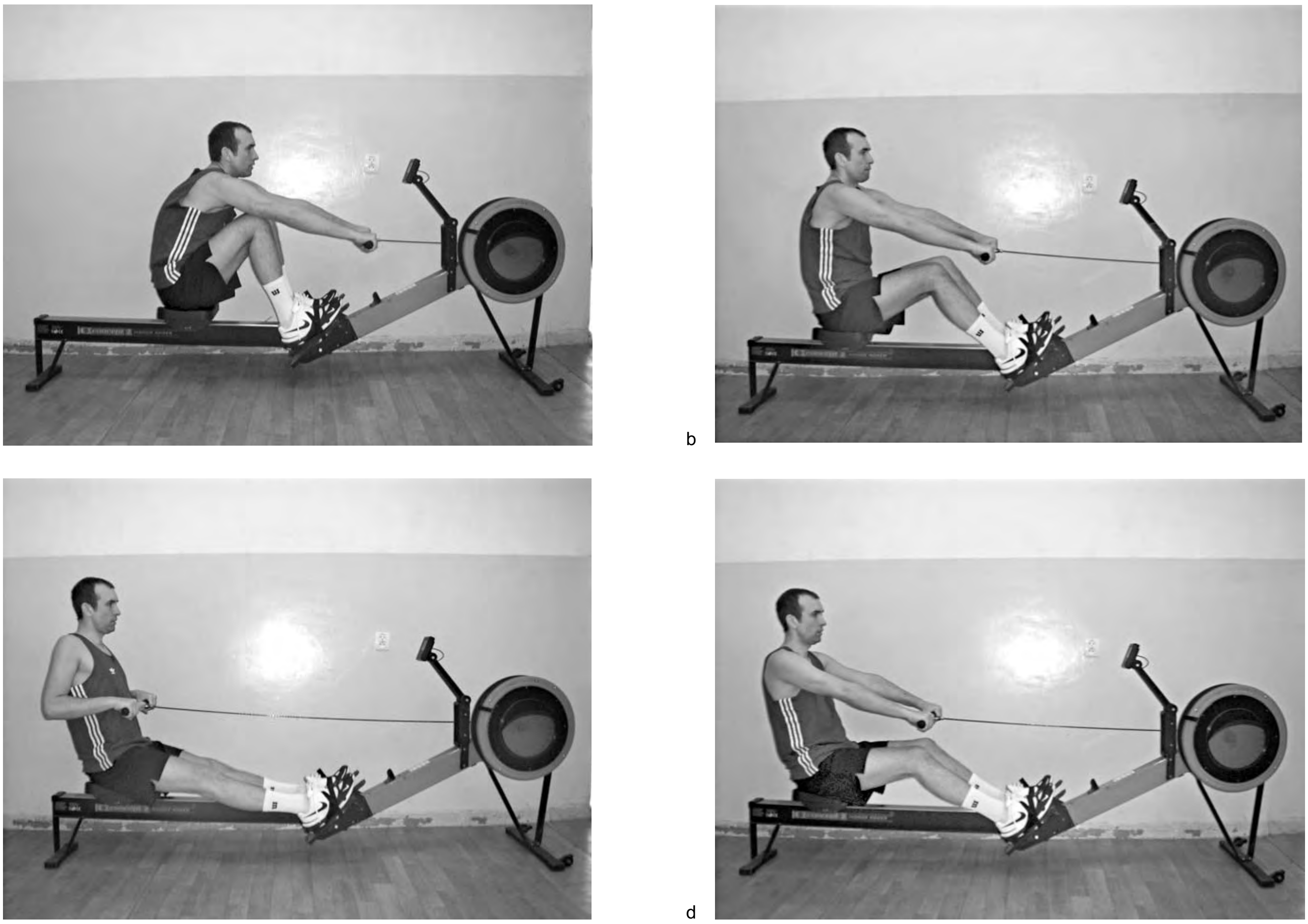
Year of study	Male students	
	Number	%
I	119	43.43
II	93	33.94
III	50	18.25
IV	12	4.38
Total	**274**	**100.00**

The measurements carried out on a Concept II Indoor Rower are commonly used in studies of prooxidative/antioxidative balance disturbances in rowers [13]. The ergometer allows nearly an ideal re-creation of all phases of rowing action (Fig. 1):

Phase I (pulling the handle) – from the starting position (a), legs bent in knees, arms straight, the trunk leaning forward – the legs slowly straighten up (b), the handle is pulled towards the chest by bending the arms in elbows, the trunk is pushed backwards (c).

Phase II (releasing the handle) – from the position with straight legs, the trunk pushed backwards and handle pulled close to the chest (c) – the legs slowly bend in knees and the arms straighten up (d) returning to the starting position (a).

Each test was preceded by a 5 min warm-up with a load ensuring the heart rate of 140/min. The ergom-



a b c d

Figure 1. Rowing action phases on an ergometer

eter resistance force could be set on a ten-level scale. The subjects performed the test (covering the simulated rowing distance of 500 m) twice at the maximum resistance force (level 10). The rowing time was displayed on the PM-2 screen. The better of the two scores (shorter time) was recorded. To ensure proper sample representativeness the following necessary sample size formula was used [14]:

$$n_0 = \frac{u_\alpha^2 \cdot \sigma^2}{d^2} \quad (1)$$

n_0 – necessary sample size,
σ^2 – sampling variance,
u_α – normal variable value N(0.1) with a set confidence coefficient (for $1 - a = 0.95 \Rightarrow u_\alpha = 1.96$),
d – admissible mean error, accepted as 1% of relative error.

When the size of the original sample n is greater than the necessary sample size, the former is taken as the proper sample. To confirm the sample representativeness, the sample should be taken from a population with the normal distribution.

To determine the subjects' rowing predispositions a five-level score scale was used (poor, satisfactory, average, good, very good) based on the three-sigma rule ($m \pm 3\sigma$).

The results obtained were analyzed statistically with the WINSTAT statistical software package [15–17]. The level of statistical significance was set at $\alpha = 0.05$. To verify the normal distribution of the time necessary to cover the distance of 500 m on an ergometer the test of goodness of fit χ^2 was applied. The analysis of variance was used to examine the significance of the impact of studied parameters on the mean time of covering the set distance. To determine the effects of independent (exogenous) variables on the dependent (endogenous) variable a polynomial regression of the 5th degree and multivariable regression of the 2nd degree were used. Also a stepwise elimination of the polynomial degree and form was applied.

Results

The distribution of rowing time required to cover the distance of 500 m seems to confirm hypothesis H_0 pointing to a normal distribution M = 104.18 and standard deviation $\sigma = 8.1649$. The number of students participating in the indoor rowing test ($n = 274$) was higher than the necessary sample size $n_0 = 235.96 \approx 236$, thus the sample can be considered representative.

Table 2. Ergometer test results on a five-point scale

Motor fitness level	Rowing time (s)	Number of subjects	%
Very good	under 92.7	15	5.47
Good	92.7 – 100.0	72	26.28
Average	100.1 – 107.3	107	39.05
Satisfactory	107.4 – 114.6	59	21.54
Poor	over 114.6	21	7.66

Table 3. Analysis of variance of indoor rowing mean times achieved by students in regard to their year of study

	Year of study	Mean (s)	Standard deviation (s)	Coefficient of variation (%)
1.	I	103.45	7.22	6.98
2.	II	103.62	7.51	7.25
3.	III	103.64	7.39	7.13
4.	IV	105.30	7.06	6.70

statistical significance F = 0.2311; probability of crossing the level of statistical significance $p(F) = 0.8747$; statistical significance level $\alpha = 0.0500$; because $p(F) > \alpha$ there is no ground for rejection of null hypothesis H_0

Tab. 2 presents the students' ergometer results over the set distance using the three-sigma rule.

Over 39% of subjects (107 male students) attained the average level of motor fitness; a lower level was noted in more than 29% (80 male students). A higher than average level of motor fitness was noted in almost 32% of subjects. 72 subjects reached a "good" level of motor fitness; only 15 students achieved a "very good" level (5.5% of the sample).

The results of the analysis of variance verifying hypothesis H_0 are presented in Tab. 3.

The analysis of the mean time required to cover the ergometer distance of 500 m revealed no statistically significant differences in regard of the subjects' year of study. A slightly worse time (1.5 s longer) was recorded in the 4th year students, which can most likely be explained by the fact that the seniors devoted generally less time to physical education.

With the accepted level of statistical significance ($\alpha = 0.05$) hypothesis H_0 (i.e. no significant differences between the achieved rowing time and the subjects' year of study) was confirmed. In the case of the other variables, i.e. subjects' body weight and body height, hypothesis H_0 was rejected in favour of alternative hypothesis H_1 with the exogenous variable *w*, i.e. ratio between students' body height and body weight.

The results of polynomial regression analysis are presented in Tab. 4. As the regression coefficients were significantly different from zero, a correlation was noted between the independent (exogenous) variable *w* and the ergometer test time (2):

$$Y = 36928.95\, w^5 - 431432.58\, w^4 + 1998420.14\, w^3 - 4581873.27\, w^2 + 5190915.68\, w - 2319297.28 \quad (2)$$

The stepwise regression failed to eliminate the polynomial degree and form. The mathematical model revealed no significant correlation between the 500 m rowing time and the *w* index (body height/body weight). In the first, third and fifth power the increase of *w* extended the time of the test performance; whereas in the second and fourth power the rowing time was reduced.

The statistical results show that only in 65.17% the endogenous variable is explained by the mathematical model. Moreover, with the coefficient of multiple correlation slightly above 0.8 and the probability of crossing the level of statistical significance (0.0493), it can be stated that the dependent variable (*Y*) determined by the independent variables can only to some extent affect the tested rowing time (Fig. 2).

Generally, it can be noted that the increase of the index *w* from about 2.36 to 2.42 significantly extends the time required to cover the ergometer distance. In the *w* interval between 2.42 and about 2.58 the time is relatively stable. Above the value of *w* of 2.58 a significant reduction of the rowing time can be noted.

In order to fit the model to the empirical data, the students' body height and body weight were taken as decisive variables (Tab. 5).

Since the coefficients of regression were significantly different from zero, a correlation was noted between

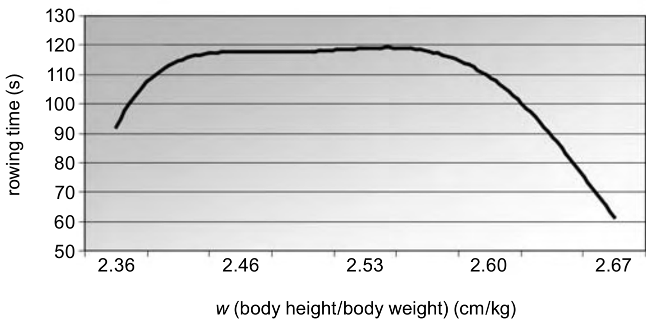


Figure 2. Correlation between rowing time and the w index

Table 4. Correlation between rowing time and index *w* (body height/body weight)

Parameter	Mean (s)	Standard deviation (s)	Coefficient of variation (%)
w (body height/ body weight) (cm/kg)	2.49	0.0974	3.91
Time – *Y* (s)	104.72	12.8784	12.30

Verification of hypothesis on the significance of regression coefficients
hypothesis H_0 – coefficients of regression insignificantly different from zero; hypothesis H_1 – coefficients of regression significantly different from zero; statistical significance F = 5.724; probability of crossing the level of statistical significance p(F) = 0.0493; level of statistical significance $\alpha = 0.0500$; percent of verified variability 65.17; coefficient of multiple correlation – 0.8070; standard deviation of the remainder – 12.4110; because $p(F) < \alpha$ null hypotheis H_0 is rejected in favour of alternative hypothesis H_1

Table 5. Correlation between rowing time, body weight and body height

Parameter	Mean (s)	Standard deviation (s)	Coefficient of variation (%)
Body weight – *X* (kg)	72.67	3.1623	4.35
Body height – *Z* (cm)	180.33	1.7321	0.96
Time – *Y* (s)	104.72	12.8784	12.30

Verification of hypothesis on the significance of regression coefficients
hypothesis H_0 – coefficients of regression insignificantly different from zero; hypothesis H_1 – coefficients of regression significantly different from zero; statistical significance F = 14.1142; probability of crossing the level of statistical significance F – p(F) = 0.0270; level of statistical significance $\alpha = 0.0500$; percent of verified variability – 95.92%; coefficient of multiple correlation – 0.9789, standard deviation of the remainder – 4.2465; because $p(F) < \alpha$ null hypothesis H_0 is rejected in favour of alternative hypothesis H_1

the independent variables, i.e. subjects' body weight (*X*) and body height (*Z*), and the dependent variable (*Y*):

$$Y = -161.46\, X - 1003.71\, Z - 2.23\, X^2 + 2.26\, Z^2 + 2.69\, XZ + 95724.62 \quad (3)$$

The stepwise regression analysis did not eliminate the degree and form of the polynomial. On the basis of the

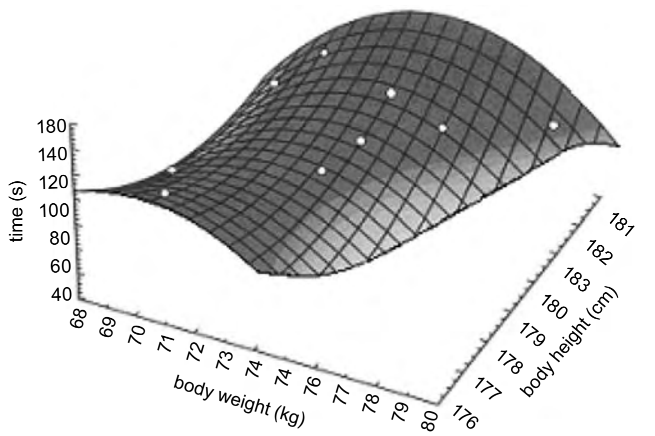


Figure 3. Correlation between rowing time, body weight and body height

derived mathematical model (2) the value of the exogenous (dependent) variable was approximated (Fig. 3).

