ISSN 1731-0652

COMMITTEE FOR REHABILITATION, PHYSICAL EDUCATION AND SOCIAL INTEGRATION OF POLISH ACADEMY OF SCIENCES

INTERNATIONAL ASSOCIATION OF SPORT KINETICS – IASK

ANTROPOMOTORYKA

Vol. 21, nr 55

INDEX COPERNICUS

UNIVERSITY SCHOOL OF PHYSICAL EDUCATION
CRACOW, POLAND

UNIVERSITY SCHOOL OF PHYSICAL EDUCATION
IN WROCLAW, POLAND

CRACOW – WROCLAW 2011

ISSN 1731-0652

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I INTEGRACJI SPOŁECZNEJ PAN

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Indexed in **INDEX COPERNICUS**

Copy-editing and proofreading: Barbara Przybyło

Design and DTP: University School of Physical Education, Cracow, Poland
Print: K&K reklama poligrafia Sp. J., 31-444 Kraków, ul. Ostatnia 22
Circulation: 150

ISSN 1731-0652

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ADRES REDAKCJI

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Poland

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Opracowanie graficzne i łamanie: Dział Projektów Wydawniczych AWF Kraków
Druk: K&K reklama poligrafia Sp. J., 31-444 Kraków, ul. Ostatnia 22
Nakład: 150 egz.

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FROM EDITORS • OD REDAKCJI

ON THE FIRST DAY OF POLISH AUTUMN: 55TH ISSUE OF *ANTROPOMOTORYKA-KINESIOLOGY* AND IASK CONFERENCE IN KRAKOW

W PIERWSZY DZIEŃ POLSKIEJ JESIENI, 55. NUMER *ANTROPOMOTORYKI* I KONFERENCJA IASK W KRAKOWIE

On the first day of autumn 2011 we give into your hands, dear readers and co-workers, the newest English semiannual version of our Krakow-Wroclaw quarterly *Antropomotoryka-Kinesiology*. In the belief that there's a special occasion to celebrate, we would like to announce the opening of the 12th International Scientific Conference "Sport Kinetics 2011" on that day.

The convergence is intended. Together with our patron: International Association of Sport Kinetics – IASK (celebrating this year its 20th anniversary and continuously run by its President, Professor Włodzimierz Starosta, who chairs the Scientific Committee of our conference) we are the organizers of this major scientific event. At our invitation, Krakow will become home to three hundred of scientists from 24 countries. At this time scientific achievements of over 170 researchers concerning the present and future of the science of human movement (the main theme on which our conference is focused) will be presented in three plenary sessions, three extended oral session, and three poster presentation sessions. It will be, for sure, the largest scientific conference held in Polish University Schools of Physical Education after the discontinuance of organization congresses on physical culture. Since then new generations of Polish scientists have grown up.

The participants of our conference will have a possibility to familiarize themselves with the tourist attractions of Krakow as well as to become aware of impressive scientific achievements of President IASK, Professor W. Starosta, who is still an active researcher, visiting the exhibition dedicated to the IASK's jubilee in the Library of AWF.

As it seems, taking part in the Krakow conference may be a very significant experience, in both logistics and... financial meanings. The last one is nowadays even more important and, who knows, may influence the number of participants. Financial matters have impact not only on Polish science. Therefore we can assume that probably only those who have something important to say in the science of human movements and who appreciate the value of scientific meetings are about to visit Krakow these days. *Per aspera ad astra*. Everything argues for the fact that the level of presented scientific papers will be high. For sure, we will find out about this soon.

Krakow conference will also provide an opportunity to establish contacts between the participants and the editorial board of *Antropomotoryka-Kinesiology*. Very helpful in this field may be free distribution to all conference participants the newest 55th issue of our journal.

What do we have in it? As usual, it contains papers of researchers from Poland and abroad.

In our opinion, the paper *Probabilistic prognosis in sport kinetics*, which opens current number of *Antropomotoryka-Kinesiology*, written by Prof. Feigenberg (Israel) and Dr. Wacław Petryński (Poland), is a piece of excellent work. The researchers adopt to the paper's purposes the assumption that the efficacy of human motor performances is limited by three fac-

tors: speed of movement, economy of motion and accuracy of movements. Therefore, they try to prove the hypothesis that these factors are strongly influenced by probabilistic prognosis (PP). In conclusion they assume that human behavior is mainly of active and not reactive nature. So the important factor influencing the run of sensorimotor events is the PP rather and not the sheer reaction to extrinsic stimuli.

To demonstrate this, five experiments were carried out. The examinees were exposed on the specific light stimuli, according to which the suitable choice of the response should be made. The measurements of reaction time enabled drawing conclusions about importance of the PP. Above-mentioned experiments confirm the authors' hypothesis that active behavior of a human is rather determined to PP and not to stimuli received from environment.

The objective of the study made by researchers from the Brazilian Laboratory Evaluation of Load, Universidade Federal de Minas Gerais, Belo Horizonte and the Department of Physical Education in Sao Paulo was to verify the chronic effects of vibration training during bilateral strength on the force and impulse difference among contralateral limbs obtained in the vertical jump. In the paper *Effect of strength training with vibration on bilateral force and impulse difference* they found out that exposure to 4-week isometric training, when applying vibrations with frequencies of 8 Hz in the direction of the resultant muscle forces' vector addition, was able to significantly decrease the force and difference between limbs impulse. Conventional isometric training and exposure to vibration frequencies of 26 Hz did not produce the same effects.

International Italian and Latvian team of researchers representing the University of Bologna, Faculty of Exercise and Sport Sciences and Department of Psychology, and Ventspils University College in Ryga in the paper entitled *The sport dance athlete: aerobic-anaerobic capacities and kinematics to improve the performance* discuss the results of the research on the issue of the relationships between physiological and biomechanical parameters of sport dancers. In the conclusion of this interesting text it is mentioned that technical skills are confirmed to be the main influencer of the performance albeit a certain degree of fitness is necessary to sustain long training and competition sessions.

The next in the order paper is written by two Czech researchers from the Faculty of Physical Education and Sports, Charles University in Prague, and devoted to speculations whether *Effect of walking on body composition and aerobic fitness in non-trained men of middle age* may be assessed by the level of aerobic fitness and body composition. For this purpose they conducted an experiment, in which they tried to verify the moving program based on walking for influence aerobic fitness and body composition in middle-aged men. Interesting results of that experiment proved that exercise with total energy content of 6270 kJ/week is enough for significant improvement of AF and motor performance by maximal exercise in non-trained subjects.

Similar results, however examined with the help of different methods, are presented in the paper entitled *Motor fitness in relation to body build and physical activity in 16-18-year-old youth,* which refers to the study carried out in Department of Biostructure, University School of Physical Education in Wroclaw. On the basis of collected observations the authors formulate startling conclusion: "Physical activity manifested itself as an important factor affecting only motor fitness in girls, whilst in boys the level of the selected motor abilities was affected solely by somatic features of the organism and not by the analyzed factors pertaining to lifestyle".

To different conclusions are led the authors of paper entitled *Place of residence and physical activity as determinants of Polish 6-year-old children's physical fitness results.* They present the results of nationwide research on 33459 children (!) born in 2000 and finishing their one-year pre-school education. The aim of the research was to determine the level of motor abilities in 6-year-olds at the end of their pre-school education. Additionally the influence of a specific environment on 6-year-old child's motor development, which could also determine the level of school readiness, as well as the level of adaptive skills in the first year of primary school, were examined. Furthermore, the following question was asked: "Does spontaneous physical activity based on parents' subjective opinions diversify the level of physical development and motor abilities in 6-year-old children?" On the basis of detailed statistical analyses of a large number of respondents' significant disproportions in the level of 6-year-olds' motor abilities between the groups distinguished by the place of residence, and children's physical activity reported by their parents were proved.

The study *Development of spatial and temporal orientation abilities in winter sport competitors* is aimed at determining changes in the level of spatial and temporal orientation in young people practicing winter sports during three-year training process (aged 15–18

years). The attempts were made to answer the following questions: "1. Can intensive physical activity essentially affect the level of spatial and temporal orientation in the athletes? 2. Are prospective changes in its level at the same level for both genders?"

During the three-year period of time an essential and statistically significant improvement in visual aspect of spatial and temporal orientation was observed in both athletic group and control group. However, the obtained results do not demonstrate the effect of training on improvement in the studied ability. The changes are of a rather developmental background. No significant sexual differences in the level of spatial orientation were observed in either athletes studied or control group throughout the period of the research.

To very interesting conclusion came the author of work *The effectiveness of cooperation in the team game (pragmatic study of unique cases).* Based on the video record, he carried out a pragmatic comparative study of players' cooperation effectiveness in club teams, including in basketball the Orlando Magic and Los Angeles Lakers and in football FC Barcelona, as well as in national representatives, including Brazil, Russia, and Serbia in volleyball.

In conclusion, he states that the evaluation of the effectiveness of double and triple collaboration may concern both the dimension of the synergy for example the synergic potential of the players, as well as the level of synergy resulting from the level of synchronization and coordination of actions absolutely dependent on each other. Synergic perception of collaboration effectiveness, accepted by the players, favors the development of added value in the team, for example task consistency and as a consequence also emotional consistency, as well as a new quality for example the combination of actions that we cannot analyze in an individualized dimension.

A very interesting discussion could be found in the article *Physical fitness norms in children and adolescents: the physical education approach about the use* of standards and standardization in sport and physical education of children and adolescents, which is contained in the section "Polemics and Discussions".

I consider that the content of the 55th issue of *Antropomotoryka-Kinesiology* may be worth reading not only during breaks between sessions of conference "Present and Future Research in Science of Human Movement". As usual, I remain with kind regards and respect sending the greetings from the royal city of Krakow.

Edward Mleczko
Editor-in-Chief
Antropomotoryka-Kinesiology

INFORMATION FOR THE AUTHORS

1. **"Kinesiology"** ("Antropomotoryka") is an official scientific quarterly of the International Association of Sport Kinetics – IASK, published at the University School of Physical Education, Cracow, Poland under the auspices of the Committee Rehabilitation, Physical Education and Social Integration the Polish Academy of Sciences.
   The magazine presents the results of original research work and experiments in the field of human motoricity and related sciences. It also publishes review articles, opinion articles and discussion of scientists evaluating the current situation and perspectives of scientific development of human motoricity.

2. **Materials for publication** (one copy of computer printouts) should be sent together with the compact disc at the following address: Redakcja "Antropomotoryki", Akademia Wychowania Fizycznego, al. Jana Pawła II 78, 31-571 Kraków, tel. 12 683 12 78, tel/fax 12 683 10 76 **or** at the e-mail address: **antropomotoryka@awf.krakow.pl**.

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   - "Antropomotoryka" accepts demonstrative, original, experimental, and historical papers, information about conferences, reports from congresses and conferences on human motoricity, short summaries of works published in foreign periodicals and book reviews on human motoricity. Original works are accepted in English.
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   - Empirical works should contain the following information: title, name(s) of the author(s), key words in Polish and in English, brief summary in Polish, summary in English (as mentioned above), introduction, material, methods, results and discussion, conclusions and bibliography.
   - The number of key words should be from 3 to 15.
   - The summary has to contain: the purpose of the work, material, methods, results and conclusions.
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   - **The reference materials should** be listed on a separate sheet of paper. Only the aterials the Author refers to in the text may be included. **They should be numbered using Arabic numerals and placed in the order they are quoted** in the work (not in the alphabetic order). Each item of the reference materials should be written in a new verse. The surname(s) of the author(s) of the quoted work should be followed by the initials of their first name(s), then the original title of the magazine where the work was published should be given. The abbreviation of the title of a magazine should be taken from the Index Medicus (or International Committee of Medical Journal Editors: *Uniform Requirements for manuscripts submitted in biomedical journals*. N Engl J Med 1997; 336, 309–315).

Examples:

a) works printed in magazines:
   - Casella R, Bubendorf L, Sauter G, Moch H, Michatsch MJ, Gasser TC: *Focal neuroendocrine differentiation lacks prognostics significance in prostate core needle biopsies*. J Urol, 1998; 160: 406–410.

b) monographs:
   - Matthews DE, Farewell VT: *Using and Understanding Medical Statistics*, ed 3, revised. Basel, Karger, 1966.

c) chapters in textbooks:
   - Parren PWHI, Burton DR: *Antibodies against HIV-1 from phage display libraries*; *Mapping of an immune response and progress towards antiviral immunotherapy*; in Capra JD (ed.): Antibody Engineering, Chem. Immunol. Basel, Karger, 1997, 65: 18–56.
   - Kokot F: *Fizjologia nerek*; w. Zieliński J, Leńko J (eds): *Urologia*, Warszawa, PZWL, 1992, 1: 9–20.

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Tabela 1., Ryc. 1., Objaśnienia, Chłopcy

Example in English:

Table 1., Fig. 1., Commentary, Boys

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[2] Malarecki I: *Zarys fizjologii wysiłku i treningu sportowego*. Warszawa, Sport i Turystyka, 1975.

[3] Bouchard C, Malina RM: *Genetics of physiological fitness and motor performance*. Exerc. Sport. Sc. Rev. 1983; 11: 112–115.

[4] Szopa J: *W poszukiwaniu struktury motoryczności: analiza czynnikowa cech somatycznych, funkcjonalnych i prób sprawności fizycznej u dziewcząt i chłopców w wieku 8–19 lat*. Wyd. Monograficzne, Kraków, AWF, 1983; 35.

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Przykłady:

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b) monografie:
   - Matthews DE, Farewell VT: *Using and Understanding Medical Statistics*, ed 3, revised. Basel, Karger, 1996.

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   - Kokot F: *Fizjologia nerek*; w Zieliński J, Leńko J (red.): *Urologia*, Warszawa, PZWL, 1992, 1: 9–20.

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Tabela 1., Ryc. 1., Objaśnienia, Chłopcy

Table 1., Fig. 1., Commentary, Boys

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Spis piśmiennictwa powinien być sporządzony według **kolejności cytowania**:

[1] Żekoński Z, Wolański N: *Warunki społeczno-bytowe jako czynniki rozwoju człowieka*; w Wolański N (red.): *Czynniki rozwoju człowieka*. Warszawa, PWN, 1987; 68–88.

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ORIGINAL PAPERS
PRACE ORYGINALNE

PROBABILISTIC PROGNOSIS IN SPORT KINETICS

PRZEWIDYWANIE PROWADOPODOBNE W MOTORYCE SPORTOWEJ

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Key words: motor control, probabilistic prognosis, sensorimotor performance planning
Słowa kluczowe: kontrola ruchowa, przewidywanie prawdopodobne, planowanie odpowiedzi czuciowo-ruchowej

SUMMARY • STRESZCZENIE

Introduction. The efficacy of any human motor performance is limited by three factors: speed of movement, economy of motion and accuracy of movements. The authors hypothesize that all of them are strongly influenced by probabilistic prognosis (PP).

Aim of the study. The main task was proving the assumption that the human behavior is mainly of affective and not reactive nature. So the most important factor influencing the run of sensorimotor events is the PP rather and not the sheer reaction to extrinsic stimuli.

Material and methods. To demonstrate this, five experiments have been carried out. To the examinee the specific light stimuli were presented, to which the suitable choice response should be made. The measurements of reaction time enabled drawing conclusions about importance of the PP.

Results. In all the five experiments the crucial role of PP has been confirmed. As the movement is the only externally observed symptom of human's brain activity, its observation enables building a model of information processing including intelligence, intuition and instinct. All these mechanisms the PP plays the crucial role. In sport, the PP enables clear differentiation between tactics and strategy. According to function of PP, the sport disciplines might be divided into groups three groups: of negligible function of PP (e.g. track-and-field sports), of important function of PP (e.g. combat sports and team games), and of decisive function of PP (e.g. chess, bridge).

Conclusions. The presented experiments confirmed the hypothesis that active behavior of a human is determined by PP rather and not by stimuli received from environment.

Wstęp. Skuteczność każdego działania ruchowego człowieka jest ograniczona przez trzy czynniki: prędkość, dokładność oraz ekonomię ruchu. Autorzy pracy wysuwają hipotezę, że na czynniki te wywiera zasadniczy wpływ przewidywanie prawdopodobne (PP).

Cel pracy. Podstawowym zadaniem, jakie postawili przed sobą autorzy, było sprawdzenie, czy prawdą jest, iż zachowanie człowieka ma przede wszystkim charakter czuciowy, a nie reaktywny. Najważniejszym czynnikiem wpływającym na odpowiedź czuciowo-ruchową byłoby zatem przewidywanie prawdopodobne (PP), a nie sama reakcja na bodźce zewnętrzne.

Materiał i metody. Aby udowodnić to założenie, przeprowadzono pięć doświadczeń. Badane osoby poddano działaniu specyficznych sygnałów świetlnych, na podstawie których miały dać właściwą odpowiedź ruchową. Pomiar czasu, po jakim następowała odpowiedź ruchowa, umożliwił autorom sformułowanie wniosków na temat znaczenia przewidywania prawdopodobnego.

Wyniki. We wszystkich pięciu doświadczeniach potwierdzono kluczową rolę przewidywania prawdopodobnego. Ponieważ ruch jest tylko obserwowanym z zewnątrz przejawem działania ludzkiego mózgu, jego obserwacja umożliwia zbudowanie modelu przetwarzania informacji uwzględniającego inteligencję, intuicję oraz instynkt. W przewidywaniu prawdopodobnym wszystkie te mechanizmy odgrywają kluczową rolę. W sporcie przewidywanie prawdopodobne pozwala na dokonanie wyraźnego rozróżnienia pomiędzy taktyką i strategią. Przewidywanie prawdopodobne może zatem stać się podstawą podziału na te dyscypliny sportowe, w których odgrywa ono niewielką (np. lekkoatletyka) lub ważną (np. sporty walki, gry zespołowe), lub kluczową rolę (np. szachy, brydż).

Wnioski. Przeprowadzone doświadczenia potwierdziły hipotezę, że aktywne zachowanie człowieka jest określone raczej przez przewidywanie prawdopodobne, niż przez bodźce zewnętrzne.

1. Theoretical foundations

In sport (and in daily life, too) effectiveness and efficiency of sensorimotor performances is of crucial significance. The former term denotes the ability to attain a desired goal, whereas the latter includes additionally the condition of achieving it with minimum outlay of effort, both energetic and mental. Usually an athlete strives for speed, economy and accuracy of movements. All these elements are associated with probabilistic prognosis [1, 2].

Speed of movement is limited mainly by biomechanical determinants, i.e. strength, power, mass and inertia of particular body elements, external resistance and flexibility of an athlete. So, they are conditioned by energetic (physiological) and structural (anatomical, biomechanical) abilities of a given individual.

Economy and accuracy of a movement depends mainly on movements' management, i.e. control and co-ordination abilities. The former needs attention focusing, whereas the latter does not.

Accordingly, firstly, the efficiency of a performance is being limited by factors of somatic nature (sensory and motor organs). Secondly, it is determined by information processing (nervous system). These elements determine the speed of stimulus identification, motor response preparation and its practical realization.

The only further potentiality of increasing of performance efficiency is the accurate anticipation, i.e. shifting the beginning of information processing before the moment of a stimulus reception, i.e. to apply the probabilistic prognosis.

The notion of probabilistic prognosis has been developed in early sixties of 20th century [3]. Already in 1962 N.A. Bernstein wrote that "… the future may be evaluated or anticipated only by means of »probabilistic prognosis« (the term coined aptly by I.M. Feigenberg), so it becomes obvious that the approach to all physiological processes which appear here needs to be based on theory of probability and its newest branches" [4].

In another work Bernstein wrote that programming of a future action may be done only on the basis of what he termed "model of desired future". He wrote: "So, we have here two interconnected processes. One of them is the **probabilistic prognosis** according to perceived current situation, a kind of **extrapolation** into some period of the future" [5].

The presented experiments show the role of probabilistic prognosis in performing the goal-aimed actions.

2. Experiments

The series of experiments have been carried out to determine the relation between current control and probabilistic prognosis. The experiments were arranged so as to eliminate (as far as possible) the influence of somatic factors and reactive information processing and to emphasize mainly the active information processing, i.e. probabilistic prognosis. The term "stimulus" means the essential physical phenomenon which triggers the response, whereas the term "signal" means the neutral physical phenomenon which precedes the occurrence of a stimulus and heralds it.

Experiment 1. Two different light stimuli, A and B, were presented to the examinee. A-stimulus was twice as frequent as the B one. When the sequence was random,

BAABAAAABABBAA<u>AAABAB</u>BAAA

the reaction time (RT) to A-stimulus (RT_A) was shorter than the reaction time to B-stimulus (RT_B), but when the sequence became ordered,

AAABABAAABABAAABAB

the RT to both stimuli got more and more uniform. Accordingly, the RT depends on probabilistic prognosis rather, and not on stimulus frequency.

Experiment 2. Two different light stimuli, A and B, were presented to the examinee. A-stimulus was nine times as frequent as the B one. Gradually the RT

became stable and the RT_A got shorter than RT_B. At this moment the experimenter started to show only B-stimulus. Surprisingly enough, at first the RT_B got longer and only later the shortening of it was observed. This result also confirms the hypothesis that the RT depends on probabilistic prognosis and not on stimulus frequency (Fig. 1).

Experiment 3. The aim of this experiment was determination of probabilistic prognosis in situation where the frequencies are not associated with probabilities. To the examinee there were shown series consisting of four light stimuli: A, B, C and D. Each series consisted of all four stimuli in random sequence. Accordingly, the overall frequency of each of them was the same. The fragment of such a sequence is shown in Table. 1. However, the probability of the first stimulus in series was equal to 0.25, of the second – to 0.33, of the third – to 0.50 and of the fourth – to 1.00. In this experiment it was shown that the RT_1 equals to 460 ms, RT_2 – to 424 ms, RT_3 – to 351 ms and RT_4 – to 207 ms, no matter what stimulus (A, B, C or D) it was (Fig. 2). So, this experiment has shown that also in such a situation the main factor is not a type of stimulus, but the probabilistic prognosis.

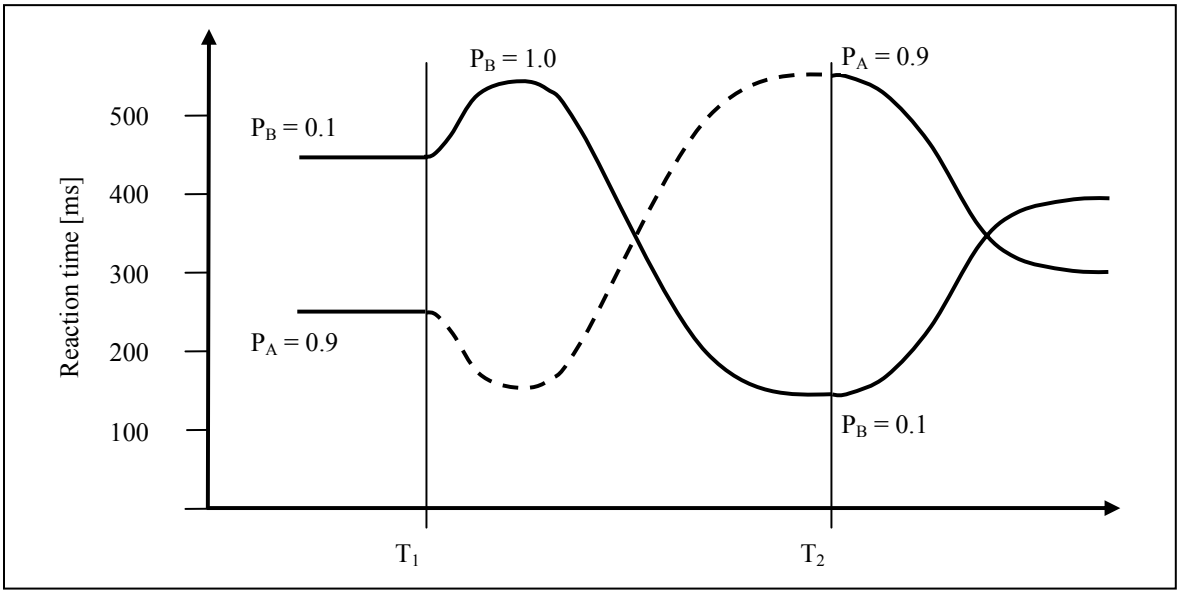

Figure 1. The influence of probability of occurrence of a given signal over the value of reaction time to this signal (experiment 2)

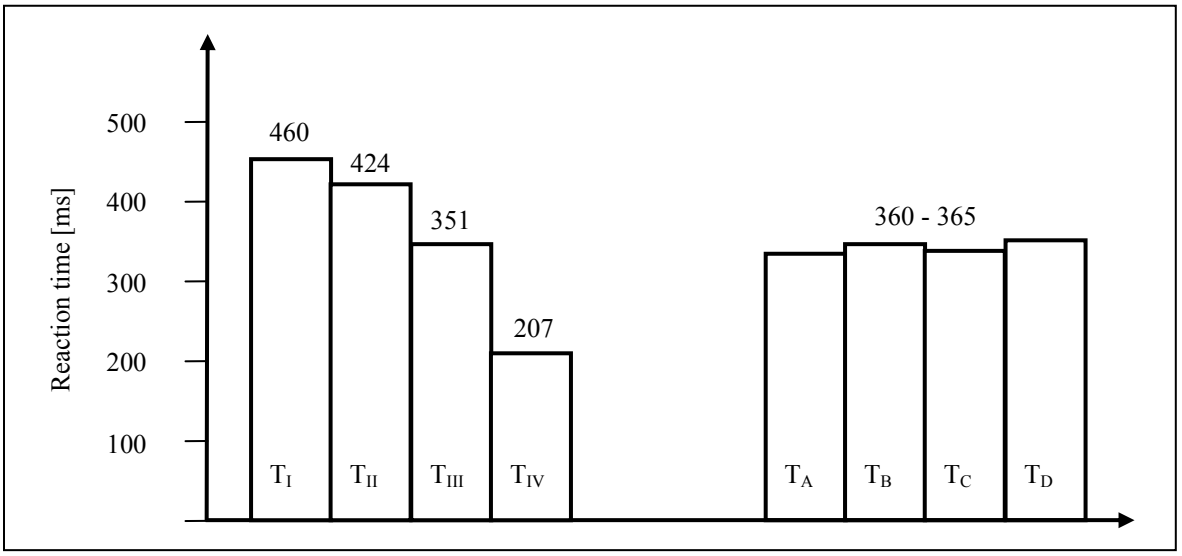

Figure 2. Reaction times to given signals grouped into Markov sequences consisting of four signals each (experiment 3)

Table 1. The sequence of A, B, C and D signals in the experiments with groups of consisting of four stimuli (experiment 3)

Sequence of stimuli	B	C	A	D	C	B	D	A	A	C	B	D
The position of a stimulus in general sequence	1	2	3	4	5	6	7	8	9	10	11	12
The position of a stimulus in a group of four	I	II	III	IV	I	II	III	IV	I	II	III	IV

Experiment 4. The aim of this experiment was determination why the reaction to stimulus anticipated with higher probability is being performed quicker. At first a sound signal was emitted and 1.5 s later – a light stimulus, calling for swift movement of left or right hand. The sound signal eliminated the temporal uncertainty, but it remained the uncertainty whether the left or the right hand will be used. In the first part of the experiment the stimuli for both hands were shown randomly. They prompted broad activation (pre-preparation) of skeleto-muscular system of both hands. In Fig. 3 there are shown the electromyographic (EMG) and galvanic skin reactions (GSR) graphs recorded in the experiment. It is to be seen the wide pre-preparation of the muscles of both left and right hand.