The mathematical model (2) and Fig. 3 show that an increase of body weight in the first and the second power reduces the time necessary to cover the set ergometer distance. A greater body height also reduces the rowing time, despite some equivocal effects (time reduction in the first power, time extension in the second power). There are also some interactive effects of the body weight and body height on the mean time required to cover the 500 m distance. The increased body weight and body height (or only one of these variables) extends the time of performing the test.

The use of exogenous variables of *X* (subjects' body weight) and *Z* (subjects' body height) greatly improves the fitting of the model to the empirical data. The percentage of verified variability exceeded 95.9%; the coefficient of correlation reached almost 0.98 and the standard deviation of the remainder decreased nearly three times as compared with the previous mathematical model.

The goodness of fit analysis proved the validity of the accepted model, which can be used for selection of individuals with potential predispositions for rowing at the academic and recreational levels.

Discussion

An ergometer test should be analysed in terms of its individual components: duration, resistance force, number of strokes per split. Such an analysis corresponds to the general view that exercise load in all sports is related to the temporal-spatial structure of movement, its intensity and training loads [18, 19].

The maximum rowing rate can be attained on an ergometer through maximization of positive forces and minimization of negative forces generated during the rowing strokes [20].

The standard ergometer distance of 500 m is often called the "anaerobic starting phase" of a 2000 m rowing run. It can be used to measure the local physical efficiency of participating muscles, providing the duration of this phase is between a few seconds and two minutes [21]. The analysis of the students' mean time values (from 103.5 to 105.3 s) required to cover the distance of 500 m showed that they fell below the upper limit of the duration time. Following Janssen [18, p. 45], depending on physical exercise duration the efforts necessary to cover the ergometer distance of 500 m can be placed between anaerobic exercise (45–120 s) and aerobic–anaerobic exercise (120–140 s) with an emphasis on the anaerobic exercise. Apart from one's ability to develop maximum force, the time in which it is sustained at a steady level and rowing technique are equally important.

It was observed that the motor predispositions essential in rowing included endurance skills in different combinations, i.e. complex predispositions[1] [compare 22], for example, special endurance or strength endurance [18, 23]. It can be thus assumed that the rower's exercise involves the basic motor skills with great emphasis on endurance skills [24].

The following rowing predispositions can therefore be identified:

- strength – overcoming the rowing resistance at the highest level on a ten-point scale;
- endurance – maintaining the exercise level between 131.7 and 132.1 s;
- speed – maintaining the proper rowing pace on a set distance;
- coordination – alternating movements of the arms and legs (bending the arms in elbows with simultaneous straightening of the legs in knees and leaning the trunk backwards).

Each predisposition features its own intensity; however, short time endurance plays here a decisive role. Short-time endurance is typical of exercise of submaxi-

[1] The concept of complex (hybrid) predispositions is related to J. Raczek's theory of structure of motor skills.

mal intensity with the duration between 50 and 120 s. The most significant component of motor fitness is aerobic endurance [25]. Despite the fact that the 500 m rowing distance is commonly classified as a short endurance distance, the time required to cover this distance falls below the upper range of short-time endurance and close to the lower limit of middle-time endurance. It is most likely due to the necessity of greater effort to cover the ergometer distance with the highest load. Thus, the energy supplies during such an exercise may involve both anaerobic processes (up to 90 s) and aerobic processes (above 4 min) constituting a complex system (90 s – 4 min) [26].

A thorough factor analysis of rowing tests will be therefore necessary and should aim at an improvement of accuracy, reliability, objectivization and economy in a 500 m indoor rowing exercise [27, 28]. Detailed studies of metabolic processes as factors determining the physical fitness over the rowing distance mentioned are also important. As Zambroń-Łacny et al. [13] noted, the number of research studies concerning the prooxidative-antioxidative balance in rowers have been extremely scarce.

The ergometer 500 m tests can be extremely useful in future studies of motor fitness, as a measurement of the state of health of physically active young people. Obviously, certain aspects of the indoor rowing tests require further research, especially the endurance skills constituting one's motor potential. Ergometer tests may constitute a significant contribution to studies of young people at different stages of their physical development. Their results presented in tables can be used for development of prospective standards and be applied in research of many other different populations.

Conclusions

1. There is a correlation between the two variables under study: subjects' body weight and body height and the mean time of covering the distance of 500 m on a rowing ergometer.
2. No statistically significant correlations between the rowing time and the subjects' year of study were found. This can be explained by the relatively broad age span of students participating in the study.
3. It can be stated that the indoor rowing time required to cover the distance of 500 m depends on the index *w*, i.e. ratio of a subject's body height and body weight. An increase of the index *w* from about 2.36 to about 2.42 extends the rowing time. In the *w* range between 2.42 to about 2.58 the indoor rowing time is relatively stable; whereas with the index *w* between 2.58 to about 2.65 a distinct reduction of the rowing time can be observed.
4. The derived mathematical model of regression of multiple variables of the second degree can be applied in the process of selection of individuals with predispositions to practice rowing at recreational and academic levels.
5. Ergometer tests should continue and possibly incorporate additional variables which may significantly affect the final research results.

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SOCIAL POSITION AND HEALTH-RELATED FITNESS: A CROSS-SECTIONAL STUDY OF URBAN BOYS AGED 10–15 YEARS

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ABSTRACT
Purpose. The study shows social differences in the context of health-related fitness and its basic components: physical activity, somatic parameters and motor fitness. The number of siblings was adopted as a social factor related to the differences. **Basic procedures.** 1652 boys aged 10 to 15 years from a large city environment were tested. They were divided into: (1) only children, (2) having one brother or sister, and (3) having two or more siblings. Their leisure time physical activity (LTPA) was assessed, basic somatic parameters were measured and motor tests were carried out. **Main findings.** LTPA frequency and duration were very similar regardless of the number of siblings. Differences in LTPA forms and LTPA partners have been revealed. Somatic parameters and motor fitness level were significantly different depending on the number of siblings. However, the analysis of motor fitness level in separate somatic categories resulted in disappearing of motor fitness differences. **Conclusions.** The inequality of social positions of urban boys is connected with the differences in the level of health-related fitness but its components are socially modified to a different degree.

Key words: social inequalities, health-related fitness, physical activity, number of siblings, urban boys

Introduction

In the 1970s, a concept of health-related fitness started to develop. It assumes a close relation of physical fitness, health and quality of life. According to an early idea of Renson et al. [1], "physical fitness can be regarded as a conglomerate of somatic, motor, and behavioral components". These basic components are affected significantly by social factors, e.g. educational and socioprofessional status of parents, degree of urbanization, family size, birth order, school type and system and ethnic group. Other scientists developed and expanded this concept creating a paradigm that encompasses health-related fitness as the core and its connections with physical activity, health status, heredity and other factors: lifestyle behaviours, personal attributes, physical and social environment [2]. As a consequence of theoretical discussion appropriate health-related fitness tests were created.

In population studies on the effect of socioeconomic factors on physical fitness and health of children and youths tests measuring mainly so called motor-fitness performance are commonly used. They are chiefly studies for which the priority objectives are the diagnosis of the physical development of children and youths nationwide or in a region, an assessment of inter-population differences, documenting the secular trends and acceleration of development, and an assessment of the degree of social inequalities. Tests are often selected only on the basis of a motor physical fitness concept in which the leading role is assigned to such motor abilities as strength, speed, endurance and movement co-ordination [3]. This does not make it possible to assess or compare the health potential of the groups of children and youths under examination, but it is rather an unintentional assessment of their suitability for competitive sport. Moreover, in some of the studies the tests used do not even include all basic motor abilities. Those related to cardio-respiratory endurance are usually missing [4, 5]. Some studies do not take into account motor abilities in the context of social inequalities, analysing only somatic parameters, which refers to both Polish studies [6, 7] and studies carried out in other countries [8–10]. Proving, on the basis of single or inappropriate research tools, that social inequalities disappear or emerge may be misleading. In some studies [11], apart from functional fitness tests and anthropometric measurements, a number of biochemical and haematological indicators were taken into account. However, the indicators crucial for health, such as the assessment of body fatness and cardio-respiratory endurance are missing. Moreover, the above-cited studies omit physical activity – a basic element of lifestyle and a crucial behavioural component of the health-related fitness concept. From the perspective of the health-related fitness concept, the studies of social differences should at least: (1) use a set of motor tests the results of which are positive indicators of specific aspects of physical health, (2) take into account somatic parameters important for health and subject to environmental influence, and (3) include physical activity in the analysis. Such an approach gives a more complete picture of the population under examination.

The aim of this study is to assess the effect of social position on the health-related fitness of urban boys aged 10–15, using combined variables of physical activity, somatic parameters and motor fitness. The social factor which was adopted as the one to differentiate the population examined was the number of siblings.

Material and methods

Participants

The material consists of the results of cross-sectional study carried out in selected schools of Poznań, a city with a population of approx. 600 thousand, which cover a standard curriculum of physical education. The age of subjects was 10 to 15 years. The total number of boys who participated in the study was 1652 (Tab. 1). Complete information necessary for the analysis was obtained from 1524 boys. The participants were divided into three groups in terms of the number of siblings:

1. only children (NS0),
2. having one brother or sister (NS1),
3. having two or more siblings (NS2).

Only children accounted for 17.7%, boys with one brother or sister – 62.1%, and boys with two or more siblings – 25.2% of the whole group under examination (Tab. 2).

The group was divided into two age categories. The first one included boys aged 10–12 years, and the second one boys aged 13–15 years. Thus, the study included children in the final phase of the prepubertal period and the initial stage of the puberty. Naturally, such a division is partly arbitrary but in general it is adequate to the one used in developmental psychology of children and youths [12], and it corresponds to the main stages of motor and somatic development adopted in anthropomotorics [13].

Table 1. Number of participants by age

Age (years)	10	11	12	13	14	15	Total
Number	256	323	313	297	371	92	1652

Table 2. Number and percentage of participants by number of siblings

Only-children		One brother/sister		Two or more brothers/sisters		Total
n	%	*n*	%	*n*	%	*n*
193	12.7	947	62.1	384	25.2	1524

Physical fitness tests and somatic parameters

Measurements of motor component of physical fitness, and somatic features were carried out with the consent of the parents and in communication with physical education teachers. Children in good health, without any medical contraindications to take part in physical education classes were admitted to participate in the tests. The tests were carried out by appropriately prepared staff of the University School of Physical Education in Poznań, in a gym, always in the morning. Motor components were tested using the European Physical Fitness Test “EUROFIT” according to its methodology [14].

The following tests were carried out: (1) flamingo balance test (general balance), (2) plate tapping (speed of upper limb movement), (3) sit and reach (flexibility), (4) standing broad jump (explosive strength), (5) hand grip (static strength), (6) sit-ups (abdominal muscular endurance), (7) bent arm hang (arm and shoulder muscular endurance), (8) a 10 × 5 m shuttle run (running speed, agility), and (9) endurance shuttle run (cardiorespiratory endurance). The following anthropometric measurements were taken: body height (BH), body mass (BM), and thickness of five skinfolds (triceps, biceps, subscapular, suprailiac and calf). Two somatic indicators were calculated:

- body mass index (BMI) according to the formula: BMI = body mass (kg)/body height^2 (m^2),
- logarithm of the total thickness of five skinfolds, hereinafter called log SFT, as a measure of thickness of subcutaneous fat tissue [15].

The values of all somatic and motor characteristics were normalised for each group of participants born in the same year. Mean value was expressed as "0" and standard deviation expressed as "1".

The following formula was used:

$X_n = (X - M) : SD \cdot Q$,

where

X_n – normalised value,

X – value of a somatic parameter or a result of one of the tests of motor fitness of a given person,

M – mean value of a somatic parameter or a test of motor fitness in a given age category (year),

SD – standard deviation of a value of a somatic parameter or results of tests of motor fitness in a given age category (year),

Q – index for fitness tests: "1" for increasing values (a higher value means a better result, e.g. in a standing broad jump); "–1" for decreasing values (a lower value means a better result, e.g. in a 10 × 5 m shuttle run).

The value of a somatic parameter or a result of a test were average when they were 0, higher than average for positive values, and lower than average for negative ones in a given age category.

In order to show the influence of somatic parameters on the relationship between motor fitness and social factors, a relative approach was used. The motor fitness differences between boys with different number of siblings were analysed in separate categories of body height, body mass, BMI and log SFT.

In order to assess the significance of differences in somatic development and motor components of physical fitness, a one-way analysis of variance (ANOVA) and Student's t-test were calculated.

Physical activity

In order to assess the behavioural component of health-related fitness, some aspects of physical activity were taken into consideration. The frequency of undertaking leisure time physical activity (LTPA) was established using a question: "How often do you take part in sport, exercise or recreational physical activities after school (in your leisure time)?". The participants had seven options of answers, from: "I exercise every day" to "Basically, I don't exercise except physical education classes". The relative duration of LTPA of the children was assessed on the basis of a question: "How much leisure time each day do you devote to the activities listed below?". Subjects had to specify in hours and minutes the duration of each of ten groups of activities, including recreational and sport activities. The times were added up and a percentage of LTPA was calculated. The boys were asked which forms of LTPA they undertake most frequently, whether they take part in any activities in sports clubs, take part in sports competitions, participate in tourism and do morning gymnastics. Moreover, the participants listed people with whom they most frequently take part in LTPA. The boys also answered the question: "Do you think that at the age of 20 you will exercise as an athlete or for pleasure?". The children could choose one of four answers from "definitely yes" to "definitely not".

Two questions in a point scale from 1 to 3 were related to encouragement ("very often", "sometimes" and "not at all" or "I don't know") and physical activity ("every week", "less than once a week" and "not at all" or "I don't know") perceived by the boys in their parents, siblings, friends and school teachers. Mean point values were calculated for each participant.

In order to establish the significance of relations between various aspects of physical activity of the boys and the number of siblings, the χ^2 test was used.

Results

Leisure time physical activity

The study reveals no significant relations between the frequency and the relative duration of LTPA of the participants (for all participants χ^2 = 8.7, n.s., and χ^2 = 6.7, n.s., respectively) and the number of siblings (Tab. 3). In older boys, significant differences are found in terms of participation in sports club activities (χ^2 = 11.0, $p < 0.05$*) and taking part in sports competitions (χ^2 = 21.7, $p < 0.01$**). Boys from NS1 group take part in these forms of LTPA most frequently, less frequently NS2 boys and least frequently NS0 boys. In the younger group, there is a relation between the number of siblings and doing morning gymnastics (χ^2 = 12.8, $p < 0.05$*). Boys from the NS2 group exercise most frequently, followed by NS0 and NS1. An average number of forms of LTPA is similar (from 2.1 to 2.3) tending to be lower in only children (Tab. 4).

Self-assessment of physical fitness in the older group is the lowest in only children and the highest in boys in the NS1 group ($\chi^2 = 22.7$, $p < 0.01$**). The number of siblings is not related to tourism nor to the expected physical activity at the age of 20.

The number of siblings is related to people accompanying the boys in LTPA (Tab. 4). With decreasing number of siblings, the percentage of participants who undertake LTPA alone (48.9% of only children vs. 37.1% of boys with two or more siblings) and with their parents (16.0% vs. 7.3%, respectively) increases, and the lower the percentage of participants who undertake LTPA with friends (73.4% vs. 80.2%) and other people (7.4% vs. 12.0%) decreases. Approximately 18% of boys who have siblings undertake LTPA with a brother or sister. Mean scores for the perceived encouragement to physical activity are slightly higher in the NS0 group and similar in other groups: only children 1.9, one sibling 1.8, and two or more siblings 1.8 points. Physical activity of significant others perceived by the participants amounts to 2.5, 2.6 and 2.5 points, respectively. The χ^2 test shows that mothers of boys with a smaller number of siblings are perceived as more often encouraging their children to physical activity ($\chi^2 = 10.5$, $p < 0.05$*), and both fathers and mothers in smaller families are more often perceived by children as physically active ($\chi^2 = 13.7$, $p < 0.05$* and $\chi^2 = 13.8$, $p < 0.05$*, respectively).

Somatic parameters

The number of siblings is significantly connected with the level of somatic parameters of the boys under examination (Tab. 5). For all participants the

Table 3. Relationships between selected aspects of physical activity and the number of siblings. Values and significance levels of χ^2 test

	10–12-years-old			13–15-years-old			All		
	n	χ^2	Trend	*n*	χ^2	Trend	*n*	χ^2	Trend
LTPA[a] frequency	813	11.9	n.s.	675	10.7	n.s.	1488	8.7	n.s.
LTPA duration	799	12.5	n.s.	682	4.0	n.s.	1481	6.7	n.s.
Morning exercises	816	12.8*	2 > 0 > 1[d]	685	4.7	n.s.	1501	7.3	n.s.
Tourism	819	0.2	n.s.	688	1.3	n.s.	1507	0.7	n.s.
Sport club	812	7.2	n.s.	685	11.0*	1 > 2 > 0	1497	10.9*	2 > 1 > 0
Sport competition	814	5.3	n.s.	677	21.7**	1 > 2 > 0	1491	11.4	n.s.
PF[b] self-evaluation	811	8.6	n.s.	684	22.7**	1 > 2 > 0	1495	15.1	n.s.
PA[c] in the future	813	7.9	n.s.	676	5.8	n.s.	1489	8.7	n.s.

[a] leisure time physical activity, [b] physical fitness, [c] physical activity, [d] number of siblings: "0" only-children, "1" one brother/sister, "2" two or more brothers/sisters, statistical significance level: * $p \leq 0.05$, ** $p \leq 0.01$, n.s. – not significant

Table 4. People listed by boys as co-participants of Leisure Time Physical Activity (LTPA, %), mean scores for perceived encouragement and physical activity of significant others and mean number of forms of physical activity depending on the number of siblings

n = 1513	Only-children		One sibling		Two or more siblings	
	Answers	%	Answers	%	Answers	%
Partners during LTPA						
Alone	92	48.9[a]	401	42.8	142	37.1
Parents	30	16.0	95	10.1	28	7.3
Siblings	–	–	168	17.9	70	18.3
Best friends	138	73.4	726	77.5	307	80.2
Others	14	7.4	92	9.8	46	12.0
	n	Mean	*n*	Mean	*n*	Mean
Perceived encouragement[b]	383	1.9	940	1.8	187	1.8
Perceived physical activity[b]	383	2.5	940	2.6	188	2.5
Number of LTPA forms[c]	373	2.1	906	2.3	180	2.2

[a] percentages do not total 100%, as the participants could give more than one answer, [b] mean scores for significant others (father, mother, siblings, best friend and class-teacher), [c] mean number of activities (sports) listed by boys as most often practiced in their leisure time

Table 5. Level of somatic parameters and motor fitness (normalised values) depending on the number of siblings (n = 1265). Values and significance levels of ANOVA and Student's t-test

Age	Number of siblings			ANOVA		Difference between		
(years)	0	1	2+	F	*p*-level	0–1	0–2+	1–2+
				Body height				
10–12	0.212	0.016	–0.143	3.713	0.025*	n.s.	0.013*	n.s.
13–15	0.083	0.044	–0.064	0.781	0.459	n.s.	n.s.	n.s.
All	0.155	0.028	–0.106	3.909	0.020*	n.s.	0.011*	0.045*
				Body mass				
10–12	0.218	0.051	–0.235	7.229	0.001***	n.s.	0.001***	0.002**
13–15	0.181	0.043	–0.131	2.731	0.066	n.s.	n.s.	n.s.
All	0.201	0.048	–0.185	9.543	0.000***	n.s.	0.001***	0.002**
				BMI				
10–12	0.194	0.057	–0.242	7.222	0.001***	n.s.	0.001***	0.001***
13–15	0.194	0.041	–0.146	3.232	0.040*	n.s.	0.020*	n.s.
All	0.194	0.051	–0.196	10.108	0.000***	n.s.	0.000***	0.000***
				Subcutaneous fat				
10–12	0.191	0.067	–0.265	8.504	0.000***	n.s.	0.000***	0.000***
13–15	0.310	–0.004	–0.143	4.983	0.007**	n.s.	0.002**	0.018*
All	0.244	0.037	–0.207	12.131	0.000***	0.018*	0.000***	0.000***
				Endurance shuttle run				
10–12	–0.243	0.026	0.055	2.772	0.063	n.s.	n.s.	n.s.
13–15	–0.465	0.070	0.063	7.284	0.001***	0.000***	0.001***	n.s.
All	–0.336	0.044	0.058	9.014	0.000***	0.000***	0.000***	n.s.
				Hand grip				
10–12	–0.003	0.079	–0.175	3.969	0.019**	n.s.	n.s.	0.006**
13–15	–0.025	0.041	–0.047	0.442	0.643	n.s.	n.s.	n.s.
All	–0.013	0.063	–0.115	3.605	0.028*	n.s.	n.s.	0.008**
				Bent arm hang				
10–12	–0.228	–0.043	0.180	5.554	0.004**	n.s.	0.002**	0.013*
13–15	–0.236	0.005	0.140	3.171	0.043*	n.s.	0.019*	n.s.
All	–0.231	–0.023	0.162	8.522	0.000***	0.016*	0.000***	0.005**
				Sit ups				
10–12	–0.042	–0.058	0.164	3.086	0.046*	n.s.	n.s.	0.013*
13–15	–0.258	0.047	0.058	2.879	0.057	n.s.	n.s.	n.s.
All	–0.136	–0.014	0.114	3.586	0.028*	n.s.	0.009**	n.s.
				Sit and reach				
10–12	–0.015	–0.016	0.059	0.353	0.703	n.s.	n.s.	n.s.
13–15	–0.176	0.070	–0.060	2.194	0.113	n.s.	n.s.	n.s.
All	–0.087	0.020	0.003	0.768	0.464	n.s.	n.s.	n.s.
				Standing broad jump				
10–12	–0.038	0.004	0.002	0.069	0.933	n.s.	n.s.	n.s.
13–15	–0.262	0.074	–0.025	3.501	0.031*	0.010**	n.s.	n.s.
All	–0.139	0.034	–0.011	2.034	0.131	n.s.	n.s.	n.s.
				10 × 5m shuttle run				
10–12	–0.149	0.028	0.007	1.149	0.317	n.s.	n.s.	n.s.
13–15	–0.347	0.089	–0.005	5.323	0.005**	0.001***	0.032*	n.s.
All	–0.234	0.053	0.001	5.331	0.005**	0.001***	0.017*	n.s.
				Plate tapping				
10–12	0.119	–0.0584	0.083	2.002	0.136	n.s.	n.s.	n.s.
13–15	–0.299	0.080	–0.025	4.422	0.012*	0.003**	n.s.	n.s.
All	–0.068	0.000	0.032	0.538	0.584	n.s.	n.s.	n.s.
				Flamingo balance test				
10–12	–0.222	–0.024	0.164	4.596	0.010**	n.s.	0.004**	0.037*
13–15	–0.303	0.017	0.045	3.503	0.031*	0.013*	0.018*	n.s.
All	–0.258	–0.007	0.107	9.543	0.000***	0.003**	0.000***	

Significance level: * $p \leq 0.05$, ** $p \leq 0.01$, *** $p \leq 0.001$, n.s. – not significant

ANOVA showed significant differences in BH (F = 3.909, p = 0.020*), BM (F = 9.543, p = 0.000***), BMI (F = 10.108, p = 0.000***) and log SFT (F = 12.131, p = 0.000***). The only-children (NS0) have the highest normalised means of these parameters, followed by boys with one brother or sister (NS1) and boys with two or more siblings (NS2). The results of measurements of boys from the largest families are significantly below the normalised mean. No significant differences were noted between the boys in groups NS0 and NS1, except for the level of body fatness in all subjects.

The excent of differences varies with the age group and the parameter analysed. In the younger group, significant differences in all somatic parameters were noted. In the older group, there is no difference in BH and BM (F = 0.781, p = 0.459 and F = 2.731, p = 0.066, respectively), and the difference in BMI (F = 3.232, p = 0.040*) and subcutaneous fat (F = 4.983, p = 0.007**) is noted. The number of siblings is the least related to BH – the differences are significant only in younger boys (F = 3.713, p = 0.025*) between the NS0 and NS2 groups. The strongest statistical differentiation is noted for log SFT – in both age categories significant differences occur between the NS0 and NS2 groups, as well as between the NS1 and NS2 groups.

Motor component

From among the five components specified in Renson's concept as more health-related, the results of four tests show significant relations with the number of siblings (Tab. 5). The results of endurance shuttle run and bent arm hang test are most strongly related to the number of siblings.