Then the stimulus for only one, always the same (left) hand was shown, and the pre-preparation became more local nature (Fig. 4).

As seen in Figure 4, the sound signal brings about activation of only left hand muscles. So, it was shown that the more accurate probabilistic prognosis, the more local and, consequently, more economic pre-preparation.

Experiment 5. The experiment has been aimed at determination how important is the locality of pre-preparation. The examinee had one or two mobile switches (MS) in hands, whereas two stationary switches (SS) were attached to the table.

In the **first part** of experiment the examinee had one MS in one hand. After a stimulus presentation, he/she should touch an appropriate SS, which were attached close to each other at the same side of the hand with the MS.

In the **second part** of the experiment the examinee had two MS in both hands, whereas one SS was placed to the left and the other to the right of the left

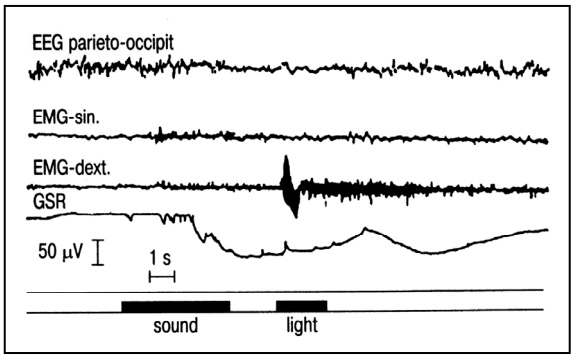

Figure 3. EMG and GSR reactions to warning signal (Attention!) and releasing stimulus at the beginning of experiment

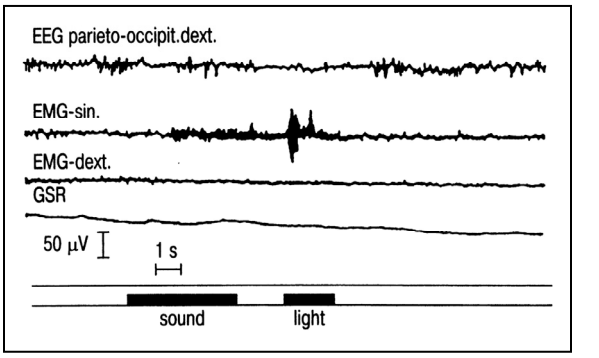

Figure 4. The sound signal "Attention!" warns that in short will be emitted the light stimulus calling for response with the left hand

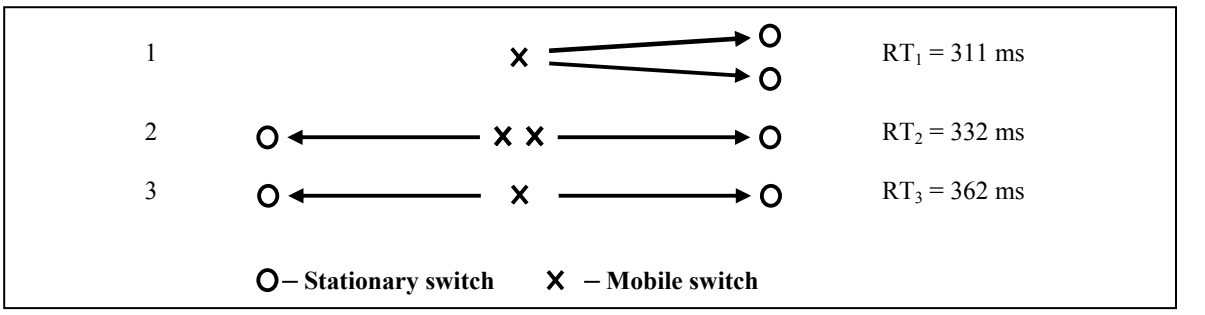

Figure 5. The arrangement of three parts of experiment 5 [6]

and right hand, respectively. After stimulus presentation, the examinee should touch the left SS with left MS or the right SS with right MS.

In the **third part** of experiment the examinee had one MS in one hand, whereas the SS were placed to the left and to the right of him/her at the same distance.

The switches arrangement and average reaction times in particular parts of experiment 5 are shown in Figure 5. It is to be emphasized that in several cases the discrepancy between measurements in the third part of experiment exceeded 400 ms.

The results of all the described experiments show how important role in speed and economy of motor reactions falls to probabilistic prognosis and the pre-preparing of musculature – the arrangement to future actions – which results of it [6].

3. Discussion

A sensorimotor performance, even the most primitive reflex, is always directed towards future [7, 8], which includes considerable amount of uncertainty. To overcome it, it is necessary to use the probabilistic prognosis to build an appropriate and realizable model of desired future. In the process of anticipation, a human adopts intelligence, intuition and instinct.

Intelligence enables construction of successful action. It needs both knowledge of full information necessary to solve the task and of all rules of information processing. Unfortunately, an individual very rarely possesses such a complete knowledge. So it is necessary to use **intuition** to guess the lacking information. The directions of searching for such lacking information, concerning both intelligence and intuition, are determined by **instinct** [9]. Accordingly, intelligence might be compared to mathematical interpolation, intuition – to mathematical extrapolation, and instinct determines both the ways of task solving (intelligence) and/or lacking information searching (intuition), respectively.

The intelligence, intuition and instinct determine the procedure of processed information, but not its modality. In the Bernstein's system of information processing [10, 11, 12, 13], which might be termed "Bernstein's ladder" [14], there are five information processing levels. Each of them has its own code of information processing (modality), which determine depth and speed of information processing. In common language, A-level is responsible for "feeling-in-hand", B-level – for movements harmony, C-level – for "measure-by-eye", D-level – for common reason, and E-level – for fantasy. The lower level, the quicker processing, but at the same time less thorough. Accordingly, intelligence, intuition and instinct may function at e.g. D-level (verbal code) or at C-level (visual code). So, different is the intelligence modality of a mathematician (E and D levels), and the intelligence of a hunter in Alaska (C level). They have to process information with various speeds and depths, so various code modalities are for them of crucial significance.

The teleceptors, specific to C-level, enabled developing some time consciousness. Its symptom is e.g. "time-to-contact" phenomenon [15, 16] or timing [17]. The time consciousness makes a basis for probabilistic prognosis, which enables the specific division of sport disciplines into three categories:

1. Track and field sports (runs, jumps, throws). The environment is highly predictable, importance of energetic factor as compared to mental ones is high, so importance of probabilistic prognosis is relatively low.
2. Sport games, combat sports (soccer, fencing, sailing, basketball, volleyball etc.). The environment is not predictable, importance of energetic and mental factors is at similar level. Fully reactive actions (without prediction) do not guarantee success, so the function of probabilistic prognosis and energetic factors are equally high.
3. Intellectual sports (chess, bridge) – importance of probabilistic prognosis crucial, importance of energetic factors negligible.

The probabilistic prognosis may concern temporal, spatial or both the aspects of situation. Extreme temporal conditions are observed in boxing. For instance, left jab of Muhammad Ali was about 40 ms. To defend himself, his opponent would have to recognize the starting hit, to take decision about counteraction and to perform it in merely 40 ms. All these processes require at least 200 ms [15], so effective sensorimotor **response** would be obviously impossible. Accordingly, the only possibility to "survive" in such situation is the accurate probabilistic prognosis, which shifts the moment of reaction initiation before the left jab starts and enabled the response completing before the Ali's left jab lands on his opponent's jaw.

Another example is the ski jump. During the in-run an athlete attains the speed of over 25 m/s. So, if the length of optimal zone for leap is, say, 0.5 m, then the jumper has to his disposal merely 0.02 s for taking-off. Without proper prediction it would be impossible, though in such a case the scope of uncertainty is limited.

In car racing the drivers reach a speed of over 300 km/h, i.e. (roughly) over 80 m/s. If we take an assumption that during the race reaction time to a stimulus amounts to 1 s, then the "zone of perception" lays some 80 m before a car. It means that to merely identify an object or phenomenon, the driver has to spot it at the distance of 80 m. If in elite racing driver a proper sensorimotor reaction takes 0.5 s, thus the "zone of proper reaction" lays 120 m before a car. Here has to be still added the distance necessary to perform the sensorimotor response of the driver to control the car, e.g. braking, which may take still more 200 m. Summing up, at speed of about 300 km/h, the "point of no return" for the car driver, necessary to perform any effective action, lays some 300 m ahead of the car. This means that to effectively control actual situation, the driver has to predict its development at least 4 s ahead of the current moment.

The example of both temporal and spatial probability may be penalty kick in soccer. The goal dimensions are: 7.32 m wide, 2.44 m high (what makes nearly 18 m^2), and the kick distance amounts to 11 m. The ball kicked by the forward may reach the speed of about 30 m/s. So, the goalkeeper has to his disposal only some 0.3 s for:

1. Recognition of shoot direction.
2. Taking decision, how to catch or bounce the ball.
3. Performing the whole action physically.

It is obvious that having so much time to disposal, the efficacious defending the goal is possible only thanks to accurate probabilistic prognosis.

Summing up, even the performance merely efficacious, both in most sports and everyday activities, needs some probabilistic prognosis. However, in sport the action has to be not only efficacious, but also optimally efficient; thus, the quality of probabilistic prognosis has to be much higher than in daily life. In sport disciplines where the tactical and strategic aspects prevail, the probabilistic prognosis may be even more important than the sensorimotor abilities (strength, speed, agility, dexterity and endurance). This may be observed even in combat sports. For instance, the aged champion of Eastern martial arts is often able to defeat much younger and better physically fit opponent. Surprisingly enough, the movements of such an old master seem to be not very quick, but they are made with perfect timing. It is possible only on the basis of reliable and accurate probabilistic prognosis.

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EFFECT OF STRENGTH TRAINING WITH VIBRATION ON BILATERAL FORCE AND IMPULSE DIFFERENCE

WPŁYW TRENINGU SIŁOWEGO ZE STYMULACJĄ DRGANIAMI NA OBUSTRONNĄ SIŁĘ I AMPLITUDĘ IMPULSU

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Key-words: strength training, vibration, bilateral difference
Słowa kluczowe: trening siłowy, wibracja, obustronna różnica

SUMMARY • STRESZCZENIE

Aim of the study. The purpose of the present research was to verify the chronic effects of vibration during bilateral strength training on the force and impulse difference among contralateral limbs obtained in the vertical jump.

Material and methods. Fifty-one untrained male volunteered to participate in this study. Volunteers were randomly distributed in 4 groups: the Isometric group (n = 13), the 8-Hz group (n = 13), the 26-Hz group (n = 13) and the Control group (n = 12). Volunteers were submitted to 4-week of isometric training (Isometric group), isometric training associated with the application of 8 Hz (8-Hz group) and 26 Hz (26-Hz group) frequency of vibration. This training was done three times a week and made up of 12 maximal voluntary contractions (MVCs) in a semi-squatting position. The Control group did not execute any kind of training and was instructed not to execute any kind of systematic physical activity during the period of the research.

Results. Only the group submitted to 8-Hz vibration frequency had a significant decrease in force (p = 0,005) and impulse (p = 0.017) difference among contralateral limbs. The 26-Hz frequency, unlike imagined, did not reduce de force (p = 0,261) and impulse (p = 0,925) difference among contralateral limbs.

Conclusions. In conclusion, exposure to 4-week isometric training, when applying vibrations with frequencies of 8 Hz in the direction of the resultant muscle forces' vector addition, was able to significantly decrease the force and impulse difference between limbs. Conventional isometric training and exposure to vibration frequencies of 26 Hz did not produce the same effects.

Cel pracy. Ustalenie długotrwałego wpływu, jaki stymulacja drganiami generowanymi podczas bilateralnych ćwiczeń siłowych wywiera na siłę i częstotliwość drgania mięśniowego kończyn kontralateralnych w wyskoku z zamachem.

Materiał i metody. W badaniach prowadzonych w ramach czterotygodniowego programu treningowego wzięło udział 51 ochotników – nietrenujących mężczyzn, których przydzielono losowo do czterech grup: pierwszej, realizującej wyłącznie program ćwiczeń izometrycznych (n = 13); drugiej, objętej dodatkowo stymulacją ciała drganiami o częstotliwości 8 Hz (n = 13); trzeciej, realizującej ćwiczenia izometryczne ze stymulacją ciała drganiami o częstotliwości 26 Hz (n = 13) oraz czwartej – kontrolnej (n = 12). W tym czasie badani z grup 1–3 trzy razy w tygodniu wykonywali 12 skurczów z maksymalną wartością MVC w pozycji półkucznej, którym w gru-

pach 2–3 towarzyszyła stymulacja drganiami. W grupie kontrolnej nie wprowadzono żadnych ćwiczeń, zalecając uczestnikom, by nie ograniczali zwyczajowej aktywności fizycznej.

Wyniki. Tylko w przypadku grupy drugiej, poddanej stymulacji ciała drganiami o częstotliwości 8 Hz, stwierdzono statystycznie istotne zmniejszenie się siły ($p = 0,17$) oraz impulsu ($p = 0,017$) między kontralateralnymi kończynami. Inaczej w grupie realizującej ćwiczenia izometryczne ze stymulacją ciała drganiami o częstotliwości 26 Hz, gdzie nie odnotowano statystycznie istotnych zmian siły ($p = 0,261$) oraz amplitudy impulsu ($p = 0,925$) między kończynami kontralateralnymi.

Wnioski. Czterotygodniowy program ćwiczeń izometrycznych, uzupełniony stymulacją ciała drganiami o częstotliwości 8 Hz o wektorze, którego kierunek był zgodny z wektorem siły mięśniowej, zmniejszył istotnie statystycznie siłę i amplitudę impulsu pomiędzy kończynami. Podobnych zmian nie stwierdzono ani w przypadku konwencjonalnego treningu izometrycznego, ani treningu izometrycznego ze stymulacją ciała drganiami o częstotliwości 26 Hz.

Introduction

Most people have a dominant side with which they perform daily tasks or sports [1]. According to Lanshammar and Ribom [2], the muscle force might be considerable different among the dominant and non-dominant side and that physical activity might influence and even accentuate this.

The muscle force difference among sides could be a result of multiple factors as previous injury [3, 4], specific sport demands [4], anatomical variations [5], neural inervations [3] or muscle activation problems [4]. This difference seems to raise the risk of injury [3, 4, 6] and might compromise performance [3].

The muscle force difference among contralateral limbs can be identified through the isokinetic dynamometer [6, 4], through the isometric dynamometer [7, 8] and through specific functional testes, such as vertical jumps [9, 10, 6, 4].

The decrease in muscle imbalance is important for a possible improvement of performance and for injury rehabilitation [1]. Strength training can reduce the difference among contralateral limbs [11 12, 13]. However, the conventional bilateral strength training may not be able to reduce this difference in force among limbs and may even increase it. This is due to the possibility of greater use of the dominant limb during the performance of voluntary contractions [14]. Thus, one solution would be to undertake unilateral strength training [13]. Another solution would be to undertake bilateral training combined with some feedback mechanism that can inform the force generated by each member. In that way, the individual can, voluntarily, control and balance the force distribution among limbs during the bilateral training [11, 12]. However, this practice can decrease the force difference among contralateral limbs from the combination of adequate stimulation of the non dominant member with reduced stimulation of the dominant member, and thus, decrease the effects of training. Perhaps the presence of an involuntary stimulation, such as the application of mechanical vibrations, during voluntary contractions might reduce stimulation imbalances during the bilateral strength training.

Vibration training has been used in training programs, as it is able to induce acute [15, 16, 17] and chronic increases in muscle force [18, 19]. Muscle response in individuals submitted to mechanical vibration has been associated with the mechanism denominated 'tonic vibration reflex'. This mechanism is stimulated by a sequence of rapid muscle stretching that occurs when applying vibration and that triggers muscle spindles [15, 21]. According to Rittweger [22], vibration exercises should be characterized by cyclic transitions between eccentric and concentric muscle contractions. The application of mechanical vibrations can to surpass the voluntary limit of strength production and to contribute to the activation of the involuntary components of muscle strength production, characterized in this case by eccentric action, with values sufficiently higher than those obtained through voluntary contractions [19]. However, no studies were found that investigated the effects of mechanical vibration on the force or impulse difference between limbs.

Taking this fact under consideration, the purpose of the present research was to verify the chronic effects of vibration during bilateral strength training on the force and impulse difference among contralateral limbs obtained in the vertical jump. Beyond that, identify the possible effects of the use of low frequencies (8 Hz and 26 Hz) on the force and impulse difference among contralateral limbs obtained in the vertical jump.

Material and methods

Participants

Fifty-one untrained male (25.7 ± 4.8 years old; height, 1.77 ± 0,08 m; weight, 74.2 ± 10.4 kg) volunteered to participate in this study. Individuals were informed about the nature of this study and signed an informed written consent form.

All procedures were approved by the Ethical Committee for Research at the Federal University of Minas Gerais. Volunteers were randomly distributed in 4 groups: the Isometric group (n = 13), the 8-Hz group (n = 13), the 26-Hz group (n = 13) and the Control group (n = 12).

Experimental Design

To identify the muscle force and impulse difference among contralateral limbs was used a countermovement jump (CMJ), performed on a bilateral force platform. Three different strength trainings were compared: conventional isometric training, isometric training with application of vibration with a frequency of 8 Hz and isometric training with application of vibration with a frequency of 26 Hz. After performing the countermovement jump test, untrained individuals were distributed in four groups. The Isometric group performed a 4-week isometric training, which was done three times a week, made up of 12 maximal voluntary contractions (MVCs) in a semi-squatting position. The 8-Hz group performed the same training with a vibration of 8 Hz applied directed in the direction of the result of muscle forces vector addition. In the 26-Hz group, the same type of vibration was applied with a frequency of 26Hz. The Control group did not perform any kind of training. After a four-week training, a new countermovement jump test was performed.

Training protocol

Conventional isometric training program

The Isometric group performed a 4-week conventional isometric training. In each training session, 12 maximal voluntary contractions (MVCs) were performed in the semisquatting position on the equipment. This equipment was adjusted so that the individual would remain with a 45º of knee flexion. Figure 1 illustrates the standard position and the equipment used during the study. The only feedback given to the volunteers was the visualization of a strength curve as a function of time simultaneous with its realization. A computer screen was placed in front of the subject. Each MVC lasted for 6 seconds, starting from the moment when peak strength was reached. There was a 5-minute recovery interval between each repetition. Each volunteer trained 3 times per week, with a 48-hour recovery interval between the training sessions. Individuals remained in the semisquatting position, bound to the equipment by a belt.

Vibration training program

The 8-Hz group performed a training program similar to that performed by the Isometric group. However, mechanical vibrations were applied in the direction of the resultant muscle forces' vector addition during the 6 seconds of the MVC. The period of 4 weeks was determined by the fact that some researchers have pointed out that this amount of time would be enough to reach significant effects during training with local vibrations [19, 23]. The vibrations applied had a frequency of 8 Hz and an amplitude of 6 mm. Vibrations with a frequency of 8 Hz and an amplitude of 6 mm, applied to the direction of the resultant muscle strength, have already been shown to be effective in the chronic development of maximal isometric strength [19]. The 26-Hz group performed the same procedures, but the vibration used

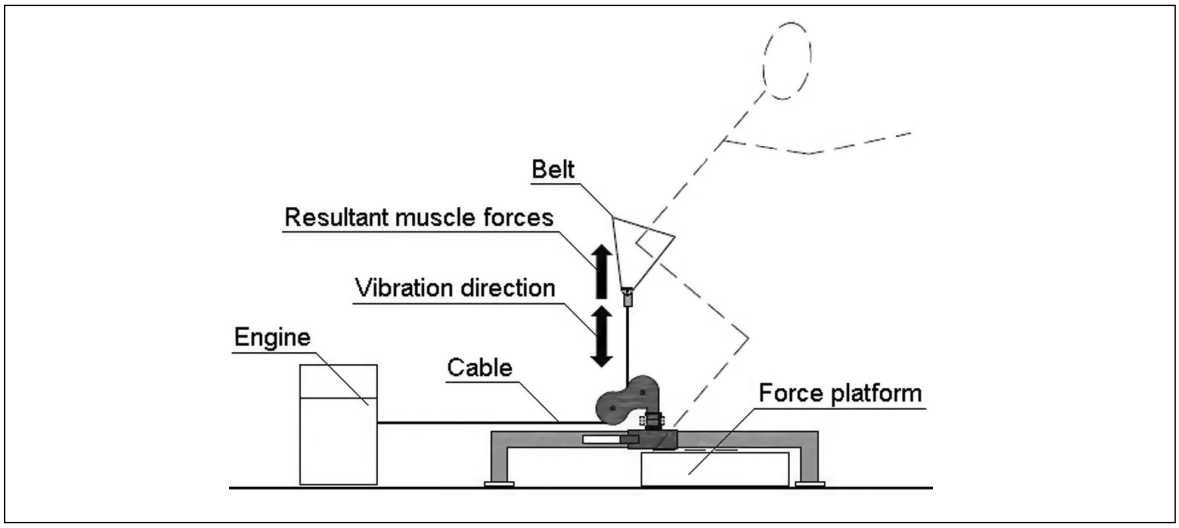

Figure 1. Equipment to evaluate the maximal isometric strength and the application of mechanical vibration

had a frequency of 26Hz and amplitude of 6 mm. The frequency of 26 Hz was chosen because it is often used in studies with mechanical vibrations.

The application of vibration in the direction of the result of muscle forces' vector addition generates small and fast stretches, particularly for the muscles which perform the MVC The individual, bound to the equipment by a belt, performed a muscle contraction, stretching the cable of the equipment. The cable was connected to an engine equipped with an eccentric axis. When the equipment was turned on, the cable was submitted to a sequence of tractions in the direction of the resultant muscle forces' vector. As in the cases in which the individual performed an isometric activity, trying to extend the knees and hips, the resultant muscle forces' vector was lined up in the vertical direction. As shown in Figure 1, the cable of the equipment was tractioned in that direction.

Control group

The volunteers in the Control group participated in the proceedings of the pre-test and post-test periods, although they did not execute any kind of training and were instructed not to execute any kind of systematic physical activity during the period of the research.