The number of siblings is significantly related to the results of the endurance test in the older group (ANOVA F = 7.284, p = 0.001***) and for all participants (F = 9.014, p = 0.000***). The bigger the number of siblings, the better the results. Significant differences occur between only children and other boys who have siblings (NS1, NS2). The results of the bent arm hang test are different depending on the number of siblings in the younger group (F = 5.554, p = 0.004**), in the older group (F = 3.171, p = 0.043) and for all participants (F = 8.522, p = 0.000***). With the rising number of siblings the level of motor fitness is increasing. The differences occur in the younger group between NS0 and NS2, and bettween NS1 and NS2, in the older group between NS0 and NS2 and in the combined group between all sibling categories.

The results of the hand grip and sit-ups tests are significantly different depending on the number of siblings in the younger group (F = 3.969, p = 0.019**; F = 3.086, p = 0.046*, respectively), and differences are noted between NS1 and NS2.

The results of the four performance-related tests are significantly related to the number of siblings to a various degree and in various age groups (Tab. 5). In the case of standing broad jump and plate tapping single relations appear in the older category between the NS0 and NS1 groups (F = 3.501, p = 0.031* and F = 4.442, p = 0.012*, respectively). The NS1 group achieves the best results in both tests, followed by NS2 and NS0.

The results of the 10 × 5 m shuttle run test show significant differences in the older group (F = 5.323, p = 0.005**) and for all participants (F = 5.331, p = 0.005**). Differences are noted between groups NS0 – NS1 and NS0 – NS2. The highest normalized means are achieved by the boys in the NS1 group and the lowest by the boys in NS0 group.

The results of the flamingo balance test differ significantly in the younger group (F = 4.596, p = 0.010**), in the older group (F = 3.503, p = 0.031*) and for all participants (F = 9.543, p = 0.000***), mainly between only children and other groups. The relation is directly proportional – the larger the number of siblings, the higher the level of performance/fitness.

Relative motor fitness

Tab. 6 shows the differences in motor fitness in boys with various number of siblings divided by absolute values of somatic parameters. The data include the whole group aged 10–15, without the division into age groups.

The ANOVA values show significant motor fitness differences between boys only in few ranges of somatic parameters. The number and significance of these differences depend on the test and the type of somatic parameter analysed. The greatest number of significant differences (nine) in results of motor tests between boys with different numbers of siblings was noted for BH, slightly fewer for BM and BMI (four and five, respectively) and only two in the case of log SFT. The analysis of motor fitness in separate categories of thickness of subcutaneous fat tissue eliminates the differences between the groups of boys with various numbers of siblings, even in the case of tests results that significantly differ if analysed without the division into somatic categories (endurance shuttle run, hand grip, bent arm hang, sit-ups, a 10 × 5 m shuttle run and flamingo balance tests). Boys with various numbers of siblings, but with a similar subcutaneous body fat, have similar results.

In three tests (sit and reach, standing broad jump, plate tapping), the differences basically do not occur after the division into categories of log SFT. Significant differences are revealed only in single categories of body height.

Discussion

As revealed, individual components of health-related fitness may be related to the adopted criterion of social inequality to a different degree. A commonly used measure of social inequalities, i.e. body height, revealed to be less sensitive than other somatic parameters. Certain aspects of physical activity, a behavioural component of health-related fitness, were different depending on social position which justifies inclusion of this kind of variables in the research into social inequalities. Moreover, the relationships between the variables of motor fitness and somatic parameters revealed another useful information allowing an additional interpretation of causes and results of social inequalities.

Physical activity

No significant differences in frequency and relative duration of LTPA between boys with various number of

Table 6. ANOVA's p-levels of differences in normalised results of motor fitness tests in boys aged 10–15 with different number of siblings. Analysis conducted for separate categories of body height, body mass, BMI and log SFT (subcutaneous fat)

Tests[a]	ESR	HGR	BAH	SUP	SAR	SBJ	SHR	PLT	FLB
Before[b]	0.000***	0.028*	0.000***	0.028*	0.464	0.131	0.005**	0.584	0.000***
Body height (cm)									
≤ 141.4	0.24	0.72	0.68	0.27	0.67	0.87	0.68	0.23	0.13
141.5–148.2	0.45	0.20	0.09	0.06	0.013*	0.71	0.30	0.59	0.045*
148.3–155.0	0.28	0.61	0.36	0.24	0.85	0.95	0.48	0.56	0.43
155.1–161.8	0.026*	0.46	0.015*	0.74	0.14	0.15	0.042*	0.93	0.39
161.9–168.6	0.001***	0.28	0.12	0.15	0.86	0.013*	0.033*	0.020*	0.07
168.7–175.4	0.11	0.14	0.14	0.24	0.47	0.59	0.53	0.54	0.97
≥ 175.5	0.77	0.64	0.23	0.50	0.67	0.46	0.57	0.21	0.63
Body mass (kg)									
≤ 35.6	0.63	0.83	0.14	0.73	0.19	0.92	0.52	0.18	0.014*
35.7–46.7	0.11	0.017*	0.09	0.14	0.76	0.19	0.39	0.50	0.15
46.8–57.8	0.047*	0.70	0.009**	0.63	0.52	0.47	0.21	0.69	0.22
57.9–68.9	0.19	0.50	0.19	0.84	0.98	0.98	0.72	0.45	0.68
≥ 69.0	0.22	0.40	0.58	0.79	0.21	0.53	0.55	0.56	0.43
BMI (kg/m^2)									
≤ 17.00	0.09	0.98	0.035*	0.67	0.07	0.40	0.44	0.76	0.07
17.01–19.50	0.031*	0.09	0.54	0.54	0.042*	0.47	0.020*	0.98	0.45
19.51–22.00	0.010**	0.54	0.08	0.56	0.96	0.26	0.33	0.63	0.10
22.01–24.50	0.76	0.09	0.23	0.35	0.20	0.10	0.08	0.35	0.77
≥ 24.51	0.07	0.21	0.14	0.52	0.40	0.51	0.54	0.53	0.57
Subcutaneous fat – log SFT (mm)									
≤ 1.43	0.44	0.60	0.16	0.80	0.13	0.87	0.71	0.30	0.21
1.44–1.65	0.07	0.23	0.16	0.80	0.64	0.09	0.036*	0.67	0.44
1.66–1.86	0.037*	0.18	0.14	0.73	0.67	0.67	0.24	0.76	0.09
1.87–2.07	0.43	0.84	0.16	0.22	0.54	0.51	0.90	0.24	0.99
≥ 2.08	0.44	0.93	0.16	0.67	0.88	0.79	0.65	0.67	0.22

[a] tests: ESR – endurance shuttle run, HGR – hand grip, BAH – bent arm hang, SUP – sit ups, SAR – seat and reach, SBJ – standing broad jump, SHR – 10 × 5 m shuttle run, PLT – plate tapping, FLB – flamingo balance test; [b] ANOVA's p-levels before dividing in categories of somatic parameters, all boys aged 10–15; significance level: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

siblings were revealed, but significant differences were found in preferred forms of LTPA: morning gymnastics, training in sports clubs and participation in sport competitions. These types of LTPA are least often undertaken by only children who generally get involved in a smaller number of forms of LTPA and show usually a lower self-assessment of physical fitness. It was demonstrated that a larger percentage of only children than other boys, undertake LTPA on their own or with parents. It could be assumed that their physical activity, due to the lack of siblings, depends to a larger extent on their parents. This opinion may be supported by psychologists who report that only children and children from small families remain with parents in relations characterised by an increased level of anxiety and attention, so parents tend to devote them more time [16, 17].

It seems that the lack of siblings and stronger emotional relations with parents may be a limitation in undertaking physical activity, which in the long run may result in decreasing the level of physical fitness. Generally, stronger correlation of LTPA of boys aged 10–15 is noted with the LTPA of their peers than with that of their parents [18]. Some authors suggest to reinforce and use the relations between peers in the context of physical activity for improvement of health and wellbeing of youths [19]. This seems to be correct because the influence of parents on physical activity of children weakens with age, as the role of the family changes in a natural way from protection to partnership [20]. There are also reports which deny the fact of intergenerational cultural transfer of physical activity in a family [21].

Somatic parameters

The results obtained in the current study concerning somatic parameters are confirmed in the studies on the connections between social variables and physical development of Polish children [22]. The family size is a very significant social factor modifying body height, mass and fatness. The level of these parameters decreases as one moves from families with a small number of children to large families. However, body height, the most common measure of the effects of social inequalities, turned out to be the least sensitive somatic variable. This puts its value as inequality indicator in question. Of course, using body height is still justified in controlling the effect of developmental advancement. Thus, the application of parameters connected with body mass, being more environmental-sensitive, would be suggested.

In the present study, smaller somatic differences depending on the number of siblings in boys aged 13–15 years was noted which may suggest that the differences disappear with age (although the cross-sectional character of the study does not allow for an unquestionable conclusion). If this in fact is the case, the equalizing of the levels of somatic parameters with age would relate to the largest extent to relatively strongly genetically determined parameters (body height) and significant differences would be maintained in the case of parameters modified more by the environment (thickness of subcutaneous fat tissue).

Motor fitness

The results presented in this study show that with a lowering number of children in the family, the lower results in motor fitness tests are noted. It should be emphasised that the relation between the number of siblings and motor fitness has changed in Poland. In the 1960s, a trend reverse to the current one was observed – the fewer the children in the family, the higher the level of motor fitness [23]. In the following decades the lack of relation between the family size and motor fitness of children began to be noted [24]. It seems that as a result of socioeconomic transformation in Poland the relation between the number of siblings and motor fitness of children and youths has changed its direction. However, the picture of differences is not uniform and depends on the region and the size of place of residence, the stage of ontogenetic development of the participants, the type of socioeconomic factors which are the criteria of division, sex, etc. Also, specific types of motor abilities "react" with a different force to social differences, as this and other studies show [3]. Various effects of social differences can be observed in the results of motor tests. Therefore, the selection of motor tests for studies the aim of which is to determine or compare the health differences in a given population should be made according to the criterion of a possibly close relation of a given test to health.

The analysis of motor fitness level in separate somatic categories resulted in the elimination of the majority of differences between boys with different numbers of siblings. In other studies, a similar control of somatic parameters resulted rather in emphasizing already existing differences or appearance of new differences.

Dissimilar tendencies shown in this study may suggest that social differences in motor fitness are determined by the factors characteristic of the local social environment. Probably the reason is also the material and methodology of studies. In other works, differences between urban and rural children were compared [5], wheras in the current study the differences within a large city population were tested. As an inequality criterion other authors use rather comprehensive indicators of socioeconomic status, and not only the number of siblings, as in this study.

In the majority of studies, the researchers focus on differences in motor fitness of children in social context, however without the control of the somatic factor [3] or controlling only the body height that shows the level of developmental advancement [5]. The study of Gołąb [4] is an exception, as the level of motor fitness was shown compared to the lean body mass.

In this study, the key somatic parameter for differences in motor fitness was the thickness of subcutaneous fat tissue. When analyzing this factor in separate categories the differences in motor fitness between boys with various numbers of siblings were in principle nonexistent. Thus, the differences in motor fitness may be treated as a consequence of differences in the level of fatness; its excessive level is a factor limiting motor fitness, in particular in tests where relative strength determines the success. The level of fatness results to a large extent from the family conditions. The greatest thickness of subcutaneous fat tissue in children from one-child families seems to be a general rule, maintained for years in various environments and at various times in spite of changes in socioeconomic conditions of life of families [25–28]. The mechanism of this phenomenon is related, on the one hand, to the economic situation of the family, and on the other hand, to the parenting method related to the number of children, as mentioned above. In one-child families the highest per capita income, the highest consumption of food products and increased concern with health are observed [29] and differences between families of only children and large families increase at times of economic crises [16].

Moreover, mothers of only children, more than in larger families, concentrate on children's nutrition [25]. Mother's professional career and the number of children in the family may modify the type and frequency of meals eaten by children and youths [30].

The factor "number of siblings" accumulates variables of biological, economic, social and psychological character which directly affect somatic parameters and physical activity which is reflected in changes of motor fitness. In Poland, this variable is related to the degree of fatness in children more than other socioeconomic variables, even the birth order. Children in one-child families with a high socioeconomic status are at a greater risk of obesity [27, 28]. In spite of its genetic determinants obesity appears to be the result of psychosocial factors to a very large degree, mainly family-related and local influences [31, 32]. Social inequality in terms of obesity and overweight is also observed at an adult age in different countries [33–35] and an intergenerational transfer of these tendencies is pointed out [36].

Social position and health-related fitness measure

In the context of social inequalities, Rona et al. [37] suggested that Tanner's paradigm according to which "growth is a mirror of society" is not sufficient for the assessment of consequences of social stratification in countries with an average socioeconomic development (e.g. Poland). Using single indicators of physical development, e.g. body height, the lack of differences between Swedish children from various social classes was demonstrated in the 1970s [38], then this phenomenon was confirmed in Sweden again [39] and other countries [8–10]. These results are interpreted as achieving a high level of development by a given country and an equal access of all citizens to its resources. One cannot question the civilization achievements and a high level of living conditions in such countries as Sweden and the United Kingdom, but even in highly developed countries the lack of social differences in terms of body height does not mean the lack of differences in other important indicators of physical development and health [33, 40, 41]. As a matter of fact, such an observation is not surprising as social inequalities in the access to the commonly desirable goods are always result of complex interactions between socioeconomic and cultural factors, life and work conditions, social status, social bond and support, individual health behaviour and other (unmodifiable) factors like gender, age and genetic conditions [42].