Test protocol

The CMJ test was applied at the pre- and post-test stages. The CMJ was used to evaluate muscle force and impulse difference among contralateral limbs by combining eccentric and concentric actions. Individuals were instructed not to lift their knees during the flight and landing phases. The horizontal and lateral displacements were minimized and the hands were kept on the hips throughout the test [21]. The angular displacement of the knees was standardized so that the subjects were required to bend their knees to approximately 90° [18]. Five jumps were performed with a 30-second interval in between, and the height mean was used for analysis

Instrumentation

To evaluate the CMJ was used a bilateral force platform (PLA3-1D-7KN/JBA Zb. Staniak®, Poland, 1000 Hz; amplifier WTM 005-2T/2P JD Jaroslaw® — Poland; software MVJ, 3.4 — Zb. Staniak® — Poland). The vibration was generated by an engine (2CV power, brand WEG, model IP55) using cable traction. The frequency of vibration was controlled by a frequency inverter (brand WEG, model CW-10).

Statistical analyses

The verification of the absolute difference among contralateral limbs (force and impulse) at different stages of the study was conducted from a T-test Students. ANOVA two-way for repeated measures (4 [group] · 2 [time]) was performed for the relative differences among contralateral limbs (force and impulse) and jump height obtained in CMJ, in situations of pre and post-test. Test reliability of all measurements was evaluated using the intraclass correlation coefficient (ICC). The level of significance was 5% ($p \leq 0.05$). All analyses were executed using the SigmaPlot for Windows Version 10.0. All values were reported as average ± SD. For comparison of pre and post-test was used relative difference among contralateral limbs, once after the training program the individuals would be adapted and changes in absolute differences would not represent the real effects of training. The relative differences among contralateral limbs of the various measures was determined using the equation (strong leg – weak leg)/strong leg × 100, which has been previously reported [4].

Results

The values of the absolute consistency and relative of the force (ICC = 0,97; SEM = 4,3%), impulse (ICC = 0,98; SEM = 2,6%) and jump height (ICC = 0,98; SEM= 1,9%) resulted in high quality and consistent values. Strength training began without a significant difference among the groups in their force, impulse and jump height. Only groups submitted to trainings (Isometric, 8-Hz and 26-Hz groups) experienced a significant increase in the height of the CMJ (Table 1).

As shown in table 2, all groups had significant absolute difference among contralateral limbs in force and impulse during CMJ in pre and post test situation.

Table 1. CMJ height values obtained pre-and post-test

Group	Jump height (m)	
	pre-test	post-test
Isometric	0,342 ± 0,62	0,356 ± 0,49*
8-Hz	0,338 ± 0,55	0,367 ± 0,54*
26-Hz	0,328 ± 0,35	0,345 ± 0,39*
Control	0,333 ± 0,40	0,333 ± 0,41

* Significant enhancement between pre and post-test ($p < 0,05$).

Table 2. Absolutes values of maximum force and impulse during the CMJ performed in pre-and post-test

Group	Limb	Force (N)		Impulse (N.s)	
		pre-test	post-test	pre-test	post-test
Isometric	Dominant	617,1 ± 119,0*	582,4 ± 124,0*	105,5 ± 22,1*	106,7 ± 20,6*
	Nondominat	548,7 ± 135,6	516,2 ± 126,6	96,5 ± 25,1	98,8 ± 20,9
8-Hz	Dominant	625,6 ± 126,1*	604,2 ± 141,0*	104,0 ± 15,7*	104,1 ± 15,9*
	Nondominat	538,7 ± 108,7	550,8 ± 121,8	91,2 ± 15,1	94,2 ± 16,2
26-Hz	Dominant	561,1 ± 135,4*	588,9 ± 105,8*	100,2 ± 15,4*	104,0 ± 12,6*
	Nondominat	469,7 ± 98,1	510,6 ± 99,5	86,3 ± 15,2	89,8 ± 15,8
Control	Dominant	523,4 ± 83,7 *	536,9 ± 91,5*	102,3 ± 16,2*	102,0 ± 16,5*
	Nondominat	485,7 ± 95,7	499,6 ± 96,7	96,1 ± 17,0	96,5 ± 18,5

* Significant difference compared to nondominant limb ($p < 0,05$)

Nevertheless, only the 8-Hz group experienced a significant decrease in the force relative difference ($p = 0,005$) among contralateral limbs. The 8-Hz group also was the only group that obtained a significant decrease in the impulse relative difference ($p = 0.017$) among contralateral limbs. The other groups (Isometric, 26-Hz and Control) did not present significant changes in force and impulse difference among contralateral limbs (Figure 2).

Discussion

As far as we are aware, this is the first research on the chronic effects of local vibrations on the force and impulse difference among contralateral limbs. For this investigation, we hypothesized that vibration training would result in a higher decrease in this difference when compared to conventional strength training. Additionally, we hypothesized that different frequencies of vibrations (8 Hz and 26 Hz) would contribute, in different ways, to reduce the difference among limbs. The results of this study suggest that local vibration training in the direction of the resultant muscle forces' vector, with adequate frequency, causes stronger positive effects in comparison to conventional isometric training.

The above was identified from the improvement in jump height of the volunteers. The 4-week isometric strength training isolated or with application of mechanical vibrations produced increases in CMJ height. These

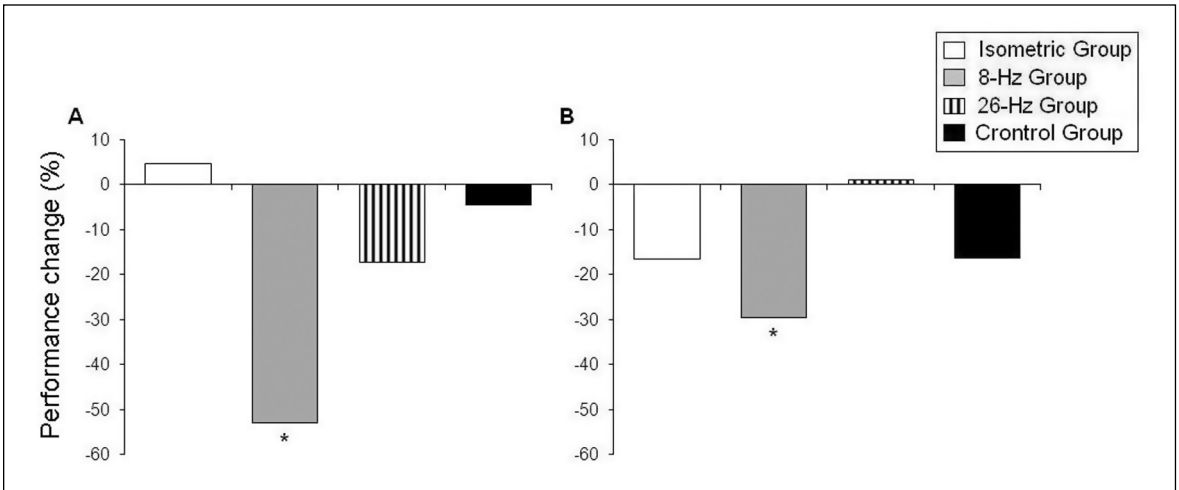

Figure 2. Percentage change in bilateral force (A) and impulse (B) difference in situations of pre and post-test

results corroborate the findings from several studies that have also found positive results when applying mechanical vibrations to vertical jumps [21, 24, 18, 20]. This increase in the height of vertical jumps may be explained by the recruitment of motoric units of higher thresholds that occurs during a vibration training [31]. Exercises with vibrations directly affect fast contraction fibers that are determinants for the performance of vertical jumps [22]. Additionally, an increase in the sensitivity of muscle spindles generated by vibration training [15] could increase the response of these proprioceptors during the cycle of stretching and shortening that occurs with a CMJ.

Other authors have used the vertical jump to identify the force difference among contralateral limbs. Newton, Gerber, Nimphius, Shim, Doan, Robertson et al. [4] and Impellizzeri, Rampinini, Maffiuletti and Marcora [6] identified force differences among contralateral limbs, being 6.1% and 6.2% respectively. Ball and Scurr [10] converted force data from Newton to body weight (BW) to allow direct comparisons between participants, and its results showed no difference of force among contralateral limbs, with average of 4.7 BW for both sides. McElveen, Riemann and Davies [9] did not identify force difference among contralateral limbs. At the present study significant force difference among contralateral limbs were identified in all groups.

Unlike most of the articles that collected only force data [10, 6, 4], it was decided to use force and impulse data, as well as the study of McElveen, Riemann and Davies [9], due to major importance of impulse in jumping performance. According to Winter and Fowler [25], impulse is fundamental to exercise, especially when projectiles are involved. These projectiles could be implements such as shot, javelin, and discus or the body in horizontal and vertical jumping. In many circumstances, it is optimization of the product of force and time that is critical for success and which determines the limits of performance. Impulse is determined mathematically by the integral of the force-time curve and is what determines the change of momentum of a body [26]. Thus, it is possible that a higher force value produces lower height jump, as a result of a short period of application of this force, thus generating a smaller impulse. McElveen, Riemann and Davies [9] did not identify force difference among contralateral limbs but found impulse difference among contralateral limbs (1,9%). As McElveen, Riemann and Davies [9], in the present study was identified impulse difference among contralateral limbs in all groups. McBride, Kirby, Haines and Skinner [27] and Ferreira, Schilling, Weiss, Fry and Chiu [28] also used impulse as an important variable in jump height.

Lee and Carroll [13] admit that the unilateral strength training is a possibility to reduce de force difference among contralateral limbs. Another option would be bilateral strength training but with the possibility of increasing this difference among contralateral limbs, due to the probability of voluntary greater use of the dominant limb [14]. Simon and Ferris [11] and Carson, Riek and Shahbazpour [12] suggest the utilization of a feedback mechanism to reduce the force difference among contralateral limbs, so the volunteer try to produce the same amount of force in both limbs. Although, it was observed that the subject was able to match the force of his stronger limb to the target force with visual feedback but was not able to accurately produce equal forces among contralateral limbs. Moreover, this practice can decrease the force difference among contralateral limbs from the combination of adequate stimulation of the non-dominant member with reduced stimulation of the dominant member, and thus, decrease the effects of training. It seems that strength training associated with vibration training is an option to reduce the force and impulse difference among contralateral limbs, without decreasing the long-term training effects. It can be demonstrated trough the different results obtained between 8Hz and isometric groups, where only the group submitted to this frequency of vibration obtained statistically significant reduction of force and impulse difference among contralateral limbs, without decreasing the long-term improvements in the vertical jump performance.

An explanation for the decrease in force and impulse difference among contralateral limbs in the training done with vibrations should be related to short periods of muscle-stretching added during the execution of training. According to Rittweger [22], vibration exercises should be characterized by cyclic transitions between eccentric and concentric muscle contractions. This sudden stretching could have optimized the action of the muscle spindles, especially of the primary endings of the spindle and the nervous stimulation rate [21], once the stretching of the muscle spindles provoked an increase in the frequency of the discharge of the sensory endings. The vibration training might have led to the results above mentioned due to reflex pathways stimulation. This kind of application of mechanical vibrations could have surpassed the voluntary limit of strength production and contributed to the activation of the involuntary components of muscle strength production [19]. Thus, the dominancy by the volunteer would be reduced.

Another aspect investigated was the comparison of the effects of the use of frequencies of 8 and 26 Hz. The effects of 8-Hz group were unexpected different from the 26-Hz group. The explanation for this fact may be the changes in the stimulation of the vibrations through the change in acceleration imposed on the individual, once the amplitude was always kept at the same level (6 mm) [15]. Also, it is known that changes in frequency have an influence on the transmissibility of the energy of vibrations in corporal tissues [29]. As local vibrations were applied, it might be the case that the transmissibility of different frequencies that were used had such a significant influence on the acceleration that reached the targeted muscles.

Conclusions

In conclusion, exposure to 4-week isometric training, when applying vibrations with frequencies of 8 Hz in the direction of the resultant muscle forces' vector addition, was able to significantly decrease the force and impulse difference among contralateral limbs. Conventional isometric training and exposure to vibration frequencies of 26 Hz did not produce the same effects. Beyond that, the isometric and vibration training did not cause a decrease in the long-term improvements in the vertical jump performance.

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Acknowledgements

The authors are grateful to "Fundação de Amparo à Pesquisa do Estado de Minas Gerais – FAPEMIG".

THE SPORT DANCE ATHLETE: AEROBIC-ANAEROBIC CAPACITIES AND KINEMATICS TO IMPROVE THE PERFORMANCE

ZAWODNIK TAŃCA TOWARZYSKIEGO: WYDOLNOŚĆ TLENOWO-BEZTLENOWA ORAZ SPRAWNOŚĆ MOTORYCZNA A POPRAWA WYKONANIA

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Keywords: sport dance, biomechanics, physiological profile, technique
Słowa kluczowe: taniec sportowy, biomechanika, profil fizjologiczny, technika tańca

SUMMARY • STRESZCZENIE

Introduction. Little is known about the relationship between physiological and biomechanical parameters of sport dancers. Partners' body contact and posture are important to achieve top results. Knowledge of the links between these aspects could be of help for couples' matching and for improving the dance technique through the assessment of relevant parameters.

Aim of the study. In our study compared with the few previous studies, we found that age and VO_2max of the dancers increased from earlier studies, while body height and weight remains similar over the years.

Material and methods. Data on hip alignment, knee kinematics, VO_2max, Anaerobic Threshold and Lactate on top level couples were compared with amateur athletes showing that the discriminator factor is the hip kinematics and that no differences exists in physiological parameters.

Results and conclusions. While we found a difference in VO_2max between males and females, we didn't find any statistically significant correlation between the athlete position in the world ranking and VO_2max, anaerobic threshold and lactate production. VO_2max and lactate of nowadays top level dancers are higher than in the past, due to increases in athletic training. Knee kinematics are described for Quickstep, Slow Waltz, Tango, Slow Foxtrot and Viennese Waltz showing great differences in lower limbs action and thus in energy requirements. In conclusion, technical skills are confirmed to be the main influencer of the performance albeit a certain degree of fitness is necessary to sustain long training and competition sessions.

Wstęp. Badaniu związku między parametrami fizjologicznymi a biomechanicznymi u tancerzy sportowych poświęcano dotąd niewiele uwagi. Wiadomo jednak, iż sukces w tańcu towarzyskim zależy od postawy ciała zawodnika oraz prawidłowego wejścia w kontakt z partnerem, stąd wiedza o tym, jak przez analizę odpowiednich parametrów harmonijnie łączyć oba te elementy jest w tej dyscyplinie sportu priorytetem, gdyż umożliwia właściwe kojarzenie zawodników w pary i doskonalenie umiejętności technicznych.

Cel pracy. Porównano wyniki badań własnych z wcześniej opublikowanymi danymi, co pozwoliło wykazać, iż zarówno wiek, jak i poziom VO_2max u współczesnych tancerzy towarzyskich przyjmują wyższe wartości w porównaniu do badań wcześniejszych, podczas gdy niezmieniona pozostaje wysokość i masa ciała.

Materiał i metody. Porównanie danych na temat ustawienia bioder, motoryki stawu kolanowego, pułapu tlenowego, progu anaerobowego i mleczanowego mistrzowskich par z danymi osób uprawiających tę dyscypli-

nę amatorsko wykazało, iż czynnikiem dyskryminującym jest w tym przypadku motoryka stawu biodrowego, nie stwierdzono natomiast różnic w parametrach fizjologicznych.

Wyniki i wnioski. Odnotowano różnicę poziomu pułapu tlenowego pomiędzy mężczyznami i kobietami, nie wykazując żadnej statystycznie istotnej zależności pomiędzy reprezentowaną przez tancerzy międzynarodową kategorią klasową a poziomem VO_2max, progiem anaerobowym czy produkcją kwasu mleczanowego. Wykazano, iż na wysoki poziom sportowy współczesnych par wpływa postęp technik treningowych. Opisano motorykę stawu kolanowego w trakcie wykonywania quickstepa, walca angielskiego, tanga, slow-foksa i walca wiedeńskiego, wykazując zasadnicze różnice w pracy kończyn górnych, a co za tym idzie – różne wymagania energetyczne w tych tańcach. W podsumowaniu podkreślono, iż wprawdzie prezentowanie wysokiej klasy sportowej przez zawodnika zależy od jego umiejętności technicznych, mimo to jednak do sprostania długim treningom i turniejom konieczna jest wysoka sprawność fizyczna.

Introduction

It is widely accepted that physiological characteristics are the basic requirement for learning and performing and sport and technical skills are built upon its. While this is a commonly accepted concept for sport with heavy muscular effort, there are controversial opinions about the "athletization" of arts performers [1]. Albeit there exist many studies on the physiological and biomechanics characteristics of classical dancers [2], very few studies concentrate on sport dance [3, 4]. The sport dance model of performance is that of "A dexterity activity with great muscular involvement" [5], thus posing the accent on the "dexterity" aspects and with an emphasis on muscular aspects of the performance. Astrand [6] classified sport dance as "extremely heavy" especially for female athletes. Due that it is a sport performed in a couple, the knowledge of aerobic and anaerobic parameters of each component of the couple is necessary for a proper physical matching. Having an idea about the physical load of ballroom dance competitions, we can refer to the International Standard Dance Music IDSF Tempo Regulation [7]. The definitions are the following:

Slow Waltz 28–30 bars per minute, 3/4 timing
Tango 31–33 bars per minute, 4/4 time
Viennese Waltz 58–60 bars per minute, 3/4 time
Foxtrot 28–30 bars per minute, 4/4 time
Quickstep 50–52 bars per minute, 4/4 time

The duration of one dance in the competition should be between 90 and 120 seconds. Ten to twenty seconds rest is allowed between each dance. A certain mix of strength, flexibility, and endurance together with the capacity to stay focused on the aesthetics of the performance is necessary factor to be successful in this sport [7]. Endurance seems to be a basic motor capacity albeit obviously not so important as in endurance sport: the long competition sessions, poses a certain load on the cardio-respiratory apparatus of the dancers, and the oxygen consumption and lactate production/sustainability capacities seem to be important supportive factors of the performance [2]. Aims of our study are to 1) provide an updated physiological profile of the male and female sport dance athletes; 2) assess differences in the couple (male vs female) both for oxygen consumption, lactate production and for biomechanical kinematics parameters; 3) provide basic biomechanical parameters of this sport useful for technique evaluation; 4) compare results of top level couple with amateur athletes.

Methods

15 males and 15 females were considered for physiological and biomechanical measures (mean age: 26,5 and 26,45 years; height 176 ± 9 and 167 ± 8 cm, weight 66,3 ± 12 and 54 ± 10 kg, mean dancing experience of 16 years). The dancer's age, compared with those reported in the study of Blanksby [4] of 23 year ago in a sample of comparable level of qualification, show a tendencies toward an increase. In the Blanskby study, the authors reported a mean age of 23,2 years for males and 21,8 for females. In our study the mean ages are respectively 26,5 and 27,8. It is interesting to note that the height does not show important changes: 176,1 and 166,8 cm for male and female in our study vs 176,8 and 165,4 cm in the Blanksby study while body weight is increased in male and decreased in females, showing a tendency toward body mass increase, 66,35 and 54 kg in our group vs 60,5 and 57,7 kg in Blanksby study for body weight. The subjects were tested for VO_2max on the treadmill (K4b^2 oxygen consumption system Cosmed, Italy) using an incremental protocol until the exhaustion. The subjects, after a warm up, started the test walking at 6 km/h (Exere, Air Machine, Italy) at 0% slope, and then the speed was increased by 1 km/h every minute until exhaustion. Maximum velocity achieved was recorded and anaerobic threshold was computed according to Whipp [8]. After the cessation of the incremental test, a drop of venous blood was taken from the ear lobe and analyzed with a Lactate Scout portable lactacydometer at three and six minutes and the higher value was

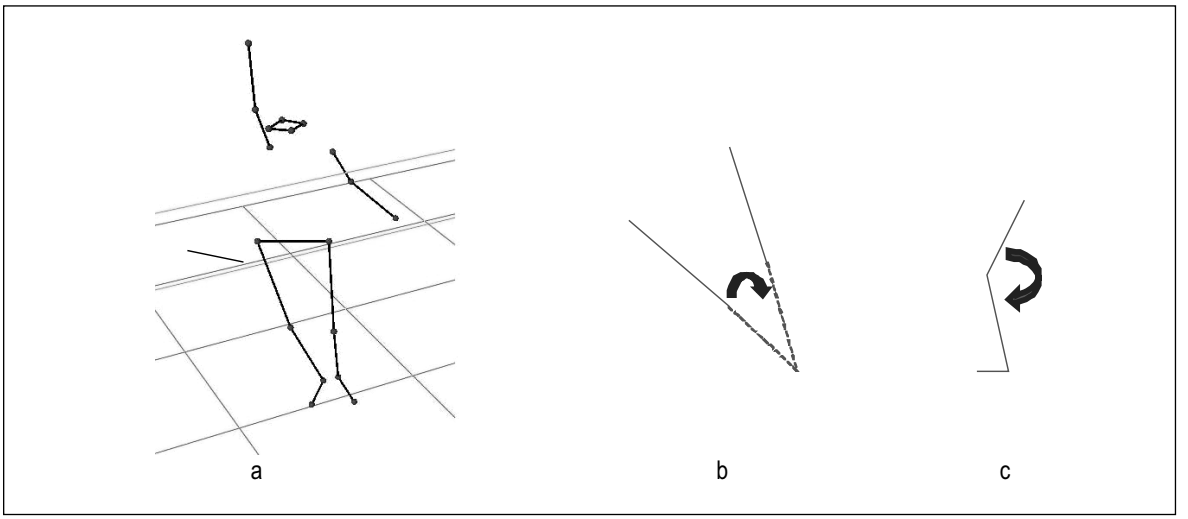

Fig. 1. Model for the computation: a) set of marker used to visualize the line between the dancer and his partner's hip line; b) the angle between the dancers' pelvises; c) the knee angle

retained [9]. As for biomechanical parameters, measures were computed during 5 dance sequences (Quickstep, Slow Waltz, Tango, Slow Fox Trot, Viennese Waltz) for both partners with a Smart 3D motion analysis system (Bts Engeneering, Italy) consisting of ten infrared cameras, using reflective markers and a sampling frequency of 250 Hz. A model consisting in 18 markers (Fig.1) used for the computation, allowing for the recording of the movements of the body of one dancer at time, while only the hip of the partner as marked. Hip angles between hips of the couple in the transversal plane (from above) and right and left knees excursion angles in all the style were computed in 3D and the absolute value was considered using the Smart Analyzer software ver. 4.3.3 according to ISB standards in reporting kinematics data [10].

Hip alignment was chosen as relevant to the performance. This angle is considered by sport dance coaches to be meaningful for the evaluation of the capacity of the couple to dance together following a correct trajectory (especially after front changes) and gives information about the path of the body center of gravity in the transversal plane. Knee flexion/extension is a common parameter to all the four styles of dance analyzed, and so it allows a description of the behavior of the athlete in the different sport dance styles. It is also a common technical feature in the couple, that must be performed with the proper tempo and amplitude by the two dancers. Cohen effect size was greater than 8.0. Statistical analysis was performed using the functions Correlations and T-test ($t_{28,\ 0.05}$) with Excel 2007 software for Windows. Significance level was set at 0.05.

Table 1. Physiological parameters of dancers

	VO_2max ml/kg/min	An Threshold ml/kg/min	Lactate (mm/L)	Max speed (km/h)
Mean	57,51	40,31	9,50	15,93
st. dev	7,97	7,26	1,98	1,54

Results

The results for VO_2max, anaerobic threshold, lactate, maximum speed achieved in the running test for the whole sample (30 dancers, 15 males and 15 females) are summarized in Table 1.

The mean value for male and female was respectively 60,4 and 46,3 ml/kg/min and the difference was statistically significant at T test ($t_{19,\ 0.05}$ = 2,43). Blood lactate was 9,58 and 8,9 mm/L and the difference was not statistically significant. These values are higher to that reported by Dalla Vedova [3], who showed a mean values of 45,8 ml/kg/min for male and 38 ml/kg/min for female with a peak lactatemia of 8.5 and 8.3 mmoles/L in a sample of professional dancers of comparable level of qualification [3]. They are also higher in respect to the values obtained by Blanksby [4], who found a VO_2max of 52,5 for male and of 42 ml/kg/min for females. Anaerobic threshold is correlated with the years of dancing experience (r = 0.589, p = 0.16). Results for biomechanical parameters of knee flexion/extension and hip alignment (degrees) are summarized in the Table 2 and graphically shown in Fig. 2.

Table 2. Kinematics of hips and knees during standard dances

	Flex angle right knee Q	**Flex angle left knee Q**	**Max hip angle from above Q**	**Flex angle right knee SW**	**Flex angle left knee SW**	**Max hip angle from above SW**	**Flex angle right knee T**	**Flex angle left knee T**	**Max hip angle from above T**	**Flex angle right knee SF**	**Flex angle left knee SF**	**Max hip angle from above SF**	**Flex angle right knee VW**	**Flex angle left knee VW**	**Max hip angle from above VW**
Male (n.15)	63.5	66,5	26	60,5	64,7	24,3	57,7	54	29,1	66,4	65,3	18,6	56,5	53,7	35,2
Female (n.15)	55,4	57,4	25	60,5	69,1	26,4	42,2	54,2	24,3	69,6	68	19,6	54,6	56,2	35,8

Q = quickstep ; SW = Slow Waltz ; T = Tango; SF = Slow Foxtrot ; VW = Viennese Waltz

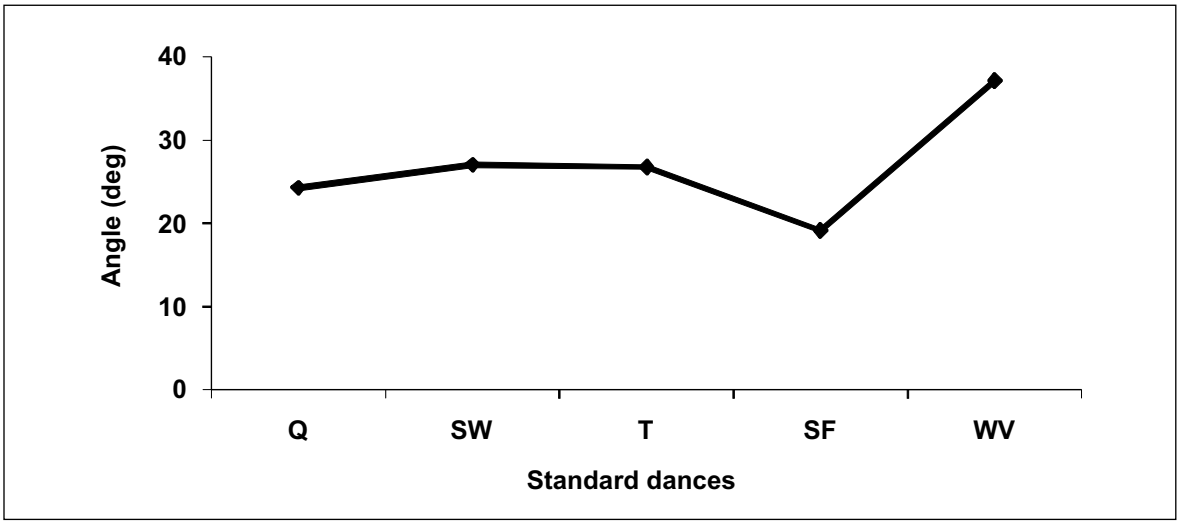

Fig. 2. Angles between dancers' hips in each standard dance (Q = Quickstep ; SW = Slow Waltz ; T = Tango; SF = Slow Foxtrot ; VW = Viennese Waltz)

To our knowledge, only one previous study exist in literature on ballroom dancers kinematics [3]. In this study, kinematics was presented as a method to study and to extract relevant parameters for training from the motion of the subjects. In this study, done at an early stage of motion analysis technology, graphs of pelvis trajectories of the dancing couple and step length were considered only in a qualitative way. The study also analyzed the pelvis oscillations in the vertical and horizontal planes in a top couple with a Fast Fourier Transform algorithm. They concluded that the pelvis oscillation was in synchronicity with the tempo and was not influenced by athlete's body height. This conclusion gives information about the ability of the dancer to follow the tempo, regardless of their body height, but does not give information about the segment kinematics. In our study, we concentrated on knee flexion angles which we found different degrees of correlation with body height in all styles where deep knee flexions are required by the movement ($r = 0.53$ in right knee in the Slow Foxtrot, 0. 48 in left knee in Tango and 0.39 in right knee in Tango; 0.25 in right knee in Slow Foxtrot; 0.20 in right knee in Viennese Waltz and 0.32 in left knee in Viennese Waltz $p < 0.05$). As the fluidity of the movement is important for the aesthetics of the dance, our results suggest that the dancers must not be too high, in order to limit the vertical oscillations of the body which can affect speed and fluidity in the horizontal plane (hip alignment). To confirm this hypothesis, we didn't found any correlation between hip alignment and

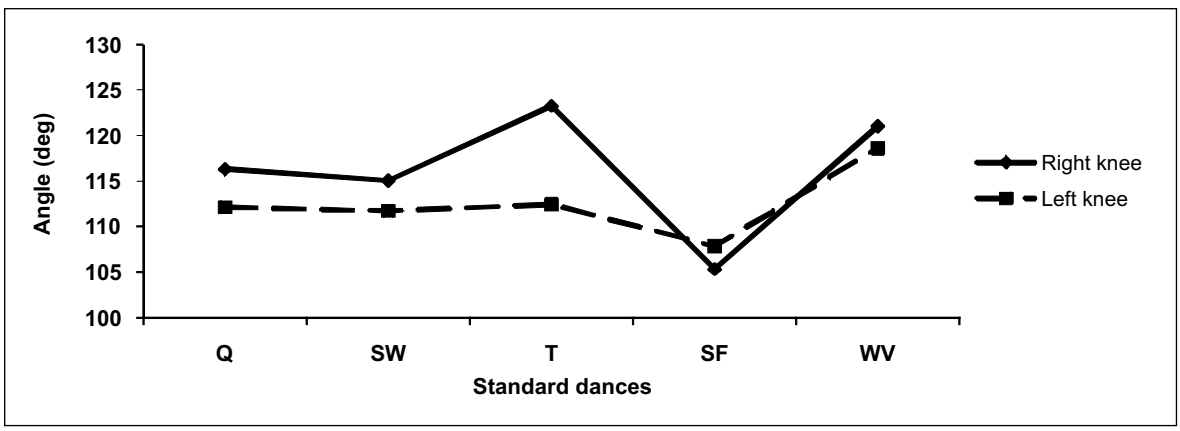

Fig. 3. Dancers' minimum knee angles in each standard dance (Q = Quickstep ; SW = Slow Waltz ; T = Tango; SF = Slow Foxtrot; VW = Viennese Waltz)

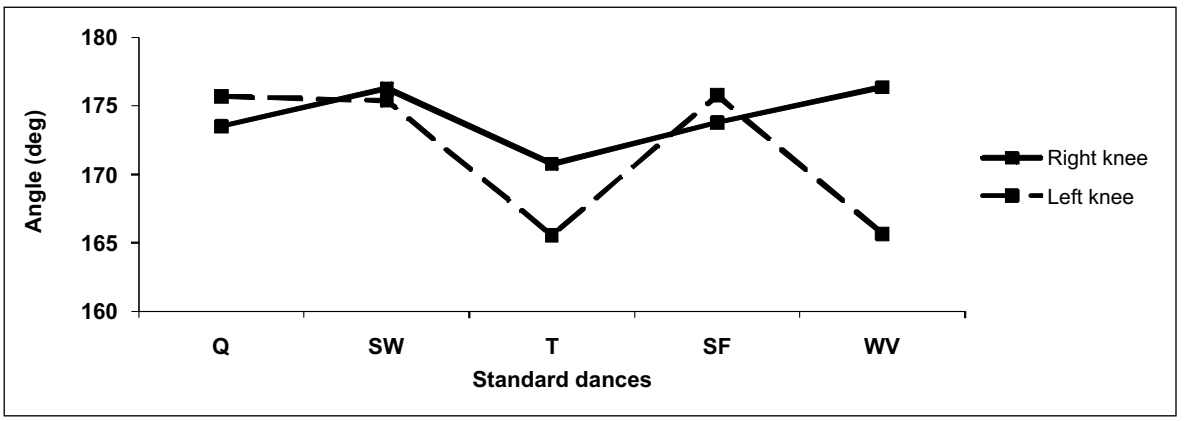

Fig. 4. Dancers' maximum knee angles in each standard dance (Q = Quickstep ; SW = Slow Waltz ; T = Tango; SF = Slow Foxtrot; VW = Viennese Waltz)

knees excursion in our sample. In the following figure 2 are shown angles between the dancer's hips in the transversal plane versus time in five standard dances. Dancers performed the same five sequences of standard dance: Slow Waltz Double Reverse Spin, Tango Natural Pivot, Foxtrot Reverse Turn, Viennese Waltz Flacker, Quickstep Polka. The angles are different in each dance. In Tango both knees angles behave in a very similar way. It is clearly visible that they follows the tempo. It is interesting to note that in all dance sequences the hip alignment between partners is not paralleled, and the spread is high. From a technical point of view it should be desirable that this angle is keep to the minimum because these sequences was danced in partners' close body contacts (Fig. 2).

Hip angle (alignment between the two dancers) show a positive correlation with dancing experience in Viennese Waltz ($r = 0.41$) and a weak correlation in Slow Waltz ($r = 0.21$ $p < 0.05$). Interestingly, hip angle alignment in Viennese Waltz is correlated with years of experience in dancing in a couple. This is also explained by the close proximity between the dancers required by this style.

Knee angles are reported in Fig. 3 and Fig. 4.

As for male vs female differences in kinematics, none of the flexion knees angles is statistically different at the T test. These differences are linked inherently to the techniques used in the different styles, to the body characteristics (height) and , where symmetrical motion of lower limbs is requested by the performance, to the guiding role of the male athletes.

Top versus non-top athletes.

Age of professional athletes (n. 12) is lower in respect to non professional (n. 18) 29 vs 25,7 years. We didn't found statistically significant differences in VO_2max, anaerobic threshold, lactate and maximum speed between professional and amateur athletes (57,5 vs 57,5 ml/kg/min for VO_2max; 39,6 vs 41,9 ml/kg/min for AnThr; 9,7 vs 9,3 mm/L for lactate; 16,3 and 15,7 km/h for max speed). Any correlation was found between the position in the world ranking of professional athletes and VO_2max, and lactate.

Hip alignment is significantly different between the professional and amateur athletes in Slow Foxtrot ($t_{18,\ 0.002} = 3,60$) and Viennese Waltz ($t_{18,\ 0.016} = 2,63$), having the top level athletes a lower angles between the hips of the two dancers thus showing a better alignment capacity (21.6 vs 26.6 in quickstep; 24,56 vs 29 in waltz; 25,1 vs 27 in tango; 14,2 vs 22,7 in slow foxtrot; 32,3 vs 43,1 in viennese waltz). Advanced athletes in comparison to amateur athletes show a less pronounced flexion angle in the right knee in Slow Waltz ($t_{18,\ 0.042} = 2,18$) and they flex the knee more deeply in Viennese Waltz in comparison to the group of amateurs (minimum angle of right knee flexion $t_{18,\ 0.014} = 2,71$ and minimum angle of left flex knee flexion, $t_{18,\ 0.004} = 3.27$). These differences can be due to strongest leg muscles.

Conclusions

Physiological and biomechanical characteristics were proposed as performance model in sport dance. The physiological profile of sport dancers, males and females and of different level of qualification was provided. We found an increase in age of the athletes competing at top level and a better maximal aerobic capacity in comparison to previous studies, while body dimensions seem to be unchanged over time. This increase in maximal aerobic capacity characteristics of

top dancers with all like hood is due to the development of sport dance athletic training in the last years. Albeit a certain degree of aerobic and anaerobic power is necessary for the performance, it doesn't seem to be a discriminating factor to achieve top level in this sport: in our study we didn't found any statistically significant correlation between the athlete position in the world ranking and VO_2max, anaerobic threshold and lactate production. Aerobic work, of course absolve other functions, in maintaining a good fitness level and in helping weight control in dancers athletes. The kinematics parameters of hip alignment in the various dance styles seems to be a discriminator parameters between amateur and professional athletes. We can do the hypotheses that differences in kinematics could be linked to strength differences between advanced and amateur athletes. In conclusion, technical skill are confirmed to be the main influencer of the performance albeit a certain degree of fitness is necessary to sustain long training and completion sessions. The methods proposed can be useful for matching the couples for sport dance performance.

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EFFECT OF WALKING ON BODY COMPOSITION AND AEROBIC FITNESS IN NON-TRAINED MEN OF MIDDLE AGE

WPŁYW ĆWICZEŃ W CHODZIE NA SKŁAD CIAŁA I WYDOLNOŚĆ AEROBOWĄ NIETRENUJĄCYCH MĘŻCZYZN W ŚREDNIM WIEKU

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Key words: walking, body composition, men of middle age
Słowa kluczowe: chód, skład ciała, mężczyźni w średnim wieku

SUMMARY • STRESZCZENIE

Introduction. An effect of physical exercise may be assessed by level of aerobic fitness (AF) and body composition (BC).

Aim of the work. In this study we verify the moving program based on walking for influence AF, and BC in middle-aged men.

Material and methods. The energy output of 6270 kJ/week was respected by construction of individual intervention moving programs. The exercise intensity at a level of 50 to 70% VO_{2max} (HR ranged from 65 to 90% of HR_{max} or 130–170 beats · min^{-1}) was used in a group of middle aged non-trained men (n = 68, age = 45.7 ± 4.2 years, BM = 79.1 ± 7.1 kg, height = 176.3 ± 4.8, BF = 19.1±4.3%, ECM/BCM = 0.84 ± 0.05, VO_{2max} · kg^{-1} = 33.1±5.3 ml · kg^{-1} · min^{-1}). The duration of exercise session ranged from 20 to 50 min, and exercise was performed 3–5 times a week.

Results. The moving programs consisted aerobic walking (min 80% of whole exercise) or cycling (min 10% of total exercise) at the level of 50 to 70% VO_{2max}. The duration of exercise session ranged from 20 to 50 min, and training was performed 3–5 times a week. The time spent at exercise per week ranged between 85–250 min. The energy output of exercise ranged from 4390 kJ to 7780 kJ [mean 6440 (960) kJ] per week. After 5 months of training, slight but significant BM loss [mean 3.5 (1.9) kg; ($p < 0.05$)], FFM increase [mean 2.6 (1.2) kg; ($p < 0.05$)], and BF decrease [mean 3.2 (1.6)%; ($p < 0.05$)] was found. Aerobic fitness increased significantly by 17 (7.3)%; ($p < 0.01$) of initial value. Similarly as VO_2max was significantly increased the maximal speed of running by 15 (2.5)%; ($p < 0.01$).

Conclusions. According to above presented data we may conclude that exercise with total energy content of 6270 kJ/week is enough for significant improvement of AF and motor performance by maximal exercise in non-trained subjects.

The study was supported by grant of Czech Ministry of Education MSM 0021620864.

Wstęp. Wpływ ćwiczeń fizycznych na organizm można ocenić za pomocą analizy poziomu wydolności aerobowej i składu ciała.

Cel pracy. Ocena wpływu programu aktywizacji ruchowej za pomocą treningu aerobowego na poziom wydolności aerobowej i składu ciała nietrenujących mężczyzn w średnim wieku.

Materiał i metody. Grupę mężczyzn (n = 68; wiek = 45,7 ± 4,2 lat życia; BM = 79,1 ± 7,1 kg; BH = 176,3 ± 4,8 cm; BF = 19,1 ± 4,3%, ECM/BCM = 0,84 ± 0,05; VO2max · kg–1 = 33,1 ± 5,3 ml · kg–1 · min–1) objęto zindywidualizowanym programem aktywizacji ruchowej, w którym założono, iż tygodniowy wydatek energii każdego z badanych wyniesie 6270 kJ. Na treningi złożyły się ćwiczenia aerobowe w chodzie (ok. 80% objętości) i w jeździe na rowerze (ok. 10% objętości). Zajęcia odbywały się 3–5 razy w tygodniu i trwały 20–50 min, tj. 85–250 min tygodniowo.

Wyniki. Badani wykonywali intensywny wysiłek fizyczny na poziomie 50–70% VO2max (HR rzędu 65–90% HRmax lub 130–170 ud. · min–1). Tygodniowy wydatek energii w trakcie ćwiczeń wynosił 4390–7780 kJ, tj. średnio 6440 (960) kJ. Po pięciu miesiącach treningu odnotowano niewielki, aczkolwiek istotny statystycznie ubytek masy ciała badanych, średnio o 3,5 (1,9) kg ($p < 0,05$), a także wzrost FFM, średnio o 2,6 (1,2) kg ($p < 0,05$), stwierdzono ponadto spadek poziomu BF, średnio o 3,2 (1,6)% ($p < 0,05$). W porównaniu do wartości początkowej wzrosła natomiast aż o 17 (7,3)% ($p < 0,01$) wydolność aerobowa, odnotowano również wzrost wartości wskaźnika VO2max o 15 (2,5)% ($p < 0,01$).

Wnioski. Na podstawie wyników badań stwierdzono, że u osób nieuprawiających sportu trening, który umożliwia tygodniowy wydatek energii rzędu 6270 kJ skutkuje znaczną poprawą wydolności aerobowej i sprawności motorycznej.

Badania zostały sfinansowane ze środków Ministerstwa Edukacji Republiki Czeskiej, nr grantu: MSM 0021620864.

Introduction

Main goals of all interventions in adults are to contribute to their independence and to the improvement of life quality. Together with these it is contribution to the health state and thus to contribute to the decrease of health care cost. All interventions must follow the physiological background and individuality of each subjects.

Age related changes in body composition (BC) have implications for physical function and health. The redistribution and increase of fat and the loss of muscle mass result in substantial decrease in functional capacity. Although BC, as well as the age-related changes in it, has a strong genetic component, it is also influenced by environmental factors. The primary influences are nutrition, disease, and physical activity [1].

Clinically, BC is viewed in terms of two compartments: fat and fat-free mass [2]. Fat mass (FM) plus fat-free mass (FFM) that are make of proteins, water, and minerals, equals to the total body mass.

Beginning in middle adulthood, FFM begins to decline gradually both in men and women, primarily due to the wasting of muscle tissue [2]. Similarly like FFM decreases with age the body cell mass (BCM) in subjects without of systematically physical training. This similarity is confirmed by a high significant positive correlation between these both variables that was found in women [3]. The BCM is the sum of oxygen-using, calcium rich, glucose-oxidising cells. This variable may indirectly characterize the ability of human to sustain a mechanical work. Because the BCM is related to FFM and this to body mass it is for standardization often used the relationship ECM/BCM. Extracellular body mass (ECM) is defined like ECM = FFM – BCM. Dependence of ECM/BCM on age is in the Fig. 1.

Numerous tools and methodologies have been developed to measure various BC parameters. The bioelectrical impedance analysis (BIA) seems to be one of the most used methods in the field conditions [4]. Regardless of which instrument is chosen to assess BC, the method is only as good as the measurement technique and prediction or conversion formula applied. The conversion formulas and prediction equations selected use must be restricted to the populations from which they were derived to remain valid [3, 4].

One of the basic themes in exercise science research has focused on the relation of exercise on improvement of physical fitness, usually measured as maximal oxygen uptake (VO_2max). Physical fitness is a broad concept, encompassing several specific types of fitness including strength, flexibility, and balance [5, 6]. In seniors the actual physical fitness state is not only the predisposition of better physical performance but it is the significant basis of their independency.

When evaluating the influence of physical activity on the human it is important to know its energy requirement [7, 8]. A positive influence is exerted only by those physical activities, when during their application a certain minimal threshold is exceeded. The level depends on the purpose for which these activities are performed.

Aim of this study was assess the influence of the moving program which contains the most frequently

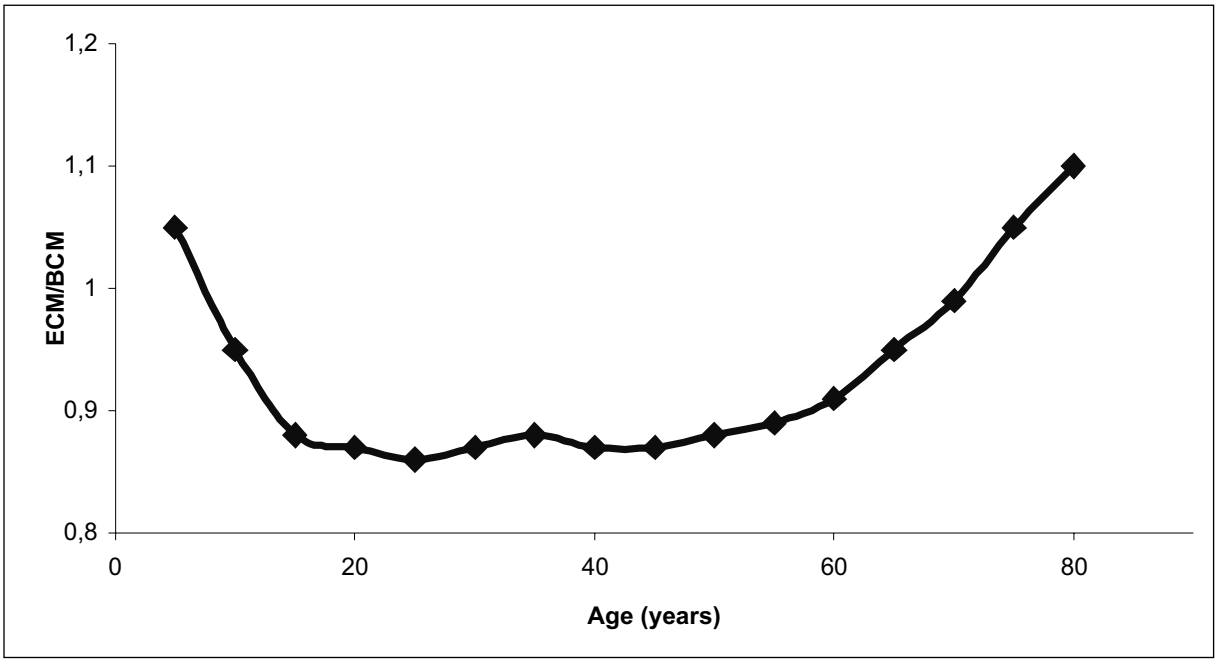

Figure 1. Dependence of the relationship ECM/BCM on the increasing age

used moving activity – walking on aerobic fitness described by maximal oxygen uptake in healthy senior women.

Material and methods

The group of 68 non-trained healthy men of middle age were participated in this study. The research was performed in men, residing in area of Prague, without objective internal limitation, who participated in physical activity programs of Faculty of Physical Education and Sports, Charles University Prague. Before the start of their participation in this study all absolved the medical evaluation together with cycle ergometer testing and dynamical assessment of ECG, and blood pressure that was realized by physician one week before the start of the program.

Selected anthropometrical and maximal functional variables are collected in Table 1.

The body cell mass was calculated using the FFM and phase angle between whole impedance vector and resistance α [3]. The extra cellular mass (ECM) is the difference between FFM and BCM – ECM = FFM – – BCM. The FFM was calculated according to modified formula of Deurenberg et al. [9].

Resistance and reactance were measured at four frequencies – 1, 5, 50 and 100 kHz (B.I.A. 2000M, Data Input, Germany) on the right side of the body by tetrapolar electrode configuration in accordance with manufacturer's specification. For the calculation of body fat content were used the prediction equation that were valid in senior women by DEXA method.

The physical performance in the field testing conditions was tested by a walking test – 2000 m walk on a flat terrain, mainly on the track. The test was realised in the time range of one week before or one week after laboratory evaluation.

The maximal functional variables determined on a treadmill with slope of 5% during a progressive walking test until subjective exhaustion. The initial speed on the treadmill was 4 km · h^{-1} on slope of 5% and was increased each minute by 1 km · h^{-1} till subjective exhaustion. The cardiorespiratory variables were measured in an open system using an on line method by TEEM 100 (Aerosport) and/or CORTEX. All analyzers were checked before and after each test by a calibration gas of known concentration. The ventilation was controlled before and after test by mechanical pump.

The energy demand of physical exercise was collected by Caltrac measurement together with assessment of energy cost of exercise from general relationship between the exercise intensity and energy that he or she needs for cover of this activity (Bunc 1994). The differences between both methods were lower than 12%.

According to our measurements in adult men (n = 196) the general dependence of oxygen consump-

tion on walking speed on flat surface in range of intensities 4–10 km · h^{-1} was established in the form

$$VO_2 \cdot kg^{-1}(ml \cdot kg^{-1} \cdot min^{-1}) = 9.577^* v\ (km \cdot h^{-1}) - 32.411$$

$R = 0.898$, $p < 0.005$, $S_{EE} = 1.52\ ml \cdot kg^{-1} \cdot min^{-1}$, $T_{EE} = 1.80\ ml \cdot kg^{-1} \cdot min^{-1}$

For calculation of energy cost from oxygen uptake was used mean energy equivalent for oxygen 4.83 kcal · min · l^{-1} (20.2 kJ · min · l^{-1}), neglecting the contribution of protein (about 15%) to the total metabolism [7].