As has been demonstrated, the social factor specified as the number of siblings is related to the level of physical activity, somatic parameters and motor fitness, but to a different extent in each case. A combined analysis and interpretation of all these groups of variables gives a fuller picture of relationships between social inequalities and health and well-being of the population allowing a more detailed interpretation of inequalities.

Thus, it seems that the population analyses of social inequalities in physical fitness and health should include a possibly wide range of adequate measurements and indicators. Their selection is easier thanks to the concept of health-related fitness which in its basic form was used in the current study. Full measurements should include morphological, musculosceletal, motor, cardiorespiratory and metabolic components [2]. Moreover, it is necessary to take into account basic elements of lifestyle, i.e. quantity and quality of physical activity, food patterns, use of stimulants and drugs, behaviour risky for health and the effect of physical environment. Extremely important is the picture of sociopsychological influences (family, local community, school, personality, motivation).

Conclusions

1. The inequality in social positions of urban boys correlates with the differences in the level of health-related fitness.
2. Significant differences in preferred forms of physical activity between boys with various numbers of siblings were found.
3. The level of body height, mass and fatness decreases as one moves from families with a small number of children to large families.
4. Smaller somatic differences depending on the number of siblings were noted in the older group of boys, which may suggest that this type of differences disappears with age.
5. In general, with the lowering number of children in the family, lower results in motor fitness tests are noted but specific types of motor abilities "react" with a different force to social position differences.

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PSEUDO-FANS – THE ANALYSIS OF THE PHENOMENON OF POLISH FOOTBALL HOOLIGANISM

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ABSTRACT
We have witnessed many intriguing social phenomena at the turn of the 20th and 21st centuries. Researchers of physical culture and sport, especially those interested in philosophical and social aspects of events, are likely to come across many surprising situations resulting from the dynamic development of social reality. Sport has undoubtedly become one of the factors that have a great influence on numerous social occurrences. From among various phenomena related to sport the author analyses the one which has riveted the attention of many people interested in sport – the stigmatization of contemporary sport by hooliganism. This problem may seem to concern mainly football (Am. soccer), but unfortunately it occurs in other disciplines as well. Although the phenomenon reaches the edges of sport and is still just within its margins, it appears necessary to conduct thorough research on it.

Key words: football, fans, pseudo-fans, hooliganism

Introduction

The paper is concerned with the introduction and analysis of a very important social phenomenon, which is football hooliganism. Several methods have been used to create this work. The basic one was, obviously, going to stadiums during football matches and actively observing various groups of recipients of sports spectacles. Talking with sportsmen, following the Internet forums and reading different publications on the subject completed the observations.

"Hooligans", "fanatics", "pseudo-fans" and "vandals" these are the words used interchangeably to describe certain (minor) part of sports audience, mainly the participants of football matches, speedway and ice-hockey [1–4].

Pseudo-fan (in Greek *pseudo* means *a lie*) is the pretence, an imitation which merely bears an exterior resemblance to a true fan. The fans differ from the pseudo-fans in the intensions with which they go to stadiums [5–8]. Pseudo-fans see themselves as representatives of clubs (cities, regions and even whole countries) standing side by side with real fans [9–10]. Their attachment to clubs' colours and symbols is often on the verge of nationalism [11–16] and fanaticism similar to religious fundamentalism. Different groups of pseudo-fans fight each other using all possible methods. The aim of those clashes is to prove who is physically stronger, who dominates in a particular area and, thus, to show – paradoxically – whose club is better [17–19].

Football hooligans are mainly active in fights and acts of vandalism; however, their actions are often preceded by serious planning and therefore can be seen as logical [7, 20–22]. Hooligans constitute a well organised community with an elaborate structure [10, 23–24]. Different groups of fans of various football clubs have complex relationships with each other. Those relationships are based on three main elements: **"friendship"**, **"hostility"** and **"agreement"** (neutral relationships). Hooligans fight according to a particular "system": to fight with fans of some clubs is simply obligatory, whereas the very same fans, at the same time, support fans of other clubs in their fights with their "enemies". There are also fans towards which they remain indifferent. Some groups of fans make tactic alliances (so called **"triads"** [8]). One of the most important "triads" in Poland is Arka Gdynia, Cracovia Kraków and Lech Poznań.

During matches of Polish national football team a relative truce is in force; fans of particular clubs can wear their colours, however, they should not manifest them.

Apart from fighting their “everlasting” enemies, **fighting the police** is a must for every football hooligan. Sometimes fans who detest each other most join their forces to fight policemen. Supporting the police in their routine, preventive activities aimed at fans of the rival club is considered “unfair”, which means that it is seen as infringing the hooligans’ code of conduct. Such behaviour disqualifies any group of hooligans.

“Hooligans league” is a constantly updated ranking of scale and effectiveness of hooligans’ actions such as acts of vandalism, brawls or scuffles with the police.

Mass media and votes on the Internet forums are authorised sources of information about those actions. Hooligans supporting Arka Gdynia, Lech Poznań, Legia Warszawa, Cracovia Kraków and Śląsk Wrocław are considered the most radical ones.

Hooligans supporting different clubs often hunt for each other. The trouble moments occur on their way to matches. Hooligans supporting rival clubs organise **“traps”** for their enemies on railway tracks, access roads to stadiums or narrowest parts of city streets [10]. That is why police forces are often organised to accompany groups of fans who travel either by special trains or special buses.

Many pseudo-fans do not wear clubs’ scarves; neither will they go to matches. They take part in “tournaments” outside stadiums. The number of “competitors” on either side is the same. The fights are organised according to strict rules – either with **“equipment”** or without it. And thus, hooligans are equipped with baseball bats, knives, axes, machetes, chains, etc. [8, 25–29]. To win such a fight means to gain prestige; that is why the hooligans train beforehand or even organise sparring fights. They rent sports halls, hire martial arts instructors and test various methods and tactics. They often wear identical sports outfits with the same inscriptions on them. Arka Gdynia fans set up a rugby team and took the second place in Polish Rugby Championship. Before the 2006 World Cup in Germany, Polish pseudo-fans pitted themselves against German pseudo-fans to find out who “the true host” of the World Cup was.

Football hooligans constitute a well-organised lobby which is gradually gaining power in modern society. Their actions are not only restricted to football stadiums. They often get involved in social disputes including those not related to sport. The examples of their actions outside stadiums are numerous – the confrontation with antiglobalists during the economic summit in Warsaw, in 2004, the pacification of university students’ festival in Łódź, in 2004, crushing legal demonstrations in Kraków, Poznań and Warsaw, in 2004–2006, to name but a few. The most active fighters in the riots in Budapest during the 50^{th} anniversary of the Hungarian Revolution were pseudo-fans along with skinheads.

The most common stereotype about football hooligans is the belief that they come from social margin. Unfortunately, among hooligans who use sports events as a pretext for brawls are the members of all social groups. Junior high school students, secondary school students, university students, managers and even policemen take part in those disturbances. Sometimes hooligans accept professionally active sportsmen (e.g. martial arts experts) to increase their chances of winning the “tournament”. Igor Sypniewski, once a member of Polish national football team, has been repeatedly arrested for taking part in hooligans’ brawls.

Conclusions

The results of the activities of football hooligans have gradually become more dangerous for the hooligans themselves and more bothersome for the outsiders who simply want to enjoy sports events. Stadium hooligans from various backgrounds have caused a paradoxical situation. The audiences of sports competitions, being obviously their reactive recipients, have become such an important element of the competition that in extreme (but numerous) cases it is the audience that makes the event impossible. By causing problems during sports events, pseudo-fans force sports officials to take serious steps such as punishing the clubs by closing their stadiums and moving matches to different places. Thus, the real fans cannot participate in the events. Football hooligans have become the terrorists for contemporary sport.

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THE ANALYSIS OF CHOSEN CHARACTERISTICS OF ALUMNI WHO STUDIED THE PROGRAM PHYSICAL EDUCATION AND SPORT AT UNIVERSITY OF WEST BOHEMIA IN PILSEN

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ABSTRACT
The aim of the survey was to monitor the development of professional career of alumni who had accomplished the Physical Education and Sport program and finished their studies at the Faculty of Education of the University of West Bohemia in Pilsen in the years 1998–2005. Of the 254 questionnaires distributed 97 were returned – reaching a 38.1% response rate. 69.1% of all alumni were those of the master program and 30.9% were non-pedagogical bachelors. 69.1% of alumni work in the field they studied (education or physical education and sport services). The following characteristics were monitored: further education, job choice criteria and retrospective evaluation of the content of education they had undertaken. When interpreting the results the author analyzed the workplace and region specifics.

Key words: graduates of the West Bohemia University, physical education and sport graduates, evaluation of study plan, professional assertion in employment

Department of Physical Education and Sport (DPES) of the Faculty of Education at the University of West Bohemia in Pilsen

The Faculty of Education in Pilsen was established in 1948 and it existed as an independent school preparing teachers of elementary and high schools until 1990.

In 1991, it became one of the founders of the newly established University of West Bohemia in Pilsen, which now consists of seven faculties [1].

Following changes in conception of preparation of elementary and high school teachers necessary changes were also introduced in curricula of physical education (PE). The reform of the whole educational system caused changes in PE study programs in terms of content and duration of the study.

For current situation in physical education at DPES of the Faculty of Education at the University of West Bohemia in Pilsen, the crucial factor was finishing the restructuralization process of the study programs.

Accreditation of the new study programs was completed in the academic year 2006/2007. Since then the Department has been preparing future teachers of physical education in the following way. First, in a three years' bachelor's degree, where students study mostly professional subjects, and then in a follow-up two years' master degree where subjects for mastering the pedagogical competence are included. Apart from those programs, the Department of Physical Education and Sport provides a three years' bachelor study program of non-pedagogical physical education and sport that also allows the students who have met the requirements of entrance exam to continue in the follow-up master study.

These study programs at DPES are taught by seventeen internal and nine external teachers. Professionalism of the staff is also projected in cooperation with the various sport federations at the regional as well as national level, which is positively reflected in the work of the department when granting instructor and coach licences to students that have passed optional study programs. On the basis of officially concluded agreements about international cooperation DPES has contacts with universities in Great Britain, Denmark, Turkey, Poland and Slovakia. Research activities of DPES take place predominantly in the Center of Sport Diagnostics. The department also closely cooperates with the Sporting Youth Foundation in Pilsen.

Introduction

On a European scale, the learning and good-quality education is currently considered to be a standard. Also, social transformation has initialized many changes in the Czech educational system.

Changes were also due to the weaknesses of the educational system in the Czech Republic at the end of the last century, when problems had cumulated and began to exert negative influence on the work of teachers. Changes in the social status of teachers – lack of recognition and social prestige, as well as poor financial reward caused serious outflow of a generation of young alumni to a better paid work, though sometimes requiring less qualification [2–4].

This situation is one of the stimuli to researchers who monitor professional careers of university alumni, for example, Janak [5], Jansa, Kocourek [6], Tilinger, Smidova [7], and others. The latest research was also the project of Grant Agency of the Czech Republic 406/052670 "Career of Alumni that Studied the Program Physical Education and Sport on Labor Market in the Czech Republic". The research was sponsored by UK FTVS in Prague and UP FTK in Olomouc, and eight other Faculties of Education from the Czech Republic, including our Faculty in Pilsen, took part in it.

In this nationwide research 4330 respondents were addressed. They were alumni of the study program "Physical Education and Sport" from 1998–2005. Of the 1855 responses returned, 891 were given by women and 964 by men.

In the paper, we present partial results obtained through the survey concerning the alumni of the study program "Physical Education and Sport" at the Faculty of Education of the University of West Bohemia in Pilsen, who finished their studies in the years 1998–2005. There were distributed 254 questionnaires, of which 97 were returned, 55 by men and 42 by women.

It is worthwhile to note a spontaneous reaction of some alumni who added detailed information about their professional or sport careers after they had finished their studies, or some recollections from that period.

Material and methods

The aim of the survey was to monitor the development of professional career of the group of alumni mentioned above. Our focus was to get up-to-date feedback about their careers and position on the labor market. Quite often these pieces of information appeared to be inspiring as regards our Department, particularly when creating new follow-up study programs that were submitted to accreditation.

The main method relied on a 17-item "Questionnaire for alumni" with choice of alternative answers. It contained four thematic units:

- current job in state, communal or federal (concerning physical education) services including private sector,
- motivation to study the "Physical Education and Sport" program, acquiring additional qualifications,
- satisfaction with current job, as seen from different points of view,
- assessment of the study program "Physical Education and Sport".

The questionnaire was tested through the pilot study and it was consequently modified for the needs of nationwide research.