The energy output on the level of 1500 kcal (6270 kJ) per week was respected by construction of individual moving programs [10]. The moving programs consisted of aerobic walking (min 80% of whole exercise) or cycling (min 10% of total exercise) at the level of 50 to 70% VO_{2max} (HR ranged from 65 to 85% of HR_{max} or 130–170 beats · min^{-1}). The duration of exercise session ranged from 20 to 50 min, and training was performed 3–5 times a week. The time spent at exercise per week ranged between 85–250 min. Rest of absolved exercise was individually dependent, and majority was home gymnastics or swimming. The duration of exercise session ranged from 20 to 50 min, and exercise training was performed 3–5 times a week during 5 months.

The intensity of exercise (heart rate) was monitored continuously by Polar Sportester and by step counter OMRON HJ-720IT-E2.

The data about qualitative contents of exercise were collected by questionnaire.

Means and standard deviations were calculated according to standard methods. The paired t-test was used to evaluate differences between means where appropriate.

Results

The standards of aerobic fitness and physical performance (mean speed of walking on distance of 2000 m on flat terrain) are presented in Table 1. The Good levels there are standards for Czech men. Poor it is mean minus one standard deviation, and Excellent it is mean plus one standard deviation. This Table could be used in field for assessment of both aerobic fitness and physical performance senior women.

Selected anthropometrical and "maximal" functional variables before and after moving program which were collected in group of 68 non-trained healthy men are presented in Table 2.

The mean of daily realized steps ranged from 9872 (450) to 13 562 (730) and was on the level recommend 10 000 steps per day [11].

The energy output of exercise ranged from 4390 kJ to 7780 kJ [mean 6440 (960) kJ] per week. After 5 months of training, slight but significant BM loss [mean 3.5 (1.9) kg; ($p < 0.05$)], FFM increase [mean 2.6 (1.2) kg; ($p < 0.05$)], BCM increase [mean 4.1 (2.3) kg; ($p < 0.05$)], ECM/BCM decrease [mean 0.05 (0.004); ($p < 0.05$)], and BF decrease [mean 3.2 (1.6)%; ($p < 0.05$)] was

Table 1. Standards of aerobic fitness ($VO_2max \cdot kg^{-1}$) and physical performance for adult men determined on a treadmill walking and during a 2000 m track walk

	Poor		Good		Excellent	
Age	**Speed**	**$VO_{2max} \cdot kg^{-1}$**	**Speed**	**$VO_{2max} \cdot kg^{-1}$**	**Speed**	**$VO_{2max} \cdot kg^{-1}$**
(yrs)	**(km · h^{-1})**	**(ml · kg^{-1} · min^{-1})**	**(km · h^{-1})**	**(ml · kg^{-1} · min^{-1})**	**(km · h^{-1})**	**(ml · kg^{-1} · min^{-1})**
25	7.5	39.5	8.5	49.2	9.4	57.0
30	7.2	36.5	8.1	45.9	9.0	54.0
35	7.1	35.2	8.0	44.4	8.9	52.9
40	6.9	33.4	7.8	42.3	8.7	50.9
45	6.7	31.3	7.6	39.9	8.5	49.2
50	6.5	29.7	7.4	38.6	8.3	47.5
55	6.3	27.9	7.2	36.5	8.1	45.9
60	6.1	26.1	7.1	35.2	8.0	44.4

Table 2. Selected anthropometrical and functional variables before and after moving program that were collected in a group of healthy senior women (n = 53)

	Before	After
Age (yrs)	45.7 ± 3.6	46.1 ± 3.6
Height (cm)	176.3 ± 4.8	176.2 ± 4.8
Body mass (kg)	79.1 ± 7.9	75.6 ± 7.8*
Body mass (%)	100	95.6 ± 4.6*
FFM (kg)	64.0 ± 4.8	66.6 ± 4.7*
FFM (%)	100	104.0 ± 5.2*
Fatabs (%)	19.1 ± 4.3	15.9 ± 4.4**
Fatrel (%)	100	83.2 ± 3.9**
BCM (kg)	40.8 ± 4.0	44.9 ± 3.8**
BCM (%)	100	110.0 ± 2.7**
ECM (kg)	34.3 ± 3.1	35.5 ± 4.0*
ECM (%)	100	103.4 ± 3.1*
ECM/BCM	0.84 ± 0.05	0.79 ±0.04 **
ECM/BCM (%)	100	94.1 ± 3.6**
HRmax (beats · min^{-1})	170 ± 7	169 ± 6
VO_2max · kg^{-1} (ml · kg^{-1} · min^{-1})	33.1 ± 5.3	38.7 ± 4.9**
VO_2max · kg^{-1} (%)	100	117.0 ± 3.3**
V_{max} (5%) (km · h^{-1})	6.9 ± 1.1	7.9 ± 0.9**
V_{max} (5%) (%)	100	115.0 ± 1.5**

p < 0.05, ** p < 0.01

found. Aerobic fitness (VO_2max) increased significantly by 17.1 (7.3)%; (p < 0.01) of initial value. Similarly as VO_2max was significantly increased the maximal speed of running by 15.2 (2.5)%; (p < 0.01) of starting value.

Highly significant dependence of maximal oxygen uptake on ECM/BCM was found in our group of men

$$VO_2\text{max} \cdot kg^{-1} \text{ (ml} \cdot kg^{-1} \cdot min^{-1}) = -2.607*\text{ECM/BCM} + 54.857$$

$$r = 0.891,\ p < 0.005,\ S_{EE} = 1.70 \text{ ml} \cdot kg^{-1} \cdot min^{-1},\ T_{EE} = 1.96 \text{ ml} \cdot kg^{-1} \cdot min^{-1}$$

The relationship ECM/BCM was increased significantly with the age in age higher than 60 years. This increase could be described by linear dependence in following form

$$\text{ECM/BCM} = 0.006*\text{age (years)} + 0.543$$

$$r = 0.874,\ p < 0.005,\ S_{EE} = 0.05,\ T_{EE} = 0.06$$

The time spent at the described exercise intensity per week ranged between 95–260 min (mean 156.8 ± 48.9 min). Walking time ranged between 82 and 233 min (mean 142.8 ± 45.7 min). In relative description of total exercise time it was range of 86.0%–95.2%. The time spent for other form of physical activities ranged between 8 and 27 min, in relative description it was in range from 11.8 to 13% of total exercise time. Rest exercise was realised like home gymnastic, swimming, jogging or cycling.

The mean field performance – time in walking test on distance of 2000 m – in the 1st evaluation was 1047 ± 31 s and was significantly worse than in 2nd measurement 965 ± 42 s (p < 0.01). The results of 2nd evaluation were about 7.8 ± 2.5 % better than results of 1st testing.

The subjects did not experience any health or serious fatigue symptoms that would limit their walking during filed test. The majority of subjects, over 90% reported no symptoms. Among the most frequently reported symptoms was pain in lower limbs.

Discussion

Walking is a viable form of physical activity that research has shown to be an effective intervention in the population without of regular physical training, producing both physical and psychosocial benefits. However, there are many barriers to physical activity for these non-trained subjects, including safety issues, access, support, and health concerns. Community mall walking programs have the potential to address several of these barriers, particularly safety and social support needs.

Functional fitness age and/or actual development state (mainly described like a biological age) is a measure of functional age that reflects a person's overall physical ability and thus the working capacity to complete daily tasks such as preparing meals and performing various household chores [12]. For the prevention of diseases and especially functional deficits and thus the independency in old age, physical activity is a simple, practicable and successful method. With increasing age and frailty or in rehabilitation training, these activities have to be more and more individualized and medically supervised.

An important physiological concept of exercise in rehabilitation and/or conditioning is the type of work that the body is performing. Dynamic work of endurance character like running, walking, swimming and cycling requires the movement of large muscle masses and requires a high blood flow and increased cardiac output. From these activities the walking is probably the most easily accessible, and often underestimated as a way to increase a subject´s overall level of fitness and/or for moving rehabilitation in non-trained subjects or in selected groups of patients. The person´s adaptation to walking is the highest from the all form of physical exercise that may be used for these goals.

Major advantage of walking over running is that it has a lower frequency of injuries and that in a group of patients the probability of exceeding of security level is lower than in running. The strain on ligaments and joints by walking is far less than for comparable running exercises. By application of walking like a group exercise form it is very important that exercised subjects are able to communicate during the exercise, what can contribute to the wellness of these subjects.

The initially values of BC and aerobic fitness were slightly worse than are the Czech population standards of this age. After 5 months of aerobic training both values of aerobic fitness and BC were significantly better than our population standards [8]). Both these improvements were significant. The positive changes in BCM and ECM/BCM means that during the imposed training the predispositions for muscle work were significantly better.

Unfortunately we have not comparable data about BCM and ECM of Czech adult population and/or other European countries. These data are lacking in to our known literature.

Beginning in middle adulthood, FFM begins to decline gradually both in men and women, primarily due to the wasting of muscle tissue. FFM is significantly lower in elderly women than in younger women [2], and it is estimated that FFM decreases 3kg per decade, on average, in middle-aged to elderly sedentary healthy adults [13] This loss is almost 1–1/2 times as great in men as women, because men were found to lose FFM at the rate of 0.34 kg · year^{-1} whereas women lost FFM at the rate of 0.22 kg · year^{-1} [14]. Between 40 and 80 years of age, men lose FFM at the rate of 5% each decade, whereas women lose about 2.5% FFM each decade [15]. At these rates, men and women lose approximately 20% and 10% of total FFM, respectively, between ages 40 and 80 years. Thus, while fat mass is increasing with age, FFM is decreasing [12].

Factor that is most important for physical independence of subjects is a muscle strength [1]. Muscle strength is strongly dependent on muscle mass and this is important in seniors, and it is a main reason of their dependency [16]. It is documented that the decline of muscle strength with age has been quantified as about 10% per decade after the age about 40 [17]. From the limited research that has been done on elderly women, there seems to be a positive relation between activity level and muscle strength (e.g. Rantanen et al. [18]) The form of physical training (strength or endurance) play decisive role for level of muscle mass and thus muscle strength.

The proportion between the ECM and BCM ratio may be used to identify fluid imbalance or malnutrition and/or to assess the predispositions for muscular work. The term malnutrition refers to the loss of structural body components, which is most accurately reflected by the BCM and an increase of the ECM [4].

The using of ECM/BCM for evaluation of physical exercise predispositions was confirmed by the signifi-

cant dependence of VO_2max on this variable. The relationship between VO_2max and physical performance was often presented in literature [e.g. Astrand and Rodahl 7]. In our group of men this dependence was significant too ($r = 0.796$, $p < 0.005$). In practice this coefficient could be used as one of important criteria for exercise program efficiency.

The significant positive ECM/BCM dependence on age could be used for assessment of actual development state – biological age in subjects. In actual case we compared real value of ECM/BCM with value that was calculated according to general relationship that was true for adult men.

In normal subjects of middle age, ECM/BCM ratios are recorded between 0.75 and 1.00. Deviations from such figures toward higher values are due either to the erosion of BCM (catabolism) or to fluid expansion in extracellular spaces (edema). In the case of dehydration, we can observe the opposite phenomenon where the ECM/BCM ration is reduced.

Because the diet of followed subject was practically without significant alterations during whole 5 months, the significant increase in both FFM and BCM may be probably caused by imposed training program.

The changes in VO_{2max} induced by endurance walking program are practically consistent with those found by Proper et al. [19], who found in group of men and women of similar age 14% increase in aerobic fitness, and significant increase in FFM and significant decrease in BF and total body mass. These results were confirmed by our data but the changes in BC variables were not so high. The cause could be in participation of both sexes on study of Proper et al. [19].

There is evidence to show that the magnitude of the increase in VO_2max is dependent on total energy expenditure of exercise, and thus on frequency, and duration of exercise as a number of previous investigations have shown improvement to be in direct proportion to the number of weekly sessions [8]. According to the results of previous studies, VO_2max as measured either in laboratory or in field has generally improved during the first months of conscription among non-trained subjects [5].

The minimum training energy expenditure required to maintain an elevated VO_2max has not been clearly established. For example the most recent ACSM prescription guidelines (1995) recommended minimal energy expenditure of 300 kcal per exercise session performed three days a week or 200 kcal per exercise session performed four days per week.

Adequate energy output has its effect both in the presence and in the absence of other influences, and the beneficial relationship continues with advancing age.

In conclusion, physical training in energy expenditure higher than 1500 kcal per week realised with help of activities on which are subjects highly adapted may significantly improve the maximal oxygen uptake, body composition and motor performance (speed of running) in non-trained men of middle age.

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MOTOR FITNESS IN RELATION TO BODY BUILD AND PHYSICAL ACTIVITY IN 16-18-YEAR-OLD YOUTH

SPRAWNOŚĆ MOTORYCZNA A BUDOWA CIAŁA I AKTYWNOŚĆ FIZYCZNA U 16–18-LETNIEJ MŁODZIEŻY

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Key words: youth, motor abilities, body build, physical activity, free time
Słowa kluczowe: młodzież, zdolności motoryczne, budowa ciała, aktywność fizyczna, czas wolny

SUMMARY • STRESZCZENIE

Aim of the study. The research was designed to find out whether physical activity analyzed along with somatic parameters would prove to be crucial for motor fitness in youth.

Material and methods. The data includes surveys and measurements collected from secondary school students from Głuchołazy, aged 16–18. Three hundred and forty-five students, 165 boys and 178 girls, were measured for body height and mass with which the body mass index (BMI) was calculated. Body build was characterized by tissue components in Sheldon's typology modified by Heath and Carter (endomorphy, mesomorphy and ectomorphy). The motor abilities level was tested by means of five fitness trials for strength, speed and coordination and additionally, a questionnaire with questions on the amount of time spent on physical activity and passive activities in free time was used. The data was processed statistically, arithmetic means and standard deviations of traits for age and sex groups were calculated, and the forward stepwise regression method was employed.

Results. In boys the most important factors in the level of particular motor abilities are the muscles of the upper limb, the endomorphy component indicating the body adiposity and massiveness of lower limb bones. The girls' motor fitness correlates significantly with the time spent weekly on physical activity and passive activities after school. Additionally, somatic parameters were selected – the musculature of the upper and lower limbs, body build slenderness and massive bone structure of the upper limbs.

Conclusion. Physical activity manifested itself as an important factor affecting only motor fitness in girls, whilst in boys the level of the selected motor abilities was affected solely by somatic features of the organism and not by the analyzed factors pertaining to lifestyle.

Cel pracy. Celem pracy było zbadanie, jaki udział w kształtowaniu sprawności motorycznej chłopców i dziewcząt w wieku 16–18 lat mają parametry somatyczne oraz aktywność fizyczna.

Materiał i metody. Materiał obejmuje dane pomiarowe i ankietowe młodzieży szkół ponadgimnazjalnych w Głuchołazach. Łącznie zbadano 343 osoby (165 chłopców i 178 dziewcząt) w wieku od 16 do 18 lat. Zmierzono wysokość i masę ciała, wyliczono wskaźnik BMI. Budowę ciała scharakteryzowano za pomocą komponentów tkankowych typologii Sheldona w modyfikacji Heath i Carter'a. Do oceny poziomu rozwoju zdolności motorycznych wykorzystano pięć prób sprawnościowych diagnozujących zdolności siłowe, szybkościowe i koordynacyjne. Przeprowadzono ankietę, która zawierała pytania dotyczące czasu przeznaczanego na aktywność fizyczną i zajęcia bierne podejmowane w czasie pozaszkolnym. W grupach wieku i płci obliczono średnie arytmetyczne oraz odchylenia standardowe cech, zastosowano także regresję krokową postępującą.

Wyniki. U chłopców najważniejszymi zmiennymi dla rozwoju badanych zdolności motorycznych są: umięśnienie kończyny górnej, komponent endomorficzny mówiący o wielkości otłuszczenia ciała oraz masywność budowy kośćca kończyn dolnych. Sprawność motoryczna dziewcząt koreluje istotnie z czasem przeznaczanym tygodniowo na aktywne i bierne zajęcia pozaszkolne, a także z umięśnieniem kończyn górnych i dolnych, smukłością budowy ciała oraz masywnością kości kończyny górnej.

Wnioski. Sprawność motoryczna dziewcząt w wieku 16–18 lat jest związana głównie z ich aktywnością fizyczną. Natomiast u chłopców w badanym okresie poziom wybranych zdolności motorycznych uzależniony jest wyłącznie od cech strukturalnych organizmu, nie zaś od analizowanych czynników związanych ze stylem życia.

Introduction

Physical fitness and somatic build of an individual undergo lifelong changes due to genetic and environmental factors, but although the development of particular somatic and functional traits varies in functioning and intensity, it follows the natural stages.

Despite the existence of invariable sequences in the growth of the organism, the physical fitness and somatic build differ between individuals. It is caused by complex interactions between genetic characteristics and environmental modulators. Physical fitness depends on a lot of factors, most commonly diagnosed ones are: age, gender, body build, the level of development of motor skills, the type of work, training and lifestyle. The relations between environmental factors and the level of physical fitness has been analyzed by many scientists [1, 2, 3, 4, 5, 6]. Many writers have also discussed the subject of dependencies between physical fitness and the parameters of the somatic structure [7, 8, 9, 10, 11, 12, 13]. Recently there has been an increase of interest in the problems of physical activity and their relation to somatic build, physical fitness and, most of all, with health [14, 15, 16, 17, 18, 19, 20, 21].

Physical activity is defined as every body movement performed by the skeletal muscles and leading to energy expenditure [22]. Physical activity is also understood as physical effort accompanying everyday professional and school tasks and chores, as well as physical effort associated with sport or recreational activities [23]. Changes occurring in the organism because of regular, recreational physical activity are invaluable for the circulatory, respiratory and nervous systems and for the bone and muscle tissues and metabolism [24, 16]. However, the beneficial effects of the regularly taken physical activity are most frequently interpreted in terms of the diminished risk of incidence of cancer and diseases of the circulatory system classified as 'civilization diseases'. Physical activity, stabilizing and reducing body mass, is the best way to prevent and fight overweight and obesity [15, 25, 26, 27], as well as to slow down aging and decrepitude [28]. In the light of the above benefits, physical activity appears to be a remedy neutralizing the negative effects of modern lifestyle [23, 15].

Physical activity during childhood and young age is critical as it is indispensable for correct and overall growth – somatic, intellectual, psychological and social [29]. Physical activity stimulates the child's body growth with proportional increment in body mass and provides a possibility for better knowledge of its environment and society, and challenges the child with a variety of situations, like accepting failures with dignity, celebrating successes, coping with stress, fatigue and weaknesses, and controlling emotions. The child learns self-control and rules observed in a given social group thus shaping its relationship with others.

Shaping positive attitudes in children and the young towards physical activity, perceived as one of the most important part of a healthy lifestyle, is ascribed in particular to family and school, and to a somewhat lesser extent to peers, mass media and sports events [30].

The research was designed to find out whether physical activity analyzed along with somatic parameters would prove to be crucial for motor fitness in youth.

Material and methods

The material comprises the data collected in the research on 343 subjects, 165 boys and 178 girls, aged 16–18. The study involved students attending all types of upper secondary schools in the town of Głuchołazy, i.e. Secondary School, Basic Vocational School, Secondary Technical School and Secondary School of Vocational Education. The examined students comprise 59.2% of the population of youth attending schools included in the research. For each subject real age was calculated, then rounded to calculate age categories (e.g. into the group of the 16-year-olds, subjects aged 15.50–16.49 were included).

The measurements of somatic traits and manifestation of selected motor traits were taken in physical

education (PE) classes, i.e. when the schools were working. The measurements were taken in the gyms at Secondary School and ZSZ. Both halls were very similar in respect of their size, height, floor, temperature and light. The subjects were familiar with the study goals and were wearing sports clothes.

Somatic traits measurements were taken by means of Martin's technique [31]. Basic morphological parameters were measured: body height (B-v) using an anthropometer with an accuracy of 0.1 cm and body mass using an electronic scale to the nearest 0.1 kg. The results were used to calculate the Body Mass Index (BMI).

Body build was described by means of Sheldon's typology modified by Heath and Carter [32, 33]. The development level of each tissue component – endomorphy, mesomorphy, and ectomorphy – was determined by means of somatic measurements. We measured: 1) skinfolds: on the arm (triceps), the shoulder blade (subscapular), the iliac crest (supraspinal), and the lower leg (calf) using the Harpenden caliper with a constant tension closing compression of 10 g/mm², with an accuracy of 0.1cm; 2) the largest circumferences of the upper arm and the calf using a tape to the nearest 0.1 cm; 3) the biepicondylar breadth of the humerus (cl-cm) and the biepicondylar breadth of the femur (epl-epm) using a sliding caliper to the nearest 0.1 cm. The adipose skinfolds, muscle circumferences and biepicondylar breadths were measured on the right-hand side of the body following Carter and Heath's instructions [33].

The level of development of motor skills was tested with five tests [34, 35]: a throw with a 2-kg medical ball (explosive strength of the upper limbs), hand grip on a hand dynamometer (static strength), standing broad jump (explosive strength of the lower limbs) shuttle run: 10 x 5m (speed), tapping test with a hand (movement speed and frequency of the upper limb).

In addition to the somatic and motor procedures, a standardized questionnaire was applied in which we used tools offered by other researchers [30, 36]. The subjects were also explained the notion of leisure time, as it was vital for the understanding of the goal of the study. In this case we used the definition by Dumazedier [37]. The examined students were asked about active and passive ways of spending time after school during the previous 30 days (late March/early April). The following activities were proposed in the questionnaire as examples of passive activities: reading press and literature, afternoon nap, hosting guests (family, friends), listening to music, watching films/television, going to the cinema, pub etc., computer work (games, internet) and some less popular activities. The active ways of spending time (types of physical activity) proposed in the questionnaire included: running/jogging, team games (football, basketball, volleyball, etc.), tennis, skating, cycling, swimming, dancing and some less popular activities. The obtained information about the frequency and duration of each activity undertaken after school was used to calculate the number of hours spent weekly in active and passive way.

The collected data was processed using Statistica 6.0 by StatSoft. First arithmetic means and standard deviations of the traits in the sex and age groups were calculated. Student's t-test for independent data was used to compare mean values, the level of $p \leq 0.05$ being considered significant. The relationship between the analyzed parameters (descriptive variables) and particular motor effects (result variables) was examined by the method of forward stepwise regression. The number of descriptive variables in the descriptive set was limited to two.

The result analysis conducted by means of the forward stepwise regression was limited to two variables which best described the selected manifestations of physical fitness because of the negligible differences in the values of the correlation coefficients between consecutive multi-element models. In the group of the descriptive variables, apart from the parameters addressing the somatic structure of the examined subjects, their real age as well as time spent weekly on passive activities and physical activity in leisure time were considered.

Results

The statistical characteristics of somatic measurements and the results of motor tests revealed a large difference between genders, which is typical for the studied phase of ontogenesis. Boys, when compared to girls, are characterized by higher mean values of all of the analyzed body build parameters except for the endomorphic component and a higher motor agility (Table 1, 2).

The obtained results reveal that in boys only three descriptive variables out of eleven are significant for the level of particular motor abilities (Table 3). The most important are the muscles of the upper limb expressed as the upper arm circumference. The following two variables are the endomorphy component informing on the

Table 1. Somatic characteristics of boys and girls

Parameters	Boys		Girls		Student's t-test boys – girls	
	$\bar{x}$	s	$\bar{x}$	s	t	p
Body height [cm]	176.89	7.24	164.24	5.87	16.42	<0.01
Body mass [kg]	66.72	11.60	55.31	8.28	9.71	<0.01
BMI [kg/m^2]	21.27	3.16	20.49	2.72	2.27	<0.05
Biepicondylar breadth of the humerus [cm]	6.91	0.40	5.98	0.38	20.36	<0.01
Biepicondylar breadth of the femur [cm]	9.63	0.59	8.66	0.58	14.11	<0.01
Upper arm circumference [cm]	24.26	2.13	19.72	1.73	19.96	<0.01
Calf circumference [cm]	33.54	2.67	31.08	2.29	8.44	<0.01
Mesomorphy	3.06	1.18	2.09	1.10	7.30	<0.01
Endomorphy	2.49	1.27	3.64	1.14	–8.11	<0.01
Ectomorphy	3.29	1.47	2.88	1.38	2.42	<0.05

body adiposity, and massiveness of the bones of the lower limbs expressed as the biepicondylar breadth of the femur. The age of the subjects and the time spent on activities during their leisure time turned out to be negligible in terms of motor manifestations in boys in the post-pubertal period, quite contrary to their female peers in whom the time spent on physical activity seems to be vital. Additionally, somatic parameters were considered – the musculature of the upper and lower limbs, body build slenderness and massive bone structure of the upper limbs.

The level of the explosive strength of the upper limbs in boys revealed the closest positive relationships with the musculature of the upper limbs and the massiveness of the bones of the lower limbs. The multiple correlation coefficient calculated for these two variables is the highest among the ones describing the selected manifestations of physical fitness and has the value of R = 0.62. In girls, the musculature of the lower limbs and the time spent on physical activity were crucial to score desired results in throws with a 2-kg ball and to gain R = 0.53. Physical activity in females helps shape explosive strength of the lower limbs, similarly as slender body build, whilst in males it is predominantly lower adiposity and massiveness of the bones of the lower limbs that add to better scores in the standing broad jump. The correlation coefficient value does not exceed R = 0.40 in both sex groups.

The speed of movements of the upper limb in both sexes revealed a relationship with only one descriptive variable, and the coefficient of multiple correlations shows one of the lowest values, below 0.25. In boys,

Table 2. Motor characteristics of boys and girls

Motor test	Boys		Girls		Student's t-test boys – girls	
	$\bar{x}$	s	$\bar{x}$	s	t	p
2-kg ball throw [m]	10.38	1.67	6.25	1.04	24.49	<0.01
Standing broad jump [cm]	212.61	22.55	163.09	16.88	20.51	<0.01
Tapping [s]	9.85	0.81	10.52	1.04	–5.95	<0.01
Shuttle run 10x5m [s]	19.68	1.32	21.75	1.25	–13.24	<0.01
Hand grip [kG]	49.57	8.69	29.33	5.53	22.82	<0.01

Table 3. Results of the forward stepwise regression analysis for the selected motor tests in respect of somatic parameters, time spent weekly on selected post-school activities and age

Parameters	Motor test				
	2-kg ball throw	**Standing broad jump**	**Tapping**	**Shuttle run 10x5m**	**Hand grip**
BOYS					
Body Mass Index (BMI)					
Biepicondylar breadth of the humerus					
Biepicondylar breadth of the femur	**0.195***	**0.318****			**0.368****
Upper arm circumference	**0.492****		**0.300***		**0.259***
Calf circumference			–0.145		
Mesomorphy					
Endomorphy		**–0.401****		**0.268***	
Ectomorphy					
Physical activity time					
Passive activities time				0.163	
Age					
R	0.615	0.390	0.243	0.323	0.548
R^2	0.378	0.152	0.059	0.104	0.300
F	39.519	11.673	4.078	7.570	27.868
Standard error of estimation	1.339	21.231	0.781	1.250	7.357
GIRLS					
Body Mass Index (BMI)					
Biepicondylar breadth of the humerus					**0.223***
Biepicondylar breadth of the femur					
Upper arm circumference					**0.396****
Calf circumference	**0.383****				
Mesomorphy					
Endomorphy					
Ectomorphy		**0.279***		–0.159	
Physical activity time	**0.344****	**0.290****	**–0.239***		
Passive activities time				–0.174*	
Age			0,121		
R	0.532	0.356	0.249	0.230	0.544
R^2	0.283	0.127	0.062	0.053	0.296
F	26.018	9.579	4.377	3.696	27.779
Standard error of estimation	0.886	15.889	1.016	1.230	4.676

* the level of significance $p \leq 0.05$
** the level of significance $p \leq 0.001$

the tapping test results are in connection with the musculature of the upper limb, and in girls – with physical activity.

Among the analyzed independent variables, only the degree of body adiposity is significant for the development of boys' speed skills. A lower level of endomorphic component saturation fosters obtaining better results in the shuttle run, and the correlation coefficient assumes here the value of R = 0.32. Whereas among girls no relationships between the selected somatic parameters and manifestations of speed skills were noticed, and the only independent variable in the model is the time spent on passive activities. The relationship of the shuttle run and the time spent weekly on passive activities took a negative direction, and the correlation coefficient is the lowest, i.e. R = 0.23.

The analysis of the relationships between the static strength of the hand and the selected somatic traits in the subjects indicates that for that type of motor abilities general size of the limbs seems to be vital. Higher musculature of the arm in both sexes and larger biepicondylar breadths of the femur in boys and of the humerus in girls promote better scores in hand grip on the dynamometer. The enumerated somatic parameters are vital for gaining the highest multiple correlation coefficient in girls, R = 0.54, and in boys, only slightly higher – R = 0.55.

Discussion

Biological phenomena are of complex nature due to a unique combination of traits in an individual under varied conditions and factors. The course of developmental processes depends on the stage of ontogenesis the examined population is at. The calendar age bracket taken into account in this research, 16–18 years, is already a post-pubertal period for girls, and for the majority of boys this is still a pubertal period. During this time the differences between the somatic structure and the level of motor activity of boys and girls arise and solidify. Thus, there is no doubt that both sexes differ in the examined period quite significantly, whereas the analyses conducted in this paper aim to explain which, among the features taken into consideration, shape the motor activity of boys and girls in this time the strongest.

In this paper the state of motor development is considered in a few respects: age, sex, somatic structure and active, or not, way of spending free time. In the examined period the calendar age takes, relatively, the most modest share in the differentiation of motor agility of the youth. The researches on the development of girls' motor skills indicate that the majority of them ends their development between the 13th and 15th year of life [38, 39, 40, 41]. In boys the discussed developmental processes last longer [42, 39, 40, 41]. Sex differences at the time and in the course of the developmental changeability of motor skills are emphasized, among others, by Przewęda [43], according to whom, because of morphological changes, taking place later in girls, in the male sex one can observe the development of strength skills lasting longer. Also, locomotive speed shows in boys the progression of results in time, whereas in peer girls this process has ended, which is confirmed by the research results obtained by, among others, Osiński [44] Przewęda and Dobosz [41], and Migasiewicz [45].

The obtained results, while emphasizing the importance of the two examined areas: somatic structure and physical activity in the shaping of human motor activity, confirm many observations made before [42, 24, 46, 47, 13]. Malina and collaborators [46] indicate the negative relationship between body adiposity and physical fitness.

Similarly, the results of longitudinal research conducted by Minck and collaborators [47] show that body adiposity is inversely associated with the results of the majority of agility trials in both sexes, and physical activity is a factor more frequently related to the level of physical fitness of women than that of men. The authors of the paper also stress that body adiposity and physical activity should be perceived as independent factors connected with physical fitness. Many authors also underline greater significance of body length parameters than body weight for the results of agility trials [46, 47, 48, 13]. At the same time, the significance of the muscle mass participation in the total body weight as an element of body build associated with physical fitness is emphasized [48]. The results of the research carried out by Milde and collaborators [13] based on the analysis of the relationships between the somatic factors and the results of Eurofit test trials among girls with Turner's syndrome (nanism) and healthy ones indicate the greater participation of body height than body weight in achieving results in the majority of motor trials of the Eurofit test.

The calendar age of girls, whose results are analyzed in this paper, is characterized by considerable slowing down and often also by the ceasing of the process of body growth in length contrary to boys. This

phenomenon could clarify the differences in the selection of areas of features explaining the results of agility trials. In girls, for maintaining the needed level of motor agility in the examined period of ontogenesis, physical activity taken up regularly is highly significant. These observations are concurrent with the Przewęda's views [42] who says that in girls after the 15th year of life the natural process of motor development ends, and further maintenance of the achieved motor level does not depend on the mechanisms of biological development, but is solely a consequence of lifestyle and physical activity taken up systematically. In boys such a relationship has not been stated. In comparison to girls, boys take up physical activity much more frequently, which is unquestionably reflected in the results of the extensive international report of the World Health Organization entitled *Health Behavior in School-Aged Children* (HBSC) [49]. The increased physical activity of boys appears to be a natural property of the analyzed developmental period, which is also observed in the examined population. Male groups were more uniform as regards the time spent on physical activity than female groups, which could result in non-disclosure of this factor among other parameters analyzed in the context of differentiating the level of motor agility. The structure of organism turned out to be much more important in the shaping of motor agility. However, it should be mentioned that the relationships between the motor test results and physical activity (in women) and the selected features of the somatic structure (in men) described in this research are significant, but not too much, which makes us careful in the final settlement of the observed phenomenon.

Conclusions

The results of this research show that motor agility in girls at the age of 16–18 is connected mainly with their physical activity, whereas in boys at this age the level of the selected motor skills depends solely on the structural features of organism, and not on the analyzed factors connected with lifestyle.

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PLACE OF RESIDENCE AND PHYSICAL ACTIVITY AS DETERMINANTS OF POLISH 6-YEAR-OLD CHILDREN'S PHYSICAL FITNESS

ŚRODOWISKO ZAMIESZKANIA I AKTYWNOŚĆ RUCHOWA JAKO DETERMINANTY SPRAWNOŚCI FIZYCZNEJ SZEŚCIOLETNICH DZIECI W POLSCE

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Key words: motor abilities, pre-school children, school maturity, physical activity
Słowa kluczowe: sprawność motoryczna, dzieci w wieku przedszkolnym, dojrzałość szkolna, aktywność ruchowa

SUMMARY • STRESZCZENIE

Introduction. The integrity of physical, motor and mental spheres of development determines the necessity of undertaking interdisciplinary research on the assessment of 6-year-old children's preparation for school education. Among numerous factors affecting "a good start" in the new environment the most significant tend to be motor ability and physical activity. The place of residence is also one of the most important determinants.

Aim of the research. The aim of the research was to determine the level of motor abilities in 6-year-old children at the end of their pre-school education. What is more, the influence of a specific environment on 6-year-old child's motor development which also determines the level of school readiness, as well as the level of adaptive skills in the first year of primary school have been examined. Additionally, the following question was asked: "Does spontaneous physical activity based on parents' subjective opinions diversify the level of physical development and motor abilities in 6-year-old children?"

Material and methods. The material is based on the results of research on children born in 2000 and finishing their one-year pre-school education. In total, 33459 children were assessed proportionally in randomly selected samples for each district (approximately 18% of the whole 6-years-old children population attending kindergartens and primary schools in 2007). The measure of physical fitness was taken through EUROFIT Tests of Physical Fitness. The statistical package SPSS 12.0 was applied to analyse the research data. The research material was grouped and statistically analyzed by means of ANOVA – analysis of variance.

Results. Significant disproportions in the level of 6-year-old children's motor abilities between the groups distinguished by the place of residence, and children's physical activity reported by their parents were proved.

Wstęp. Integralność sfer rozwoju sprawia, iż obecnie ważne jest podejmowanie badań interdyscyplinarnych w kontekście oceny przygotowania dzieci w wieku 6 lat do szkolnej edukacji. Wśród wielu czynników warunku-

jących „dobry start" w nowym środowisku jest sprawność i aktywność ruchowa. Istotne znaczenie ma również środowisko zamieszkania.

Cel badań. Celem badań było określenie poziomu rozwoju sprawności motorycznej dzieci 6-letnich kończących roczne przygotowanie do edukacji szkolnej oraz wpływu wybranych typów środowisk na sferę motoryczną dziecka 6-letniego warunkujących osiągnięcie stopnia dojrzałości szkolnej oraz adaptację w pierwszej fazie szkoły podstawowej. Dodatkowo zadano pytanie: czy spontaniczna aktywność ruchowa wyrażona subiektywną oceną rodziców badanych, sześcioletnich dzieci różnicuje poziom ich rozwoju fizycznego i umiejętności ruchowych?

Materiał i metody. Materiał stanowią wyniki ogólnopolskich badań dzieci urodzonych w 2000 roku, które kończyły roczne przygotowanie do edukacji szkolnej. Łącznie zbadano 33459 dzieci, zachowując proporcje procentowe w doborze losowym próby w każdym województwie (około 18% populacji dzieci 6-letnich uczęszczających do szkół i przedszkoli w 2007 roku). Podstawą oceny sprawności motorycznej był test EUROFIT. Obliczno statystyki posługując się pakietem SPSS 12.0. Materiał badawczy pogrupowano i poddano analizie statystycznej, wykorzystując jednoczynnikową metodę wariancji ANOVA.

Wyniki. Wykazano zróżnicowanie w zależności od miejsca zamieszkania oraz aktywności ruchowej dzieci, deklarowanej przez rodziców.

Introduction

The problem of physical fitness in different stages of ontogenetic development in terms of environmental factors has always received deep interest reflected in numerous studies. Nowadays, as a result of politicians', pedagogists' and the entire society's attention which has been drawn to the attempt at reducing the school entrance age, more and more frequent multifaceted research on 6-year-old children is conducted. The integrity of physical, motor and mental spheres of development, as well as social adaptation skills is emphasized in most publications [1, 2, 3, 4, 5, 6, 7, 8]. Physical fitness and spontaneous physical activity play a significant role in the developmental integration. Many authors indicate that proper motor development affects not only a child's health condition, but also intellectual development, the process of socialization, life experiences, greater independence, as well as positive self-image [9, 10, 11, 12, 13]. The research findings reveal that lower level of child's development in terms of motor skills and physical activity can be manifested through the lack of self-confidence and growth in qualities which indicate socializing problems hindering school learning and adaptation to the new environment.

Physical fitness and its components depend on the amount of child's physical activity [7, 8, 14, 15, 16, 17, 18, 19]. It is extremely important for children particularly in the period of their rapid growth, enhancement and improvement. The need for physical movement results from subconscious desire for physical activity which seems to be an essential factor affecting child's development. The important correlations between general fitness and physical activity have been proved by numerous studies [20, 21, 22]. However, according to some authors, these correlations tend to be weak [23]. Taking the above mentioned relationships into consideration, some of the researchers measure the efficiency of cardiovascular system or motor abilities which may become the source of information about the amount of spontaneous physical activity [24, 25, 26, 27].

The environment in which a child is raised has considerable influence on the level of physical fitness. Dichotomic division of economic-cultural conditions distinguished by the size and social nature is the most frequently applied [28]. At present, mutual and strong relationship between social, cultural and natural factors has been emphasized what is fundamental for the existence of researched populations within urban and rural ecosystems or ecological niche [29]. Monitoring of children and young people's functional development within the above-mentioned ecosystems proves disproportions in the level of rural and urban children's development which are increasing in the process of progressive development. Therefore, it might be concluded that the fact of living in an urban area, as well as high socio-economic status create favourable conditions for not only higher somatic parameters, but also better general physical fitness and some of its aspects. As a consequence, two specific profiles of physical fitness depending on the place of residence have been distinguished: agility and speed-based profile prevailing in urban areas, as well as strength and endurance-based profile typical of rural population [29, 30]. Disproportions in the level of specific motor competencies and aerobic capacity between children and young people living in different either rural or urban environments may be reduced thanks to participation in different forms of physical activity [31].

Based on the observations mentioned above, an attempt to assess the level of motor abilities development

in 6-year-old children at the end of their pre-school education has been made. What is more, the influence of a specific environment (either urban or rural) on 6-year-old child's motor development which also determines the level of school readiness, as well as the level of adaptive skills in the first year of primary school have been examined. Additionally, the following question was asked: "Does spontaneous physical activity based on parents' subjective opinions diversify the level of physical development and motor abilities in 6-year-old children?

Research material and methodology

The material is based on the results of research on children (girls and boys) attending one-year pre-school education in randomly selected kindergartens and primary schools in Poland. In total, 70 000 children born in 1999–2000 were examined. This group amounted to approximately 18% of the whole 6-year-old children population in 2007. It was a representative sample with respect to the division of population according to administrative districts, living environment (urban area, rural area, towns in urban-rural communities, rural areas in urban-rural communities), and the type of educational institution [32]. The research was conducted in two stages. Stage I, in April and May, involved children finishing their one-year pre-school education. During Stage II (September-October) children at the beginning of their one-year pre-school education were examined. To accomplish the module of motor abilities, 64 Physical Education teachers were directly engaged in this part of research. They were properly trained by the authors of the project. The training was directly supervised by the authors of the study.

During the first stage of our research, 33459 girls and boys (97.8% of the total number of the children involved in the research – Table 1) were examined within the module assessing the level of physical fitness. EUROFIT test samples to assess physical fitness of 6-year-old children were chosen according to availability and quality of sport facilities in schools and kindergartens in Poland, as it had been assumed during the initial stage of the project. Due to limited time and expenses anticipated in the initial stage of the project, two physical tests were abandoned: static hand grip strength, as well as circulatory and respiratory efficiency. The research programme was supposed to measure general balance („flamingo balance"), the speed of arm movement, flexibility, running speed, abdominal muscles power, explosive strength of lower and upper limbs based on EUROFIT tests [33]. In case of explosive strength of upper limbs test a simplified version of this trial was applied: children were expected to remain straight-arm hanging (time trial) as previous research proved that more than a half of children are not able to perform this test in its original (non-modified) version. During the test a proper order of the trials was maintained. A data record which enabled the authors to collect information on the percentage proportion of children who were not able to complete particular tests of motor abilities was introduced.

The results were sorted according to dependent variables. In the age, sex and environment groups previously established, as well as 6-year-old students' spontaneous physical activity reported by their parents, basic statistical characteristics were calculated (arithmetic mean and standard deviation). While analysing the differences in average values of somatic traits and motor abilities in relation to the place of living and the level of physical activity, the analysis of variance – ANOVA was applied at first.

The research results

In Tables 1–6 basic statistical characteristics of 6-year-old children examined during Stage I of the project "Six-year-old child on the threshold of school education" are displayed. The following random variables were taken into consideration: sex, place of residence, and spon-

Table 1. The number of children in two stages of research

The data of research	Age	Total (N)	Boys (N)	Girls (N)
I stage IV – V / 2006	6,83	33459	17134	16325
II stage IX – X /2006	6,28	32670	16867	15803

Table 2. Physical fitness description of 6-year-olds children's groups – stage I.

Characteristics – Physical fitness	Boys		Girls		p
	N	$\bar{x} \pm SD$	N	$\bar{x} \pm SD$	
Balance [n/min]	9544	15,5 ±14,73	9938	14,73 ± 7,24	0,001
Plate tapping [s]	16398	24,33 ± 5,81	15695	24,79 ± 5,76	0,001
Sit and reach [cm]	13666	0,62 ± 5,65	13087	2,07 ± 5,51	0,001
Standing-broad jump [cm]	13614	101,91 ± 20,01	13059	94,34 ± 18,43	0,001
Sit and ups [n/30 s]	12125	10,50 ± 4,47	11533	10,02 ± 4,40	0,001
Arm hang [s]	10280	19,95 ± 9,83	10597	18,8 ± 9,6	0,001
Speed shuttle run10x5m [s]	13584	26,95 ± 3,77	13050	27,58 ± 3,72	0,001

taneous physical activity. The total number of the researched children fluctuated depending on the test performed. The biggest number of children were not able to accomplish the balance trial. The total proportion of children who had difficulties in one-leg standing amounted to 41.78% of the total number of the researched children (boys more frequently than girls did not accomplish the task). The other tests difficult for children were the following: straight-arm hang time trial assessing strength of arms and sit-ups (a series of forward bends from lying position) assessing abdominal muscles power. However, the proportion of children who were not able to accomplish these tasks was considerably lower than in case of "flamingo balance" (general body balance) and amounted to 37.61% and 29.30% respectively. During the research on 6-year-old children, a significant dimorphism was proved. Boys were distinguished by higher average parameters in physical performance tests. Girls were more flexible and achieved better results in the body balance test (Table 2).

Having the research results analyzed, significant disproportions in the level of 6-year-old children's motor abilities between the groups distinguished by the place of residence (living in either urban or rural areas) were proved. In case of boys, the most important differences were revealed in flexibility (a forward bend from upright sitting position), explosive strength of lower limbs (standing broad jump), as well as strength of arms (straight-arm hang trial), ($p \leq 0.001$). In case of the rest of fitness test trials, slight differences were noticed but not proved by the analysis of variance (ANOVA) – Table 3. Similar changes were found in the group of girls. The differences proved by the analysis of variance were visible in flexibility, strength of arms ($p \leq 0.05$), explosive strength of lower limbs and running speed ($p \leq 0.001$) – Table 4. It must be emphasized that in case of both sexes, only in straight-arm hang trial rural children achieved better average results. As far as the other fitness test trials are concerned, children living in rural areas achieved lower level of development.

Table 3. The test F value for physical fitness in boys according place of residence.

Characteristics – physical fitness	Boys				F	p
	City		Village			
	$\bar{x}$	SD	$\bar{x}$	SD		
Sit and reach [cm]	0,78	5,82	0,41	5,38	16,316	0,001
Standing broad jump [cm]	102,51	19,89	101,06	20,29	19,309	0,001
Sit and ups [n/30 s]	10,51	4,49	10,06	4,39	0,357	0,55
Arm hang [s]	19,45	9,78	20,79	9,83	41,705	0,001
Speed shuttle run [s]	26,93	3,82	27,77	3,68	2,755	0,091

Table 4. The test F value for physical fitness in girls according place of residence

Characteristics – physical fitness	Girls				F	p
	City		Village			
	$\bar{x}$	SD	$\bar{x}$	SD		
Sit and reach [cm]	2,21	5,71	1,88	5,22	4,447	0,012
Standing broad jump [cm]	95,31	18,36	93,02	18,43	15,341	0,001
Sit and ups [n/30 s]	9,91	4,41	10,06	4,39	1,621	0,198
Arm hang [s]	18,27	9,62	19,55	9,53	3,938	0,020
Speed shuttle run [s]	27,45	3,75	27,77	3,68	12,476	0,001

Table 5. The test F value for physical fitness in boys group according physical activity

Characteristics – physical fitness	Boys						F	P
	Not at all		Sometimes		All the time			
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD		
Sit and reach [cm]	0,59	5,55	0,46	5,64	1,01	5,69	5,458	0,004
Standing broad jump [cm]	100,39	20,17	101,98	19,83	102,49	20,31	6,491	0,002
Sit and ups [n/30 s]	10,51	4,47	10,44	4,47	10,48	4,48	2,057	0,128
Arm hang [s]	20,55	9,66	19,71	9,82	20,24	9,91	11,887	0,001
Speed shuttle run [s]	26,94	3,68	26,89	3,74	27,11	3,86	4,062	0,010

As it is commonly believed, physical activity is one of the most important factors which diversify the level of motor abilities. In case of children, increased physical activity positively affects the process of growth. This results in bigger total body size, better body functions and higher level of physical abilities. Therefore, in parents' survey, the question concerning the frequency of child's daily, spontaneous physical activity was raised. It may be noticed that the level of children's daily physical activity reported by the parent respondents, as well as the place of residence determined the level of children's physical fitness (Tables 5 and 6). The comparison of arithmetic means for both sexes revealed significant differences in these groups. In the researched population only abdominal muscles power balanced on the similar level. In case of boys, frequent daily physical activity contributed to better average values in test trials of flexibility and explosive strength of lower limbs. It might be noticed that boys de-

Table 6. The test F value for physical fitness in girls group according physical activity

Zdolności motoryczne	Girls						F	P
	Not at all		Sometimes		All the time			
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD		
Sit and reach [cm]	1,91	5,44	2,06	5,47	2,35	5,56	4,447	0,012
Standing broad jump [cm]	92,42	18,30	94,73	18,29	94,69	18,67	15,341	0,001
Sit and ups [n/30 s]	10,15	4,33	9,96	4,41	10,04	4,38	1,621	0,198
Arm hang [s]	19,01	9,62	18,61	9,56	19,25	9,83	3,938	0,020
Speed shuttle run [s]	27,96	3,89	27,52	3,75	27,61	3,69	12,476	0,001

scribed by their parents as physically inactive achieved better parameters of abdominal muscles power, strength of arms and running speed (Table 5).

The results in the group of girls are slightly different. Four tests out of five (flexibility, explosive strength of lower limbs, strength of arms and locomotor speed) proved considerable differences, and the direction of the changes confirmed the widespread and commonly accepted opinion that higher level of physical activity determines development of motor abilities (Table 6).

Discussion

Physical fitness is an integral part of child's development which facilitates active participation in everyday life. Thanks to physical fitness a child receives and converts external stimuli in a coordinated and deliberate way. A young person also develops practical and sport skills. Six-year old child is able to master various movement combinations, such as jump and run, catch and throw, as well as run and kick a ball [34, 35, 36]. Additionally, dimorphic differences are visible in the types of physical activities, and in various aspects of physical fitness [37]. The results of the research on 6-year-old children proved this regularity. Girls in comparison with boys, similarly to Sekita's research [1988], achieved better average results only in the flexibility test [38]. In relation to the research on children living in rural areas of Kielecczyzna, they were also better in the balance test [39]. In all-Poland research over the physical condition of children and young people, 7-year-old girls achieved higher level of development in both abilities discussed above than their peers. The results of the research on 7-8-year-old children reveal that boys have a clear advantage in the speed of run, throw and jump, whereas girls are more flexible and have better manual dexterity [35, 40]. The analysis of data obtained by Surynt and Wójcik-Grzyb (2005) indicates that 6-year-old girls are characterized by higher level of strength which was assessed through standing broad jump, whereas in the group of 7-year-old children higher level of development in all the physical fitness tests was noticed [41]. Dimorphic differences in the level of motor competencies tend to result not only from different physical activities undertaken by children from the early childhood, but also from some biological indicators. Despite the similar level of most somatic traits in prepubertal children, some of the traits, e.g. bigger arm muscle mass, as well as its size, especially in case of boys may be significant for achieving better results in physical activities which involve the strength of arm, such as throwing a ball [42, 43, 44].