The questionnaires were sent to alumni of the study program "Physical Education and Sport", and were to be answered from September to December 2005. The respondents had been guaranteed the anonymity but they could sign the questionnaire, if they wanted to.

The data obtained were statistically analyzed and collected in frequency tables, being presented per cent and also graphically in doughnut charts.

Results and discussion

The alumni accomplished studies following two types of programs. These were a non-pedagogical bachelor study program of physical education and sport (30.9% questionnaires returned) or master study program of physical education for elementary schools (4 year study) or high schools (5 year study) in combination with other majors (69.1% questionnaires returned) (Fig. 1).

In Fig. 2, we show frequency charts of answers given by women (43.3%) and men (56.7%).

Fig. 3 reflects reasons for the choice of the study program Physical Education and Sport. Two thirds of the alumni (66%) marked the answer "I like to do sport", 17.5% chose "I was interested in sport". Only 7.2% of the respondents marked "I like to work with children, among people". Still less respondents (4.1%) indicated the answer "I liked the job of a teacher". The remaining five choices with frequency of 1% can be considered as interpretatively insignificant. 83.5% of the alumni marked as clear priority and motive, generally speaking, the need for movement or interest in sport.

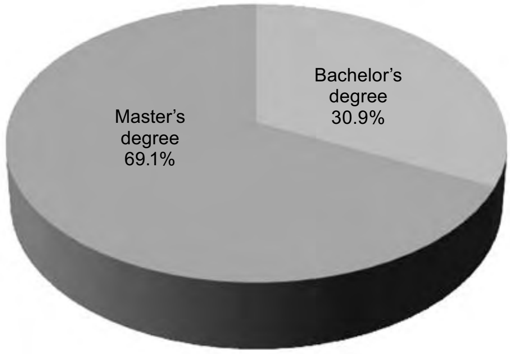

Figure 1. Study program

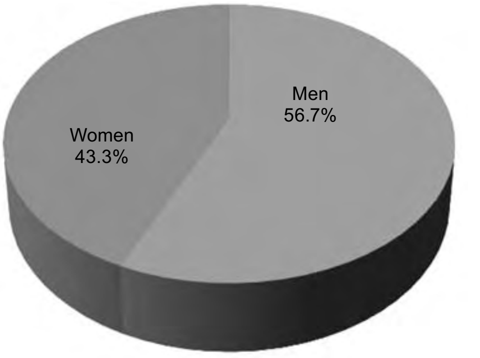

Figure 2. Characteristics of respondents

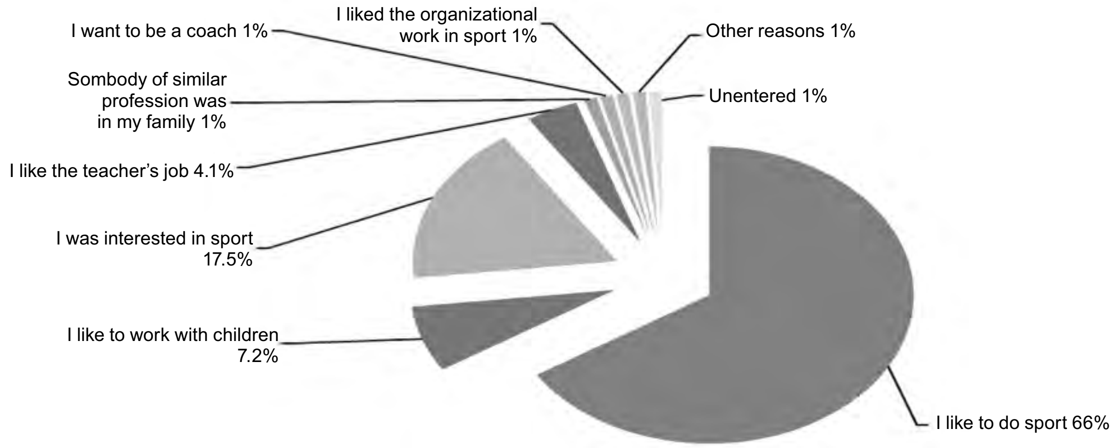

Figure 3. The reason for entering the study of physical education and sport

Considering the experience gained during lessons we can state that personal direction of students plays an important role during studies. On the other hand, it is often expressed in their sometimes distorted ideas about the content and forms of physical education and sport. At least the first year of the study is devoted by some students to developing and shaping of appropriate approach to study requirements. Obviously, more often it is during bachelor non-pedagogical study that the idea prevails that study will be like a "training camp". This results in certain underestimation of so called theoretical subjects (anatomy, history of physical culture, and so on). These ideas are projected to a certain extent onto the course of education, due to which some students have difficulties with filling actual, mostly practical, credit requirements.

We must state that the reason for this is not only personal but it is also due to many other factors generally infuenced by social conditions and to a certain degree by regional specifics, too.

We can assume that the "need of movement" (66%) and "interest in sport" (17.5%) is positively expressed even during studies when selecting optional programs leading to getting various types of coach or instructor licenses. Certain motivational role, e.g. in soccer, can be possibly played by the perspective possibility to use coach licenses, which students can get during studies, in nearby Germany. Already when studying, some students, soccer players, participate in German regional competitions. Some, after finishing active player's career, also find professional job in Germany as an assistant of coach or a coach, where they commute approximately 2 or 3 times a week. We also notice this cross-borders phenomenon, but to a much lesser degree, among students playing handball. They use coach license, which they got during their studies, and this "part-time job" considerably enhances their living standards.

Our experience gained during implementation of the system of optional subjects to study programs, the output of which are coach or instructor licenses recognized by relevant sport federations are as follows. In terms of the content of the studies we are assured that university education is not necessary for acquiring licenses, e.g. in soccer UEFA does not expect university education. But on the basis of agreement with individual sport federations the offer and possibility of acquiring coach and instructor licenses during studies contributes to their attraction in current market-oriented offer of studies at the Czech universities preparing bachelors and masters in physical education and sport. Naturally, the problem is not theoretical basis of license study but it can be the missing or short coach practice.

In the analysis of data concerning the problem of employment 59.8% of alumni point to the work in educational system as their main profession. 9.3% work in federal services in the area of physical education and sport (coach, instructor or other profession). Almost one third of alumni (27.8%) work in other fields, which is quite a big number, though expected, and 3.1% belong to unemployed (Fig. 4).

A detailed analysis of frequency of the full time job is presented in Fig. 5. The highest percentage of alumni are employed in elementary education (34%), and then higher education (16.5%) follows. 4.1% of them teach PE at private schools, 3.1% at universities and 2.1% at vocational schools. Altogether, 59.8% respondents work as PE teachers.

A detailed interpretation of the data is much more difficult and not so clear. In reality, many of the alumni of bachelor non-pedagogical study teach at various types of school. Their trend is "to go to teach", which was also confirmed by entrance exams to follow-up master study for the academic year 2007/2008, because there were over 30 alumni of non-pedagogical bachelor study of physical education and sport. Some of them already teach in the various types of schools in the regions of Pilsen and Karlsbad. It is yet true that especially in the regions of Sokolov and Karlsbad there is lack of qualified teachers of physical education.

On the other hand, some alumni of master study work outside the area of education, often in various

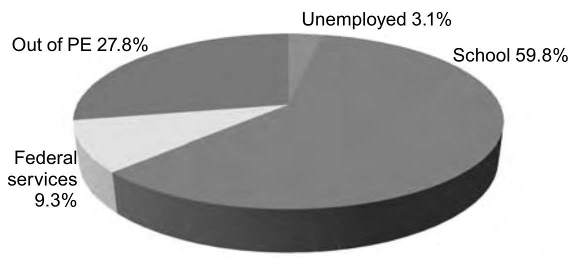

Figure 4. The main job

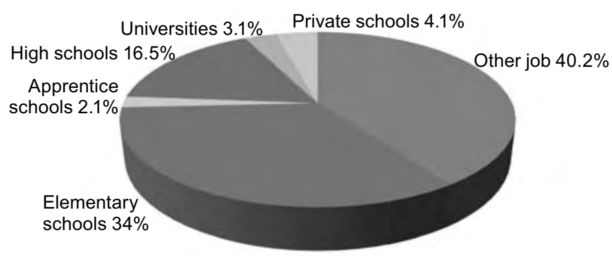

Figure 5. The main job – schools

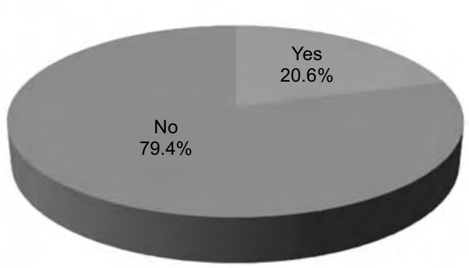

Figure 6. Additional education

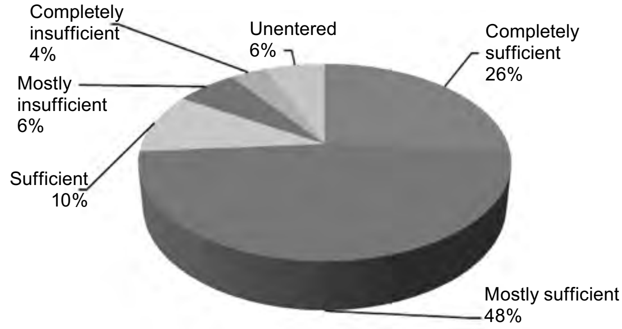

Figure 7. Do you consider education for your current job sufficient?

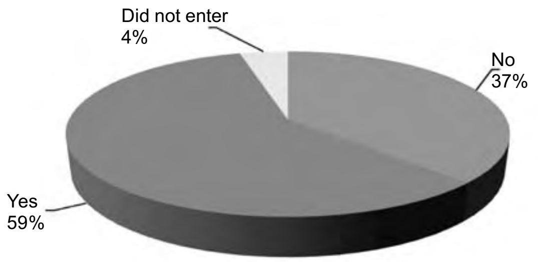

Figure 8. I received additional education or qualification after finishing the studies

managerial positions, using benefits of their creativity "of physical education teacher", adaptability and communication abilities.

Results in Fig. 6 show certain satisfaction with education acquired or repulsion to additional education (79.4%). We can only hypothesize about the causes of such a situation. This can, for example, be a short time interval (1–7 years) since the end of the studies. Another reason can be not motivating, or more precisely not existing, system of career growth of teachers or amount of financial evaluation of their work.

Fig. 7 even more strongly documents the facts mentioned above. 86.6% of alumni consider gained education as sufficient (21.6% as completely sufficient, 39.2% mostly sufficient, and 25.8% as sufficient) and only 8.3% as insufficient (3.1% as completely insufficient and 5.2% as mostly insufficient). 5.2% of respondents did not express their opinion.

In Fig. 8, a certain discrepancy in the answers of respondents is clearly seen. 58.8% of alumni state that after finishing the studies they gained additional education or qualification, which does not markedly correspond with the results mentioned (e.g., 86.6% consider education as sufficient) (Fig. 6, 7). One probable explanation is that our alumni consider also short one-day or few-days educational courses and seminars as additional education.

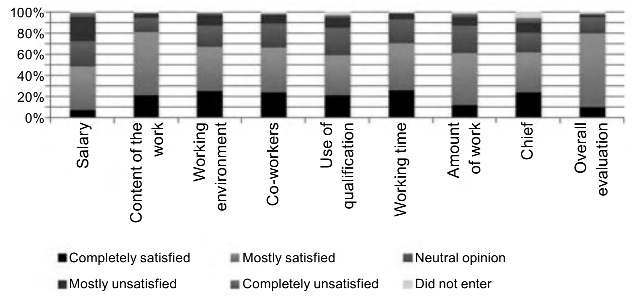

Figure 9. Job satisfaction

Results indicating satisfaction of our former students with current job are presented in Fig. 9. Satisfation with salary was stated, as expected, only by 48.4% of respondents (but complete satisfaction only by 7.2%), dissatisfaction was stated by 26.8% of respondents. The highest satisfaction was with the content of the work (80.4%), then with the working time (70.1%), working environment (67%) and co-workers (66%). Less satisfaction was with superiors (61.8%), and the biggest dissatisfaction (13.4%) with salary. Satisfaction with the amount of work was indicated by 60.8% and with use of qualification by 58.7% respondents.

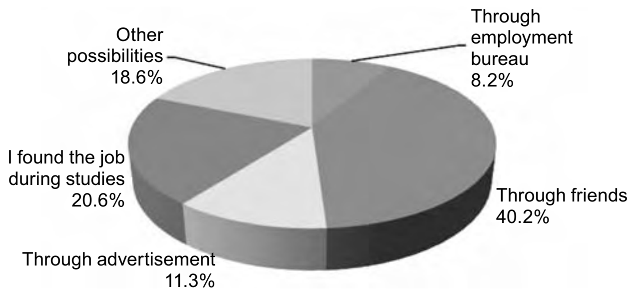

Figure 10. The way of searching for a job

Fig. 10 depicts the way of seeking a job. 20.6% of alumni got a job already during their studies. This corresponds with our experience from practice because quite a big number of students start to teach externally part-time when they are in the last grades of their study. If they study part-time, this even allows them to work full-time.