The end of pre-school period and the early school period, due to variety of physical activities, relatively high fluidity, flexibility, rhythmicality and harmony in their performance determine dynamic development of all the motor abilities [28, 29, 35]. Relating selected parameters of motor abilities measured in 6-year-old children to the results obtained in other authors' research, it may be claimed that both girls and boys achieved lower average values in standing broad jump, compared to their peers examined by Sekita [38] i Momola [45], but, at the same time, close to the results achieved by children in Gdańsk [14, 16]. The research over the children living in the Świętokrzyski region proves that boys achieved better results – on average by 6.2 cm, than girls. Six-year-old Polish boys were characterized by slightly lower level of development in explosive strength of lower limbs than their peers form Kielecczyzna. Comparative analysis of the average values for running speed and abdominal muscles power in relation to children from rural areas of Kielecczyzna proves higher average level of 6-year-old children in strength and lower average level in speed [39].

Comparative analysis of the research results on motor abilities of 6-year-old children living in different environments (either urban or rural) and the results obtained by other authors reveal certain similarities. Having researched children from Podkarpacki region, Momola [45] noticed statistically significant differences in locomotor speed and explosive strength of upper limbs. In case of running speed, urban children proved to be faster ($F = 15{,}161$, $p < 0{,}05$), whereas their explosive strength was weaker ($F = 3{,}118$, $p < 0{,}05$). According to Sekita [38], urban children are characterized by higher level of strength than rural children what seems to be associated with higher indicators of somatic development in case of children living in urban areas. This has been proved by the current research [46]. Taking physical condition of prepubertal children (aged 7.5 – 9.5) into consideration, a different phenomenon has been noticed [30]. Rural children appeared to achieve better results in speed and strength tests, including those assessing abdominal muscles power, strength of arms, static hand grip strength, as well as in the endurance tests. According to the authors, „with age this situation changes and urban youth gains advantage which increases after the period of puberty." It is clearly visible in case of rural girls who, with age, are becoming significantly less fit, compared to urban girls. This results from rural girls' lifestyle, neglecting physical activities, as well as the lack of proper preparation within families and schools for independent care of physical condition [30, p. 91].

The achievements to date prove relationships between the process of development and physical activity which determines Body Mass Index (BMI), body mass or its constituents [47, 48], as well as general physical fitness and its components [49]. The research also reveals that children with low confidence in the abilities to undertake various physical activities are characterized by poor coordination and low level of daily physical activities [50, 51]. The regression analysis shows that motor abilities prove 8.7% of variance in physical activity [51].

It should be also emphasized that majority of research concerning these issues present fitness as the effect of increased sport activity in various periods of ontogenesis. The research results are often taken from the national reports which tend to draw attention of politicians, educational authorities and public opinion to the key problem of fitness and physical activity of the young generation which will influence the future society. Within the research on 6-year-old children in Poland, in the questionnaire for parents, the questions on their children's physical activity were included in order to receive a parents' response to the question on the level of spontaneous physical activity undertaken by their children. It was subjective parent's opinion, not always relevant to facts. In the group of girls, with the exception for the abdominal muscles power, and in the group of boys only in two movement tasks: sit and reach test (forward bend), as well as standing broad jump, parents' opinion coincide with the results of the research concerning the impact of physical activity on the level of the whole body physical abilities. In the group of boys, whereas, in the rest of movement skills tests and abdominal muscles power test the opposite tendency occurred. Parents are able to express their opinion on typical exercises which they sometimes initiate when playing with children. The abdominal muscles power test is a type of trial which does not often occur while playing. It needs to be learned and then regularly repeated in order to strengthen particular muscles. Children at that age focus on physical activities involving strength of legs and arms, as well as movement demanding accuracy which prepare them for mastering arm motor ability. The lack of clear tendency to achieve higher values in other tests by the group of physically active boys may have resulted from different parents' attitude to their children evaluation. There is always a tendency to compare the child with his/her peers. On the other hand, high physical activity might result in hyperactivity. This problem ought to be examined and explained in deeper analysis which would consider not only parents' opinions, but also the most common health problems.

Conclusion

The results of the research conducted over the group of 6-year-old children in Poland enable the authors to formulate the following conclusions:

1. In the group of reported research subjects, signs of dimorphism proved by motor abilities tests are noticeable. Boys tend to be characterized by better strength of arms, explosive strength of lower limbs, abdominal muscles power, speed of cyclical movement and running speed; whereas girls are more flexible and have better body balance.
2. The place of residence determines the level of children's motor abilities. Children living in urban areas more frequently achieve better results in comparison with their peers from rural areas.
3. Children's spontaneous physical activity reported by their parents determines the level of motor abilities in case of both sexes. The tendency to achieve higher average results is noticeable particularly in case of girls reported to be physically active „all the time".
4. Physically active children tend to achieve better results of the tests. In the group of physically active urban girls there is relatively high proportion of children with low mark category.

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DEVELOPMENT OF SPATIAL AND TEMPORAL ORIENTATION ABILITIES IN WINTER SPORT COMPETITORS

ROZWÓJ ZDOLNOŚCI ORIENTACJI CZASOWO-PRZESTRZENNEJ ZAWODNIKÓW SPORTÓW ZIMOWYCH

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Key words: coordination motor abilities (CMA), spatial and temporal orientation, winter sports
Słowa kluczowe: koordynacyjne zdolności motoryczne (KZM), orientacja czasowo-przestrzenna, sporty zimowe

SUMMARY • STRESZCZENIE

Aim of the study. To determine changes in the level of spatial and temporal orientation in young people practicing winter sports during three-year training process (aged 15–18 years). The attempts were made to answer the following questions: 1. Can intensive physical activity essentially affect the level of spatial and temporal orientation in the athletes? 2. Are prospective changes in its level at the same level for both genders?

Material and methods. The material for the study consisted of the results of continuous research of male and female students from LO ZSMS (Liceum Ogólnokształcące Zespołu Szkół Mistrzostwa Sportowego – Secondary School at the Sport Championship Schools Complex) in Zakopane. Comparison material was collected during parallel investigations of their peers. The results of a complete three-year research were used for analysis of development of spatial and temporal orientation. They were obtained from 33 subjects (12 female and 21 male athletes) in athletic group and 59 subjects (19 female and 40 male non-athletes) in control group. All the persons studied were 15 years old at the initial moment of the measurement. The measurements were taken by means of Piórkowski apparatus with stimulus emission rate 107/min and cross apparatus using free series (without a fixed rhythm) through registration of time (in seconds) of performing tasks (49 impulses) by either of hands.

Results and conclusions. During the three-year period of time, an essential and statistically significant improvement in visual aspect of spatial and temporal orientation was observed in both athletic group and control group. However, the obtained results do not demonstrate the effect of training on improvement in the studied ability. The changes are of a rather developmental background. No significant sexual differences in the level of spatial orientation were observed in either athletes studied or control group throughout the period of the research.

Cel pracy. Określenie zmian poziomu orientacji czasowo-przestrzennej u młodzieży uprawiającej sporty zimowe w trakcie trzyletniego procesu treningowego (w okresie pomiędzy 15. a 18. rokiem życia badanych). Poszukiwano odpowiedzi na następujące pytania: 1. Czy zwiększona aktywność fizyczna może w istotny sposób wpłynąć na poziom orientacji czasowo-przestrzennej zawodników? 2. Czy ewentualne zmiany jej poziomu będą przebiegać jednakowo u obu płci?

Materiał i metody. Materiał opracowania stanowią wyniki badań ciągłych uczniów i uczennic –33 młodych sportowców, w tym 12 dziewcząt i 21 chłopców – uczęszczających do LO ZSMS w Zakopanem (Liceum Ogólnokształcące Zespołu Szkół Mistrzostwa Sportowego) i uprawiających sporty zimowe. Materiał porównawczy zebrano w trakcie prowadzonych równolegle badań ich nietrenujących rówieśników – 19 dziewcząt i 40 chłopców z grupy kontrolnej. Do analizy przebiegu rozwoju orientacji czasowo-przestrzennej wykorzystano rezultaty kompletnych trzyletnich badań. Wszyscy badani w momencie rozpoczęcia badań byli w wieku 15 lat. Pomiary wykonano za pomocą aparatu Piórkowskiego z zaprogramowaną szybkością bodźców 107 impulsów na minutę oraz aparatu krzyżowego z zastosowaniem serii „free" – bez narzuconego rytmu – przez rejestrację w sekundach czasu wykonania zadania (49 impulsów) za pomocą dowolnej reki.

Wyniki i wnioski. Na podstawie trzyletnich badań w obu grupach: zawodniczej oraz kontrolnej stwierdzono znaczną oraz statystycznie istotną poprawę wyników aspektu wzrokowego orientacji czasowo-przestrzennej. Uzyskane wyniki nie wskazują jednak na wpływ treningu sportowego na poprawę rozpatrywanej zdolności. Stwierdzone zmiany mają raczej podłoże rozwojowe. Ponadto w całym trzyletnim okresie badań nie stwierdzono istotnych różnić płciowych w poziomie orientacji przestrzennej, i to zarówno wśród badanych zawodników, jak i uczestników grupy kontrolnej.

INTRODUCTION

An important aspect of a training process is ensuring proper development of abilities to control and verify movements. This requires taking into consideration that it is at the stage of planning a macrocycle, training units oriented towards development of coordination motor abilities (CMA). In order for this to be achieved the knowledge of CMA, their development phases in human ontogenesis, genetic predisposition and susceptibility to the applied training stimuli. It is also important to emphasize certain abilities which are adequate for a particular discipline of sport since they essentially determine time and quality of motor learning. Therefore, coordination abilities are a prerequisite for improvement and stabilization of sport-related technical and tactical abilities and their adequate utilization in relation to the situations and conditions which occur [1].

Performing movements and adaptation of movements to changing external conditions is controlled by nervous system and is based on the same principles in all humans. However, it does not mean that the processes occur in all individuals with the same accuracy, differentiation, mobility or speed. These individually variable properties of the processes of control and regulation determine the level of coordination abilities [2, 3].

An essential role in sport is played by abilities of an athlete to precisely define position of their body and its changes in relation to a point of reference and to perform movements in a specific direction, i.e. spatial and temporal orientation abilities [1]. In the case of winter sports, this is even more important because of slippery, frequently unstable and uneven surface the athletes must move on. Level of spatial and temporal orientation depends in particular on proper cooperation of a number of analysers, of which the greatest importance is from visual and auditory analysers, since this is them which condition reliable assessment and control of spatial condition of a particular activity [4, 5].

The multifaceted character of spatial and temporal orientation points to its complex background, with fundamental importance of the processes of acquisition and processing information which are performed in central and peripheral nervous system. Efficiency of functioning of these systems considerably determines spatial orientation [6, 7]. Main predispositions of these abilities include efficiency of visual, auditory, vestibular, tactile and olfactory senses. These senses provide information to nervous system about position of the body in relation to the points of reference. Therefore, spatial orientation can be typically considered within three major (visual, auditory and proprioceptive) aspects [8].

Different authors seem to agree that a major effect among a variety of types of information which determine the level of a characterized ability is from visual stimuli [2, 9, 10, 11]. This is confirmed by observations of scientists who investigated the relationships between conflicting pieces of visual and tactile information. In the case of this conflict, a leading function is overtaken by vision [12].

Spatial orientation is also possible by means of auditory sense, however, perception of auditory space is less efficient than the visual one. Hearing allows only for determination of direction and the distance from the source of sound [13].

Kinaesthetic perception and sense of equilibrium seem to be the most important kinaesthetic sensation and provides information about spatial position of the body [11]. Receptors located in muscles inform about the state of tension in individual parts, which allows for adoption of a particular position of body parts [14].

Spatial and temporal orientation seem to be the most genetically dependent among all the CMAs. Heritability ranges from 0.4 to 0.6 [15]. Its development during the process of growing is similar to coordination abilities. According to Hirtz [10], 25% of overall increase in spatial orientation is obtained by the representatives of both genders at the age of 8 on average, 50% at the age of 11, 75% at the age of 13, with full development at the age 15–16: this period of a relative stabilization is ended in both genders in fifth decade of life [15, 16]. The scope of dimorphism in this ability is insignificant, without a clear tendency towards domination of either of the genders. Men reach higher level of spatial orientation as late as at the phase of stabilization of its level [1, 3].

Above presented results of research works are mainly of cross-sectional character. They rarely concern formation of spatial and temporal orientation abilities at junior age, frequently concerning only the individuals with low and high level of abilities.

In comparative analyses, a precondition is application of accurate and reliable methods of diagnosis of individual aspects of spatial orientation, particularly in terms of accuracy. Laboratory measurements seem to be the most objective in this respect. In the present study, the authors used the most popular and therefore easily comparable measurements of visual aspect of spatial and temporal orientation in Piórkowski apparatus and cross apparatus in consideration of the fact that there is lack of a reliable diagnostic tool among currently used methods of measurement of aspects of orientation [1].

The authors of the present study attempted to determine changes in the level of spatial and temporal orientation abilities throughout a three-year training process (at the age of 15 to 18) in young people who practice winter sports compared to untrained peers. Both in study group and in control group the results were obtained based on three-year longitudinal study. The attempts were made to reply to the following questions:

1. Can intensive physical activity significantly affect the level of spatial and temporal orientation in the athletes?
2. Are prospective changes in its level similar for both genders?

MATERIAL AND METHOD

Study group

The material of the study consists of the results of continuous research of male and female students from LO ZSMS (Liceum Ogólnokształcące Zespołu Szkół Mistrzostwa Sportowego = Secondary School at the Sport Championship Schools Complex) in Zakopane who practice winter sports (speed skating, Nordic combined, downhill and cross-country skiing). The investigations were made two times a year in half-year distance (seven times in total). In order to analyse the development of spatial and temporal orientation, the results of a complete three-year research were used. The results analysed included the results for 12 women and 21 men who were 15 at the initial moment of measurement.

Young people from ZSMS Zakopane came from different regions of the country. Only in the case of downhill skiers one can observe that they lived in Podhale region. Recruitment to the school is based on previously obtained sports results in their disciplines, which makes them a selected group. The athletes were subjected to a specialized training specific to their own disciplines. The trainings were scheduled once a day (ca. 3h); the athletes also participated in a variety of training camps and competitions. The trainings were carried out by qualified coaches from ZSMS.

Comparative material was the results of analogous investigations which covered young people from TE ZSE (Technikum Elektryczne Zespołu Szkół Elektrycznych = Technical Secondary School at the Technical Schools Complex No. 3 in Nowa Huta). They were conducted parallel with the investigations in Zakopane once a year. In order to analyse the development of spatial and temporal orientation, the results of a complete three-year research were used. The results analysed included the results for 19 women and 40 men. All the students from control group participated only in curricula-based activities of physical education.

Research apparatus and procedure

US-6 Piórkowski apparatus and AKN-102 cross apparatus were used in order to assess visual aspect of spatial and temporal orientation.

During the investigations based on Piórkowski apparatus, stimuli emission rate was 107/min with a minute long time of the test. The main test, after previous explanation of the principles, was preceded with 20-sec warm-up with invariable apparatus settings. The subjects were asked to press, with either of hands in sitting position, one of ten buttons on the panel over which a light signal appeared in the form of an arrow. The result of the test was the number of properly responded light stimuli.

In the case of measurements with cross apparatus, a series without a set rhythm was used with

registration (in seconds) of the time of performing the task (49 impulses). Similarly to the test with Piórkowski apparatus, the subjects were previously familiarized with the course of the test and performed a 20-sec warm-up. Realization of the task consisted in possibly fastest pressing the buttons which were located at the crossing of two (vertically and horizontally) lights that were switched on in one of seven columns and lines. Pressing improper button caused locking another light signal which was released only after proper correction of the activity. The subject performed the test with either of the hands in sitting position.

Analysis of the data

In order to obtain the reply to the research questions, the results were elaborated by means of generally accepted methods of descriptive statistics.

In consideration of lack of normal distribution in certain data, confirmed with Shapiro-Wilk test, further analyses used non-parametric tests. In order to demonstrate the differences between the athletic group and control group and differences in the area of gender, test of significance of differences in two independent groups was employed (Mann-Whitney U-test). In order to demonstrate differences between the measurements in the same group, Friedman test from ANOVA group was used. The differences were adopted as statistically significant if the significance level was $p < 0.05$. The athletic groups were normalized against the background of the peers and the sexual dimorphism coefficients were calculated. The calculations were performed on STATISTICA 7.0 package.

RESULTS

Analysis concerned the results of measurements obtained in Piórkowski and cross apparatuses. In the case of athletic groups, 7 complete measurements were taken, whereas in control groups the measurements were repeated 4 times.

In consideration of changes in mean values of the results obtained from Piórkowski apparatus for each of the studied groups, in all cases, in relation to the athletic group, control group or gender, increase in the number of proper reactions can be observed (Fig. 1). The improvement in athletic group is distinct until 5th measurement and then the values come closer to their maximal levels at which they are stabilized until the end of the study, which is confirmed by reduction in the variability range. Analogical changes were confirmed among the female athletes.

Similar path was reported for changes in mean results from tests with cross apparatus. Test time was considerably shortened between 1st and 5th measurement, after which improvement in the results was insignificant. Similarly to measurements with Piórkowski apparatus, stabilization of the results was connected with reduction in the level of standard deviation (Fig. 2).

In order to demonstrate that the observed improvement in the results in three-year time of measurement is statistically significant, a non-parametric significance test for multiple dependent variables of ANOVA group (Friedman test, Tab. 1) was employed. In all the cases, statistical significance of the observed changes is undeniable. Both in study group and control group they are significant with over 99% probability ($p < 0.001$). This concerns both Piórkowski apparatus and cross apparatus.

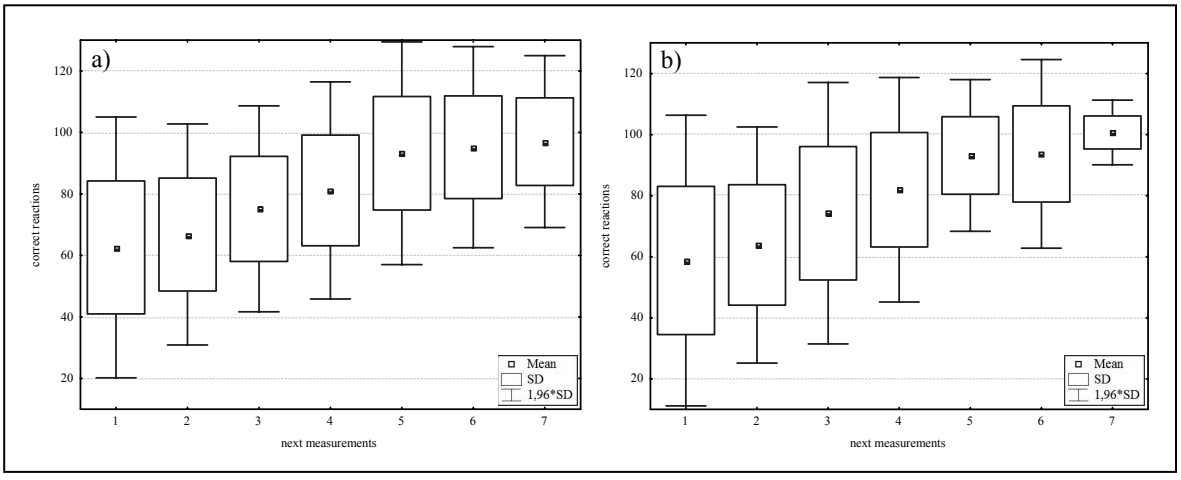

Figure 1. Changes in arithmetic mean of proper reactions obtained in Piórkowski apparatus in the athletic group in individual tests: a) men; b) women

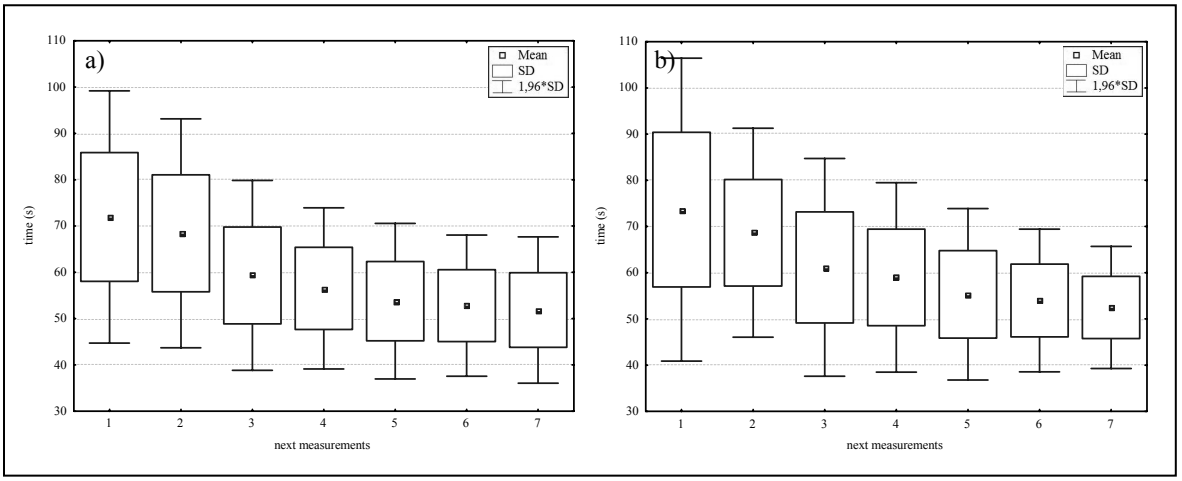

Figure 2. Changes in arithmetic mean of proper reactions obtained in cross apparatus in the athletic group in individual tests: a) men; b) women

Table 1. Results from Friedman significance test for differences for multiple dependent samples, χ^2 statistics and Kendall's coefficient of concordance τ (values calculated for 7 measurements for athletic groups and 4 measurements for control groups)

Group	Trial	Friedman ANOVA test and Kendall's τ			
		n	χ^2	*p*	τ
ZSMS man	PA	21	106,38	**0,00000**	0,84
	CA	21	103,40	**0,00000**	0,82
ZSMS woman	PA	12	64,28	**0,00000**	0,89
	CA	12	57,34	**0,00000**	0,80
ZSE man	PA	40	61,92	**0,00000**	0,52
	CA	40	47,99	**0,00000**	0,40
ZSE woman	PA	19	39,12	**0,00000**	0,69
	CA	19	29,93	**0,00000**	0,53

statistical essential values were distinguished in bold type

Legend: PA – Piórkowski apparatus ; CA– cross apparatus; p – significance level; χ^2 – chi-squared statistics ; τ–Kendall's coefficient of concordance

Particularly significant changes were observed in those athletes for whom Kendall's coefficient of concordance τ adopted the values below 0.8 and the statistics χ^2 was over 100. Similar values were observed in female athletes.

In order to assess whether the observed changes are a consequence of natural development or, in the case of athletic group, the result of higher physical activity, the indexes normalized for athletic group against the control group were calculated. In the case of the results from cross apparatus, coefficient signs for indexes were changed in order to allow for easier data interpretation (Fig. 3).

Analysis of the obtained values of normalized indexes (NV) reveals hardly recurred differences in the level of spatial and temporal orientation abilities between researched groups. Only in the 6th and 7th research in the male group ($p < 0.03$; $p < 0.05$) and in the 7th in female group ($p < 0.01$) these differences are significant. But in accordance to Piórkowski and cross apparatus, the values of NV exceed significantly the value of 0.6s ($p < 0.01$; $p < 0.15$) only in the case of the last research in female group (Fig. 3a). In the other cases the advantage of athletic group is not significant ($p < 0.05$).