40.2% of respondents got a job "through friends", so it occurrs that personal contacts play an important role in education when seeking a job. On the other hand, only 8.2% of alumni got a job through an official institution, that is, employment bureau, and 11.3% through advertisement.

In Fig. 11, we can see criteria of current job selection. The largest number of alumni (38.1%) indicate as the main criterion of selection prospects of material advantages. Next, 16.5% of respondents point to financial attraction. One fifth (20.6%) of them prefer attraction of the job content. From the social point of view a negative sign characteristic of alumni from the Faculty of Education of the University of West Bohemia in Pilsen is that merely 4.1% of respondents consider social assessment of their work as the most important criterion. Personal satisfaction with the work is the priority for only 3.1% of respondents.

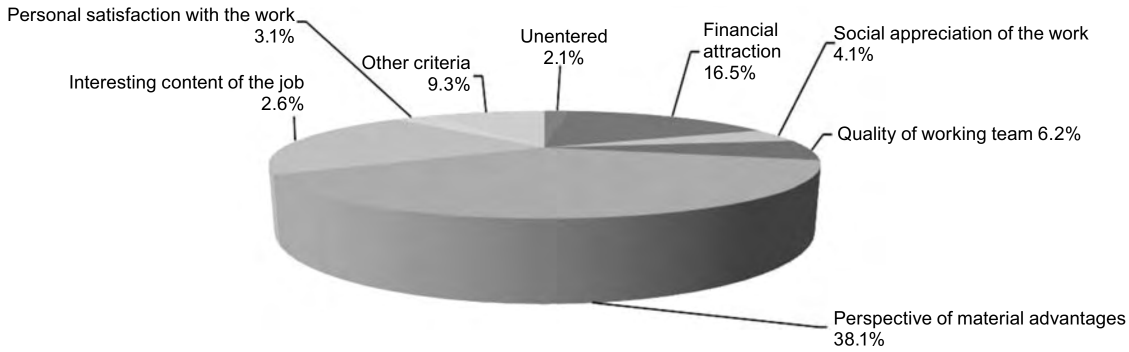

Figure 11. Criteria when selecting current job

As regards this criterion, our results quite strongly differ from the results of other universities. Besides general social criteria there can be regional demographic specifications of Pilsen and Karlsbad regions. We can assume that closeness and quite easy access to the border regions of Germany may influence, for example, value orientation of our alumni. The above statements are evidenced by 54.6% of respondents who mention prospects of material security (material advantages 38.1% + financial attraction 16.5%) as the criterion of personal satisfaction.

Similarly assessed were "too theoretical education" (63.9% did not agree) and "overlapping of knowledge" (74.2% did not agree). 38.1% of respondents expressed preference to the "amount of knowledge instead of deeper knowledge".

90.7% of respondents do not evaluate the amount of lessons in the program as too big. This fact does not correspond with the current trends of decreasing the amnount of face-to-face teaching. A certain role is played here by the specifics of the study program physical education and sport.

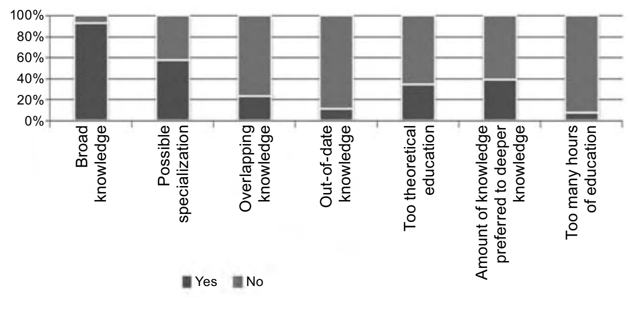

Figure 12. Physical education

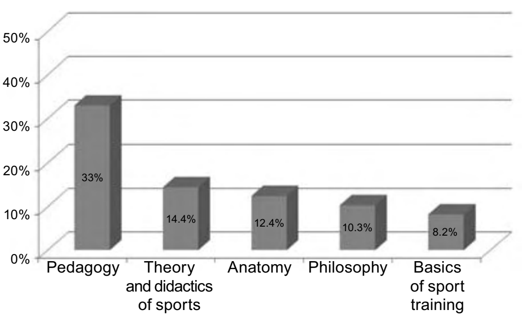

Figure 13. The most important subjects

In Fig. 12, we present results from monitoring education at DPES from the point of view of its conception and structure. 90.7% of respondents are convinced that accomplishing the physical education and sport programs gave them broad knowledge. Satisfaction with the possibility of specialization is indicated by 56.7% of alumni, which we understand especially as positive assessment of the possibility to gain coach and instructor licenses during studies.

As pretty positive assessment we can consider the statement of 86.3% respondents who said that education mostly did not contain old knowledge, which should be an elementary condition of the university education.

In Fig. 13, pedagogy is presented as the most important subject (33%), which can also be interpreted as a positive additional feedback assessment of this subject. With marked distance are presented the theory and didactics of sport (14.4%), anatomy (12.4%), philosophy (10.3%) and basics of sport training (8.2%).

The least important subjects are presented in Fig. 14. 37.1% of respondents put philosophy in the first place. We must state certain discrepancy in their assessment because it is clear from Fig. 13 that one tenth of respondents put philosophy in the fourth place.

In our opinion, unexpectedly 15.5% of alumni marked history of physical education as the second least

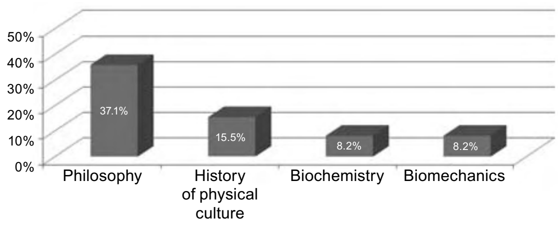

Figure 14. The less important subjects

important subject. As one of the possible explanations we see position of the subject in the study program, where it was included in the winter semester of the first year as limiting subject. From this indication it is clear that failing this subject meant the end of studies even in the frame of the credit system. This, quite hard uncompromising mechanism for students, was marked as "prolonged entrance examination". In the current follow-up study programs, the limiting subjects do not occur. We do not suppose that the reason for the aforementioned assessment of the subject was teacher's requirements.

In the third and fourth place, there were mentioned biochemistry and biomechanics (both 8.2%).

Subjects which according to respondents were most missing in education are presented in Fig. 15.

For interpretation of the subjects mentioned above, the variance of the assessment of this question was significant. A scale of 19 subjects was too wide. The pedagogical practice was marked as the most missing subject (9.3%). But it is necessary to mention a certain possibility of inaccurate understanding and presentation of the questions. The respondents completed pedagogical practice as a part of individual didactics of sports, as well as in the form of observing and continual pedagogical preparation at schools. That is why we understand the assessment with so low percentage (the subject was chosen by 9 respondents) rather as a minor impulse to extending the forms of pedagogical practice. Still lower percentage is noted in the case of such subjects as basics of sport training and biochemistry (6.2%), rehabilitation and non-traditional sports (5.2%). Another paradox (see philosophy) is that biochemistry is included in the most missing subjects and the least important subjects at the same time.

Out of remaining 14 subjects, 10 were chosen just once and for 4 of them the choice ranged from 3.1% and 4.1%, which meant three or four choices.

From the point of view of objective significance it is necessary to emphasize that of the 97 respondents only 54 selected 19 subjects and 43 (44.3%) did not indicate any subject. We can interpret this in terms of an absence of concrete idea or indecisiveness and uncertainty of alumni in answering the question about the subjects which were most missing in the studies. We consider the choice of subjects in this case as informative with quite low predicative value.

Conclusions

Of the 254 questionnaires addressed to the alumni of non-pedagogical bachelor or master program Physical

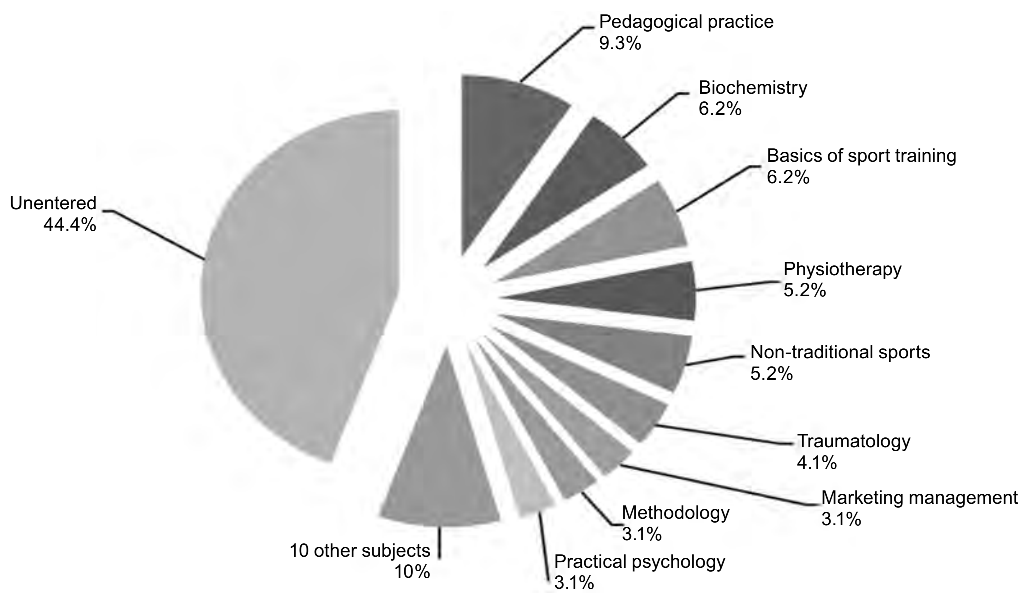

Figure 15. Subjects considered to be the most missing in the study program

Education and Sport, who finished their studies at the Faculty of Education of the West Bohemia University in Pilsen in the years 1998–2005, 97 were answered. This gives a 38.1% response rate. We received most of the questionnaires from respondents who had finished their studies in 1998 (17.5%), and the least number from the 2005 graduates (1%). As regards the years 1999–2004 the number of answers ranged from 10 to 15%.

The percentage of master study alumni is 69.1% and 30.9% of bachelor study. From the results presented it is clear that 69.1% of alumni work in the field they had studied (education or services in the field of physical education and sport) and 27.8% are employed in other fields.

In terms of education the answers appear to be inconsistent, because 86.6% of respondents consider education as sufficient, but on the other hand, 58.8% of them say that they gained additional education or qualification after finishing their studies. It is probable that these were only part time courses and seminars. The majority of the alumni (40.2%) got their job "through their friends" and the least (8.2%) got their job through employment bureau.

In overall evaluation, 79.4% of respondents expressed satisfaction with their job but only 48.4% of them expressed satisfaction with salary. Only 3.1% of the respondents prefer personal satisfaction to the work itself, compared to 54.6% of alumni who consider the perspective of material advantages (38.1%) or financial attraction (16.5%) as the main criteria. It is possible that these approaches are influenced by the feasibility of confrontation with the living standards of the inhabitants of nearby Germany.

Concerning the content of the studies, 90.7% of the respondents stated the possibility of acquiring broad knowledge. 86.3% of them think that the studies did not mostly contain outdated information, which should be obvious and expected condition of the university education.

A 38.1% preference to the "amount of knowledge instead of deeper knowledge" can be a certain sign. Specifications of the physical education and sport program are probably reflected in 90.7% answers of respondents, who do not consider the amount of lessons during studies as "unnecessarily many lessons of education". The possibility of specialization during studies is mentioned by 56.7% of alumni, which offer is readily available as they can get licenses of a coach and instructor.

Quite reasonably, but maybe unexpectedly, 33% of respondents consider pedagogy as the most important subject. Philosophy was marked as the least important one (37.1%).

The scores of subjects which alumni marked as most missing, have very low validity. 19 subjects were selected by 54 respondents. 43 respondents did not mark any subject.

Acknowledgements
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CONFERENCE REPORTS

CONFERENCE "SOCIOLOGICAL ASPECTS OF SPORT"

On May 27 and 28, 2009 a scientific conference "Sociological aspects of sport" took place in Poznań, Poland. The conference organizers were the Department of Sociology of Everyday Life of the Institute of Sociology, Adam Mickiewicz University in Poznań and the Arsenal City Gallery in Poznań which provided the conference venue.

The speakers focused on a wide variety of social problems of contemporary sport such as the impact of politics on sport; modern materials and technologies and transformations of sport practice (setting new records, techno-doping, textile doping); changes in sports presentation and athletes' image-making in the media (sport commentaries, press releases, TV broadcasts, Internet reports); and the social phenomenon of sport spectacle. A considerable section of the conference was also devoted to electronic sports (e-sports, cyber-sports, cyber-athletics) and sport gender studies. Many conference papers tackled the problems of sport fans and sport hooliganism, fair play, social function of sport and the sport Trojan horse – banned substances. Finally, selected papers concentrated on the relationships between sport and economy (quite a significant topic in view of the upcoming 2012 UEFA European Football Championship in Poland and Ukraine).

The organizers' main assumption was an improvement of the hitherto neglected position of sport – one of the most vivid and emotional areas of social life – in the area of social sciences. At present, sport has become a social phenomenon which cannot be simply ignored by social scientists. The official conference announcement clearly reflected the place of sport in modern sociology:

"Firstly, sport can be perceived as a specific crossroads of various practices (social, cultural, economic, legal, technological, etc.), deriving from a plethora of different logics and rationalities. It is therefore an incentive to new perceptions of existing and apparently well-defined tendencies and social phenomena of modern sport, and of new trends characteristic of postmodern society.

Secondly, sport can also be perceived as an autonomous area, independent of the logic of free market and power, and featuring its own rationality based on the 'spirit of competition'. Thus, sport becomes a reference point for modern axio-normative systems, remaining (at least in its original assumption) in opposition to the commonly accepted praxis. It is worth considering how sport can be perceived as a manifestation and realization of axio-normative systems.

Thirdly, sport can be regarded as an area of implementation and discovery of macro-structural tendencies. It can be noted that these tendencies (legal, economic, technological, etc.) can be implemented at the micro-level, e.g. in the context of sport teams supporters. In other words, sport offers an average participant in socio-cultural life the possibility to experience first hand these social processes, which normally seem distant and unimportant.

Fourthly, sport constitutes a reference frame for daily practices. The media picture sports events as patterns to be followed. Professional athletes are perceived as celebrities who deserve to be written about, read about and emulated, not because of their sports achievements but because of their lifestyles.

The aim of this conference is to perceive sport as an indicator of changes of postmodern society and its tendencies. This approach can bear fruit as sport has become directly accessible to all walks of life. It is becoming one of the main grounds for practicing of sociology of everyday life".

The conference participants ensured the highest quality of conference papers. The conference also attracted the interest of many young people, which is a positive signal for the future development of sport philosophy and sociology.

After positive reviews the conference proceedings will be published in a single volume. I am truly convinced this publication will be of great interest not only to experts in the humanities and social sciences but to all readers.

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Department of Philosophy and Sociology
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INAUGURATION OF THE INTERNATIONAL SOCIETY FOR THE SOCIAL SCIENCES OF SPORT

On February 13, 2009 the newly established International Society for the Social Sciences of Sport (ISSSS) was officially included in the Register of Associations, Other Social and Professional Organizations, Foundations and Public Healthcare Centers of the Polish Ministry of Justice. The seat of the Society is the Józef Piłsudski University of Physical Education in Warsaw, ul. Marymoncka 34. The research journal "Physical Culture and Sport. Studies and Research" published by the Józef Piłsudski University of Physical Education has become the Society's official organ.

The Society's Founding Committee includes President prof. dr hab. J. Kosiewicz, dr A. Stępnik, dr J. Femiak, mgr B. Chełmecki, dr J. Żyśko, mgr M. Piątkowska, dr M. Lenartowicz, dr A. Smoleń, dr P. Rymarczyk, dr hab. prof. AWF Z. Dziubiński, dr J. Chełmecki, dr J. Mosz, dr P. Bany (all from the Józef Piłsudski University of Physical Education in Warsaw), as well as dr hab. prof. UR S. Zaborniak, dr hab. prof. UR Wojciech Cynarski from the University of Rzeszów.

The main goal of the ISSSS is the development and popularization of humanistic (philosophical, sociological, psychological, pedagogical and historical) knowledge of sport. The Society's theoretical and empirical activities concern cultural, axiological, moral, esthetic, pedagogic and organizational aspects of sport from the historical and contemporary perspective. The Society's research covers various areas: from record-seeking sport (Olympic, professional, spectator) and qualified tourism to sport for all, physical recreation, recreational tourism, amateur sports, mass sports, school sport, physical education, sport and physical education for the disabled and sports games and plays.

For many years, researchers representing the above fields have lacked a common platform, unlike representatives of natural sciences associated with sport: for example, the annual European College for Sport Sciences (the last one attended by more than 2 000 people) has been mostly concentrating on the biological sciences of sport. For the ISSSS founders prospective congresses and publications are to become new cognitive challenges integrating activities of representatives of all social sciences concerned with physical culture and sport.

The newly-established International Society for the Social Sciences of Sport has received endorsement from a number of researchers from all over the world, such as President of the Asociacion Latinoamericana de Estudios Socioculturales del Deporte, Prof. Miguel Cornejo from Chile and the Vice-President Prof. Wanderley Marchi from Brazil, who agreed to join the ISSSS Executive Board. Other renowned supporters of the Society include Prof. Joseph Maguire (UK) – former President of the International Association for the Sociology of Sport; Prof. Steve Jackson (New Zealand) – current ISSA President; Prof. Jay Coakley (USA) –outstanding sociologist of sport; Prof. Mike McNamee (UK) – founder and former president of the British Philosophy of Sport Association; Prof. Sigmund Loland (Norway) – former president of the International Association for the Philosophy of Sport and current President of the Norwegian School of Sport Sciences; Prof. Georg Anders (Germany) – President of the European Association for the Sociology of Sport; and Prof. Otmar Weiss (Austria) – co-founder and former president of the EASS.

All these experts as well as many other prominent researchers have agreed to participate in the first Conference of the International Society for the Social Sciences of Sport organized by the Polish Ministry of Sport and Tourism and the Józef Piłsudski University of Physical Education in Warsaw on September 23–26, 2009. The conference title will be "Social sciences and modern sport." The following thematic sessions are to be expected:

- Subjective aspects of sport from a philosophical perspective
- Theoretical and empirical aspects of sport sociology
- Historical and present-day manifestations of sport and Olympism
- Psychological determinants of sport
- Pedagogy and challenges of modern sport
- Social bases of sports training and competition
- Praxeological assumptions of management of sport
- Tourism and recreation in view of social needs

Prepared by Tomasz Sahaj, Ph.D.
on the basis of information received from
prof. dr. hab. Jerzy Kosiewicz,
President of the International Society
for the Social Sciences of Sport

COMPETITION

COMPETITION OF RESEARCH PAPERS
on
PHYSICAL EDUCATION TEACHING
for Prof. Bogdan Czabański's Award

Submission requirements:
- Only papers published in the year prior to the date of competition may be submitted
- Papers (offprints) must be sent before the end of March of each year to the Organizers' address:

Akademia Wychowania Fizycznego
Katedra Dydaktyki Wychowania Fizycznego
ul. Witelona 25, 51-617 Wrocław, Poland
tel. 0 (prefix) 71 347-31-69, fax 348-25-27
www.awf.wroc.pl/czabanski
e-mail: olepio@.awf.wroc.pl

- Independent academics must not partake in the competition
- Former award winners must not partake in the competition
- A research paper can be a team work effort, but the team of authors must not include an independent academic

Evaluation criteria:
- Submitted papers must be **research papers**
- All papers must be on the subject of physical education teaching

Jury:
Three independent academics, Professors of the University School of Physical Education in Wrocław, Poland:

- Prorector for Research
- Head of Chair of Physical Education Didactics
- Head of Chair of Swimming

The jury convenes annually on **April 24**. The jury's final decision will be made available to all participants.
Only one paper is awarded with the prize (diploma of merit and 1.000 PLN).
The award is presented each year during the inauguration ceremony of the academic year at the University School of Physical Education in Wrocław, Poland.

CONFERENCES

International Scientific Conference

PHYSICAL EDUCATION AND SPORT IN RESEARCH 2009
Aging and Physical Activity

Rydzyna (near Leszno), Poland, 11–12 September 2009

Conference Director

Prof. Dr hab. Wiesław Osiński

Honorary Patronage

Prof. Dr hab. eng. Czesław Królikowski
Rector of the State School of Higher Vocational Education in Leszno

Prof. Dr hab. med. Jerzy Smorawiński
Rector of the University School of Physical Education in Poznań

Prof. Dr hab. Juliusz Migasiewicz
Rector of the University School of Physical Education in Wrocław

Prof. Dr hab. Włodzimierz Starosta
President of the International Association of Sport Kinetics

Keynote Speakers

Prof. Dr Wojtek Chodzko-Zajko – USA
Prof. Dr hab. Anita Hökelmann – Germany
Prof. Dr Han CG Kemper – The Netherlands
Prof. Dr Robert Malina – USA
Prof. Dr Peter O'Donoghue – Great Britain
Prof. Dr hab. Wiesław Osiński – Poland
Prof. Dr hab. Włodzimierz Starosta – Poland
Prof. Dr hab. Josef Wiemeyer – Germany

Aim of the Conference

The Conference will provide the latest scientific knowledge and offers for discussion and the exchange of both ideas and experience in the controversial issues of physical activity, aging, physical education, fitness and sport. The purpose of the Conference is to contribute to public welfare through scientific, literary and educational activities, and to secure mechanisms for dissemination of knowledge for the public good.

We desire to organize not only serial conferences and scientific congresses, but also to establish a regular exchange of information and concept in a large family of people, the people who devote their lives to scientific research on sport science. We seek scholars of more and more recent disciplines and from various parts of the world to join our activity.

Conference topics

- Physical Education, Sport for All, Fitness and Health
- Aging and Physical Activity: Application to Fitness, Sport and Health
- Biology and Medicine of Sport and Exercise
- Adapted Physical Activity and Sport for Disabled
- Top-level Sport
- Research Methodology in Physical Activity
- Free topics (poster sessions only)

Presentation forms

- Plenary sessions
- Short oral presentations (should not exceed 10 minutes)
- Poster sessions

Language

The official language of the Conference for oral presentations will be English (without any translation). English or Polish language is possible for poster presentations.

Conference Secretariat

Dr hab. Robert Szeklicki
Akademia Wychowania Fizycznego
Zakład Teorii Wychowania Fizycznego i Antropomotoryki
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Tekst prac empirycznych wraz ze streszczeniem, rycinami i tabelami nie powinien przekraczać 20 stron, a prac przeglądowych – 30 stron znormalizowanych formatu A4 (ok. 1800 znaków na stronie, złożonych 12-punktowym pismem Times New Roman z zachowaniem 1,5 interlinii). Redakcja przyjmuje teksty przygotowane wyłącznie w edytorze tekstu Microsoft Word. Strony powinny być ponumerowane.

The *Human Movement* journal, issued semi-annually, accepts for publication original papers and review papers in various aspects of human movement (e.g., sociology, psychology, pedagogy, exercise physiology, biomechanics, motor control, sport medicine) in a broad sense of the term: physical education, recreation, physiotherapy, health and fitness, and sport science. Authors are not paid for their articles. Letters to the Editor, reports from scientific meetings and book reviews are also welcome. Articles written in Polish and English will be accepted. After acceptance, articles in Polish will be translated into English by the Editorial Office.

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Preparation of the manuscript

Experimental papers should be divided into the following parts: title page, blind title page, abstract with key words, introduction, materials and methods, results, discussion, conclusions, acknowledgements, references. In papers of a different type, sections and their titles should refer to the described issues.

STRONA TYTUŁOWA

Na stronie tytułowej należy podać:

1. Tytuł pracy w języku polskim i angielskim. 2. Skrócony tytuł artykułu w języku angielskim (nie dłuższy niż 40 znaków), który będzie umieszczony w żywej paginie. 3. Nazwiska autorów z afiliacją. 4. Imię i nazwisko autora (autorów) wraz z adresem do korespondencji, numerem telefonu, faksu i koniecznie e-mailem.

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Przed tekstem głównym należy umieścić streszczenie w języku angielskim, zawierające około 250 wyrazów i 3–6 słów kluczowych (ze słownika i w stylu MeSH). Powinno się ono składać z następujących części: Purpose, Basic procedures, Main findings, Conclusions.

TEKST GŁÓWNY

Tekst główny pracy empirycznej powinien zawierać następujące części: wstęp, materiał i metody, wyniki, dyskusja (omówienie wyników), wnioski, podziękowania (jeżeli potrzebne), przypisy (jeżeli występują), piśmiennictwo (zawarte tylko w bazach danych, np. SPORTDiscus, Medline). W pracach innego typu należy zachować logiczną ciągłość tekstu, a tytuły poszczególnych jego części powinny odzwierciedlać omawiane w nich zagadnienia.

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The title page should contain: title of the article, name and surnames of author(s) and their affiliations, name and address of the author responsible for correspondence about the manuscript with fax, phone, and e-mail address; and a short running head of no more than 40 characters (count letters and spaces).

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ABSTRACT

The second page should contain the abstract (ca. 250 words). The abstract should be divided into: Purpose, Basic procedures, Main findings and Conclusions. It should emphasize any new and important aspects of the study.

Below the abstract, authors should provide (and identify as such) 3 to 6 key words that will assist indexers to cross-index the article. If suitable MeSH terms are not yet available for recently introduced terms, present terms may be used.

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