In order to provide statistical verification of insignificant differentiation between both groups, its signifi-

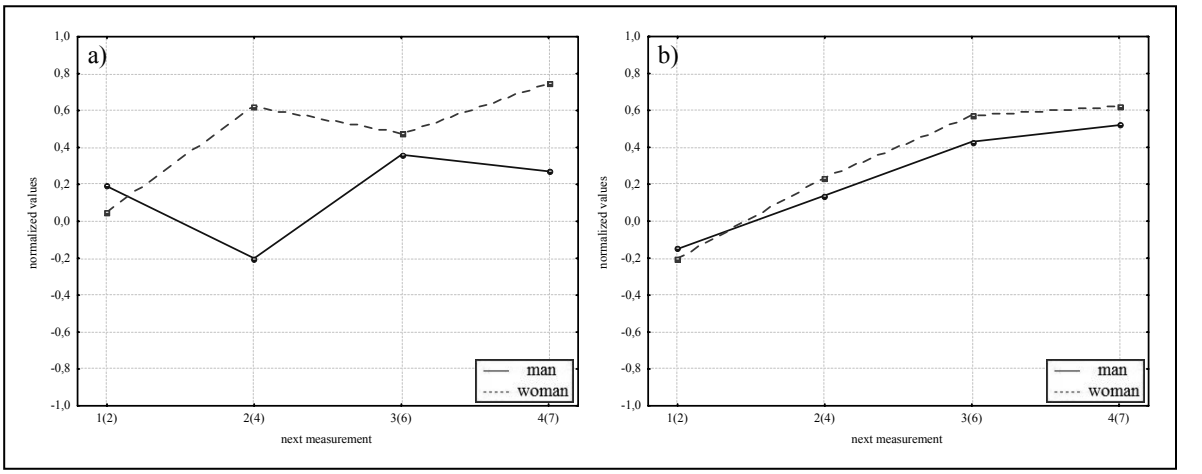

Figure 3. Normalized values of the results from the athletic group against the background of the control group: a) Piórkowski apparatus; b) cross apparatus

NV – normalized values: (xexp.- xcomp)/scomp

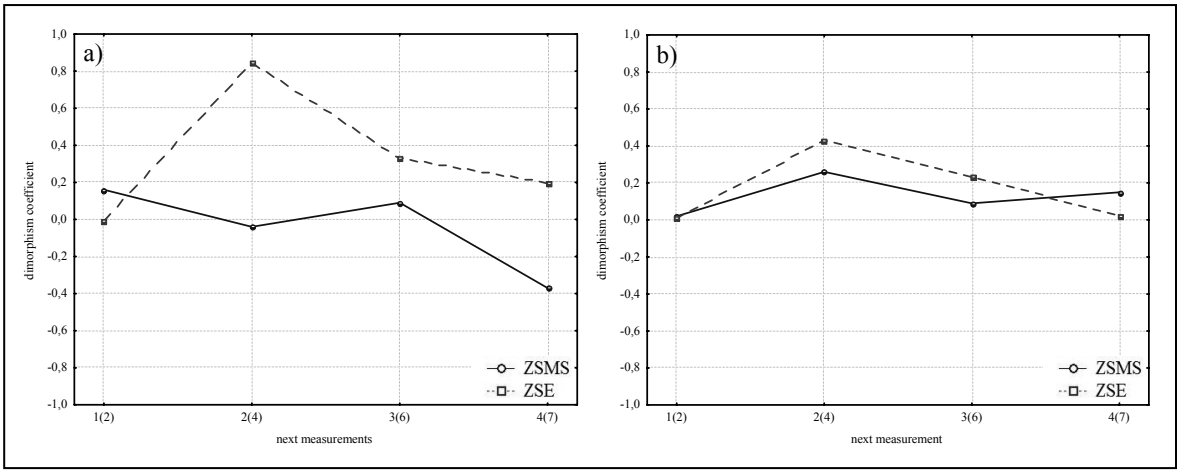

Figure 4. Level of sexual dimorphism coefficients in the athletic and control group: a) Piórkowski apparatus; b) cross apparatus.

DC – dimorphism coefficient $2(x♂ - x♀)/(s♂ + s♀)$

cance was verified for 4 series of the research which were similar in time. In order to achieve this goal non-parametric significance test for two independent variable (Mann-Whitney U-test). The obtained results were presented in Table 2.

Only 3 of 16 analysed differences turned out to be statistically significant: all of them concerned two last measurements. In consideration of NV, differences between the mean values and their statistical significance verified with U-test, one should observe lack of reasons for explaining a considerable (reaching nearly 40%) increase in the results in both apparatuses with an enhanced physical activity in the athletes.

The last of the analysed problems was occurrence of sexual dimorphism in spatial and temporal orientation. In order to settle this question, the procedure was similar to the case of intergroup differences i.e. sexual dimorphism coefficient (DC) was calculated and then the attempt was made to verify its validity with U-test (Tab. 2, Fig. 4).

In the athletic group, level of sexual DC did not exceed the threshold of 0.5s in none of the cases and, analogously, none of them was statistically significant. In control group, differentiation was minimally higher and, in one of the cases, it was significant. Analysis of the whole period of research reveals unequivocally that no sexual differences can be observed in either trained or untrained group of young people.

Table 2. Results from Mann-Whitney U-test for determination of significance of differences between the athletic and control group in individual studies and significance of sexual differences in both groups

Group	Trial	Significance level *p* in next research						
		1	2(1)	3	4(2)	5	6(3)	7(4)
ZSMS/ZSE men	PA		0,6352		0,4740		**0,0274**	0,1570
	CA		0,5518		0,2941		0,1031	**0,0470**
ZSMS/ZSE woman	PA		0,8574		0,0775		0,0585	**0,0085**
	CA		0,9841		0,5092		0,1196	0,1520
ZSMS/ZSMS dymorphis	PA	0,9853	0,8683	0,5424	0,6447	0,6447	0,5926	0,5424
	CA	0,9559	0,8974	0,5926	0,4487	0,7540	0,6447	0,6714
ZSE/ZSE dymorphis	PA		0,9040		**0,0084**		0,2834	0,1879
	CA		0,6817		0,1879		0,3375	0,7784

statistical essential values were distinguished in bold type

Legend: PA – Piórkowski apparatus ; CA– cross apparatus

DISCUSSION

It is a common occurrence under conditions of competition that proper behaviour of an athlete depends on their speed of assessment of situation and control of spatial conditions of the activity. The same applies to winter sports. Therefore, spatial orientation should be consciously stimulated from the beginning of competitive careers [17, 18]. Formation of individual CMAs through training, including spatial orientation is of the utmost importance, however, frequently neglected by coaches.

The goal of the present study is an attempt to determine changes in the level of spatial and temporal abilities in young people at junior age, practicing winter sports, subject to a systematized many-year training process. The attempts were made to determine the scope of these changes with differentiation of gender of the subjects and through separation of developmental factor (comparison of the obtained results with the results of control group) and assessment whether they resulted from natural development or intensive physical activity.

Undoubtedly, the level of the considered ability was significantly changed throughout the analysed range of age of the subjects. In the athletic group, the rise was impressing (from 35% to 41%). In control group, similar results were obtained for tests with Piórkowski apparatus (from 30% to 32%), slightly different in the case of cross apparatus (17%). No statistically significant differences were found between the experimental group and control group. Therefore, one should accept that considerable improvement in the athletic group did not result from increased physical activity but it could be caused by ontogenesis.

Comparisons of the obtained results with the studies by other authors confirms the observations Szopa et al. [15]. Those authors, using the same research method, found a relative stabilization of visual motor coordination between 17 and 19 year of age. Similar results, confirming continuation of development of spatial orientation after turning 16 (where, according to Hirtz [10], its full development can be observed) was also obtained by Bodasiński [19]. This researcher, who carried out the investigations on 17-year-old handball players in year-long training cycle, confirmed 18-percent improvement in the results of his own motor test. The author's investigations confirmed a relative stabilization of the results compared to the previous period between 17 and 18. Increase in the results in this period amounted to barely 3.5% in male athletes and 5.5 to 7.5% in female athletes.

In consideration of the relationship between the trained and the untrained, it is difficult to find information about the research of spatial and temporal orientation in the group of age analysed in this thesis. But some thesis can be found, in which the authors researched youth in the age in 10–13. They show the advantage of sports groups [20, 21].

Interesting studies were carried out by Zwierko [22], who investigated, under laboratory conditions (Vienna Test System), peripheral perception in 20-year-old athletes compared to their peers. The author did not demonstrate differences between the both groups in her research. Therefore, there is lack of unequivocal determination of the effect of training on improvement in the level of orientation. The results of author's own studies seem to support the reports by Szopa et al. [15] of considerable genetic control of this ability. However,

it should be remembered that the utilized apparatus allows for barely fragmentary determination of visual aspect of spatial and temporal orientation [23].

The obtained results of the research unequivocally demonstrate lack of significant sexual differences in terms of the studied ability, thus confirming observations by other authors [1, 15, 24, 25] in relation to spatial and temporal orientation.

CONCLUSIONS

The studied visual aspect of spatial and temporal orientation in the considered age range (15–18 years) developed dynamically in both the athletic group and control group between 15–17 year of age and then it stabilizes at its maximal level until the end of studied period. No statistically significant differentiation was observed between the compared groups, which pointed at the lack of considerable effect of training on development of the studied ability. The development of its level should be preferably attributed to developmental factors. Apart from minor exceptions, no significant sexual differences were found within the whole three-year period of the research in terms of the analysed ability, either in the studied athletes or the control group, which confirms observations by other authors concerning lack of significant sexual dimorphism of coordination abilities.

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THE EFFECTIVENESS OF COOPERATION IN THE TEAM GAME (PRAGMATIC STUDY OF UNIQUE CASES)

EFEKTYWNOŚĆ WSPÓŁDZIAŁANIA W GRACH ZESPOŁOWYCH (PRAGMATYCZNE STUDIUM INDYWIDUALNYCH PRZYPADKÓW)

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Key words: interdependence of players' actions, dimensions and levels of synergies, effectiveness criteria

Słowa kluczowe: bezwzględnie od siebie zależne działania zawodników, wymiary i poziomy synergii, kryteria efektywności

SUMMARY • STRESZCZENIE

Introduction. The characteristic feature of contemporary team games is the high level of dynamic and situation-based organization of the players' actions, and this gives a new meaning to the collaboration. Particularly in these combinations, in the performance of which two or three players whose actions are absolutely dependent on each other participate, the skill of cooperation plays a leading role. Identification of the determinants of team effectiveness requires evaluation of the level of synchronization and coordination of the players' actions because this has an influence on the revelation of various dimensions and levels of synergies. Therefore, while evaluating the effectiveness of team actions, the players should not be treated as separate entities but as sub-subjects co-contributing to the success of the team as an entity.

Aim of the study. To present the possibility of measurable identification and justification of the importance of synergism in the performance of absolutely interdependent actions in team sport games.

Material and method. Based on the video record, a pragmatic comparative study of player cooperation effectiveness in club teams, including in basketball the Orlando Magic and Los Angeles Lakers and in football FC Barcelona, as well as in national representatives, including Brazil, Russia, and Serbia in volleyball.

Results. The results obtained allowed identification of various dimensions and levels of synergism in the team game including: the effectiveness of collaboration among selected players in the positioning of offensive actions and in creating scoring situations, as well as the effectiveness of performing combinations (variants) in the creation of scoring situations and in the positioning of action in the game.

Conclusions. The results obtained enable formulation of the conclusion that the evaluation of the effectiveness of double and triple collaboration may concern both the dimension of the synergy for example the synergic potential of the players, as well as the level of synergy resulting from the level of synchronization and coordination of actions absolutely dependent on each other. Synergic perception of collaboration effectiveness, accepted by the players, favors the development of added value in the team, for example task consistency and as a consequence also emotional consistency, as well as a new quality for example the combination of actions that we cannot analyze in an individualized dimension.

Wstęp. Współczesne gry zespołowe charakteryzuje wysoki poziom dynamiki oraz strategia oparta na kreowaniu sytuacji punktowych, dzięki czemu idea współpracy zawodników nabiera nowego znaczenia. Współpraca ta odgrywa kluczową rolę zwłaszcza podczas wykonywania kombinacji wymagających udziału dwóch lub trzech

graczy, których działania są bezwzględnie od siebie zależne. Identyfikacja czynników wpływających na efektywność gry zespołu wymaga oceny stopnia synchronizacji i koordynacji działań poszczególnych graczy, gdyż wpływają one na różne wymiary i poziomy synergii. Oceniając skuteczności działania zespołu nie należy zatem traktować poszczególnych uczestników gry jako samodzielne podmioty, ale jako współwykonawców, którzy wnoszą wkład w sukces zespołu jako całości.

Cel pracy. Przedstawienie narzędzi do identyfikacji i ewaluacji synergizmu, a także uzasadnienie jego znaczenia w wykonywaniu działań bezwzględnie zależnych w grach zespołowych.

Materiał i metody. Na podstawie zapisu wideo przeprowadzono pragmatyczne badania porównawcze skuteczności współdziałania graczy drużyn klubowych, w tym Orlando Magic i Los Angeles Lakers (koszykówka) oraz FC Barcelona (piłka nożna), a także czołowych zespołów świata w siatkówce, m.in. Brazylii, Rosji i Serbii.

Wyniki. Badania umożliwiły identyfikację różnych wymiarów i poziomów synergizmu w grze zespołowej, takich jak zwiększenie skuteczności współdziałania wybranych zawodników w akcjach ofensywnych przez właściwe ich rozmieszczenie na boisku i kreowanie sytuacji punktowych, a także skuteczność wprowadzania kombinacji (wariantów) sytuacji punktowych oraz wykorzystania przestrzeni w grze.

Wnioski. Ocena skuteczności współdziałania dwóch i trzech zawodników może dotyczyć zarówno wymiaru synergii, na przykład synergicznego potencjału graczy, jak również poziomu synergii wynikającego z synchronizacji i koordynacji działań bezwzględnie od siebie zależnych. Synergiczne postrzeganie skuteczności współpracy przez zawodników sprzyja rozwojowi wartości dodanej w zespole, zachowaniu spójności w realizacji zadania, a w konsekwencji – także emocjonalnej spójności, daje również nową jakość przez połączenie działań, których nie możemy analizować osobno.

INTRODUCTION

When defining sports games, Panfil [1] states that they are surprising and risky systems of skilful action and cooperation in the offence and anticipated counteraction and counter-cooperation in the defence by participants of the game aiming at achievement of uncertain individual, common and opposing objectives according to accepted rules (regulations and strategy). Skilful solving of situations in the sports game by cooperation and counter-cooperation consists in combining, in a way ordered with respect to objectives executed in the game, of actions of players in various two-player and three-player variants performed at a various tempo, with flexible utilization of the game space.

Contemporary team games, performed at a high level of sports effectiveness, are characterised by high level of dynamic and situation-related organisation of actions taken by the players, and this gives new meaning to the cooperation. Particularly in those combinations in which two or three players take part, whose actions are absolutely dependent on each other, the skill of cooperation plays a leading role. Therefore, identifying of determinants regarding team effectiveness observed at a high sports level requires taking into account the evaluation of the level of synchronization and coordination of actions performed by the players to a broader and broader extent because these factors determine revealing of various dimensions and levels of synergies [1, 2].

The review of literature indicates that the attempts of describing the team game as a set of actions taken by the players are undertaken for many sports games. Identification of players' actions, especially in football, taking into account differentiated criteria is a subject matter of interest for many Polish [3, 4, 5, 6, 7, 8, 9] as well as foreign researchers [10, 11, 12, 13]. Also for basketball and volleyball, the attempts are made to describe the sports game in various aspects, as a set of actions taken by individual players [14, 15, 16, 17,18].

However, the team game is an entity exceeding its parts i.e. players considered in mutual isolation. Therefore, explanation of actions of the sports team requires an integral approach which consists in treating the team of players as a dynamic system for the description of which it is necessary to take into account influences and material relations occurring in it and with which various levels of synergies are revealed. In the situation where two or more actions are dependent on each other in the sports game, the synergy is revealed in the form of reinforcement of these actions (catalysis) including: single-directional-effect 2 + 2 = 2 + 3, or bi-directional-effect 2 + 2= 3 + 3, as well as appearance of a new quality, different from actions of players creating it – effect 2 + 2 = Q, and modifying the new quality into a new quality-effect Q = T .

Hence, the dimension and level of synergy results from cooperation of players understood as a dynamic process of jointly conscious or jointly intuitional (result of earlier common experiences) situational selection of game objectives, variants of common performance and common achievement of them. The common achievement of an objective includes actions enabling achievement of objectives of the game, includ-

ing the ones relatively and absolutely mutually dependent, as well as actions facilitating achievement of the game objectives, absolutely dependent on actions of partners with the balls or playing against the ball.

Actions absolutely dependent on partners enabling achievement of the game objectives, which are the subject matter of this study, include cooperation of 2 or 3 players performing mutually synchronised and coordinated actions aiming at achievement of an individual objective of the game. In the attack, this is positioning of the game or creating score-gaining situations by handling the ball using two-player or three-player teams. On the other hand, in the defence, this is cooperation of players in doubling or tripling counter-action against the player with the ball. The absolute dependence on partners means that presence of the partners is necessary for achievement of the game objectives (solving a given situation), and feedback will be a regulator of the cooperation.

Dominating importance of synchronization and coordination of the players' actions observed in teams effective in sport causes the necessity to perceive cooperation as a separate entity because the dynamics of cooperation, characteristic for the play of teams effective in sport, makes it impossible to determine the level of individual contribution of cooperating players in the result achieved together. Component actions are so dependent that we can regard the common effort of the players as a separate entity. Therefore, when looking for high sporting effectiveness in the team game or, on the contrary, registering low sporting effectiveness, synchronization and coordination of actions rather than individual dimension of actions by individual players should be analysed. Thus, the effectiveness of handling the ball to an equal degree depends on the player passing and receiving the pass, and mainly on the feedback of their actions. Similarly, effective doubling of the defence play depends equally on players participating in it, and in particular on feedback of their actions. Perceiving cooperation through the level of synchronization and coordination makes it easier to analyse cooperation in combinations and variants because factual reasons of skilful cooperation lie just in coordination or in synchronization of actions, rather than in actions themselves [1, 19, 20, 21].

Hence, when assessing the effectiveness of team actions at a high sport level, the players should not be regarded as separately operating units but as subunits jointly contributing to the success of the entity i.e. the team.

OBJECTIVE OF THE STUDY

The objective of the study was to justify the importance of synergy in the team game and presenting the possibility of identifying it at various levels and in various dimensions during performance of absolutely dependent actions in the game by teams presenting high sporting effectiveness.

RESEARCH QUESTIONS

1. Are there any differences in the level of players' cooperation in a personal aspect ?
2. Are there any differences in the level of players' cooperation in an interpersonal aspect ?
3. Are there any differences in the level of players' cooperation in a positional aspect ?
4. Are there any differences in the level of players' cooperation in an interpositional aspect ?
5. Are there any differences in the level of players' cooperation in a team aspect ?

METHOD

Based on video recording of football, basketball and volleyball games, taking into account the criteria described by the author [1], offensive actions of players, absolutely dependent on each other, were identified.

By performing basic mathematical operations, the indices of cooperation effectiveness were calculated, including:

a) Cooperation activity index (A) – sum of registered combinations using two or three players, regardless of their result,
b) Cooperation effectiveness index (S) – sum of registered combinations using two or three players, finalized by achieving the aim of the game,
c) Cooperation worth index (C) – sum of scores, with various value resulting from differentiated influence of combinations on the game result and difficulties of performing it, obtained from registered effective combinations using two or three players (tab. 1.),
d) cooperation reliability index (N) – product (S) \ (A),
e) synergy index – (C) x (N) : 100.

The obtained data provided the basis for the pragmatic comparative study of cooperation effectiveness in combinations using two or three players, analysed at a various level and in various dimensions.

Table 1. Worth of ball passes capturing the game space, used in positioning of offensive game (using the example of football)

Receiving player	Passing player	Worth
Without opponent	without receiving with opponent	7
	without receiving without opponent	6
	with receiving with opponent	5
	with receiving without opponent	4
With opponent	without receiving with opponent	3
	without receiving without opponent	2
	with receiving with opponent	1
	with receiving without opponent	0

RESEARCH MATERIAL

The material was the data obtained from video recording of unique cases of club team games, representing high sporting effectiveness, including in basketball Orlando Magic and Los Angeles Lakers and in football FC Barcelona, as well as national volleyball representations of Brazil, Russia and Serbia.

1. **Research material for evaluation of personal and interpersonal synergies**

The material was the data obtained from observation of six football games of FC Barcelona, played in the League Championship organized by UEFA in 2007 \ 2008 season, starting from 1\8 to 1\2 of the finals. The play of Football Club Barcelona is a unique research material (case) because this club represents high and stable sporting effectiveness which is confirmed by numerous sports successes in an international area.

2. **Research material for evaluation of positional and interpositional synergy**

The material was the data obtained from observation of two basketball games between teams representing the clubs of Orlando Magic and Los Angeles Lakers played in the 2008 \ 2009 season in the League finals organized by the National Basket Association in the United States. The league tournaments organized by the National Basket Association provide a unique research material (case) because teams participating in it represent high sporting effectiveness in games regarded as the most effective in sport.

3. **Research material for evaluation of team synergy**

The material was the basis obtained from observation of three volleyball games of teams representing Brazil, Russia and Serbia, played between them in the World League organized by the International Volleyball Federation in the 2008 \ 2009 season. The play of the teams representing Brazil, Russia and Serbia provides a unique research material (case) because these teams represent high and stable sporting effectiveness which is confirmed by numerous sports successes in an international area and three first positions in the FIVB ranking (tab. 2.).

Table 2. Differentiation of the sporting level of the competing teams

National representation	Brazil	Russia	Serbia
Number of scores obtained in direct competition of the teams	5	3	1
Set ratio (won : lost)	6 : 3	4 : 3	2 : 6
Position and scores in the FIVB ranking in 2010 [1)]	1st position 247.5 scores	2nd position 185 scores	3rd position 167.75 scores

[1)] **source:** www.fivb.com

RESEARCH RESULTS

1. Personal dimensions of synergy in positioning of the offensive play

The positioning of actions in the offence includes placing and relocating of players allowing performance of actions relatively or absolutely dependent, ensuring maintaining of the ball and capturing of the game space, and aiming at allowing creation of a score-gaining situation or maintaining of the game result. In the publication, positioning of the offensive play using absolutely dependent actions were analysed. The analysis covered passes made in positioning of the game by specific players in situations with various degree of difficulty. The players of the team playing football in FC Barcelona fulfilling various functions resulting from the position taken in 1: 4 : 3 : 3 layout will be described in a synergic way. The identification will be presented in a personal aspect, as a specific synergic potential of the players, also in an interpersonal aspect. The passes used in positioning of the game made and received by specific players fulfilling various functions in the game resulting from their positions occupied in the 1: 4 : 3 : 3 layout were registered.

The position of a goalkeeper is kept by Valdes fulfilling defensive functions that he defends ball shots on goal, and offensive functions that is he begins positioning in the offensive play. Positions in the defence line are kept by two centre defenders (Puyol and Milito) fulfilling mainly defensive functions, participating also in positioning of offensive play and two side defenders (Abidal and Zambrotta) fulfilling both defensive tasks as well as creating score-gaining situations. Positions in the midfield line are kept by the centre midfielder (Toure) who positions offensive game and also fulfils the function of a creator of score-gaining situations, and side midfielders (Deco, Xavi or Iniesta) fulfilling both defensive tasks, positioning offensive play and also creating score-gaining situations. Positions in the attack line are kept by the centre striker (Eto) whose task is to gain scores and create score-gaining situations, and two side strikers (Henry and Messi) whose task is to create score-gaining situations, getting scores and fulfilling defensive tasks.

1.1. Personal synergy in positioning of the offensive play

Personal effectiveness of players' cooperation will be presented as a specific synergic potential of individual players. This potential will be analysed, both in quantitative dimension in the aspect of activity, effectiveness and worth of cooperation, and in qualitative dimension based on evaluation of reliability and synergy indices with respect to making and receiving ball passes during positioning of the offensive play.

Table 3. Quantitative indices of effectiveness for ball passes to partners used in football game positioning

Players – tasks / Indices		Pass performance activity (A)	Pass effectiveness (Sk)	Pass worth (C)
Dominance of defensive tasks	Pugol	6	5	21
	Zambrotta	10	8	32
	Touré	17	15	55
mean value		11	9	36
Balance of offensive and defensive tasks	Deco	24	18	70 !
	Iniesta	17	15	56
	Xavi	31!	28	112 !!
mean value		24	20	80
Dominance of offensive tasks	Ronaldinho	6	5	26
	Eto'o	8	5	20
	Messi	12	8	31
mean value		9	6	26

The data presented in Table 3 allow formulating of several conclusions, including:

- offensive and defensive players make more than twice as many passes of the ball capturing the play space (on the average 24 passes) than offensive players (on the average 9 passes) or defensive players (on the average 11 passes),
- worth highlighting is particularly high activity of Xavi in performing ball passes capturing the play space i.e. 31 passes,
- please note also the fact that offensive players i.e. Ronaldinho and Eto'o make fewer passes capturing the play space (6 and 8 respectively) than players fulfilling mainly defensive tasks i.e. Zambrotta (10 passes) and Touré (17 passes),
- effectiveness of passes capturing the play space made by offensive and defensive players is twice as high (on the average 20 effective passes) than for defensive players (on the average 9 effective passes) and nearly four times higher than for players fulfilling mainly offensive actions who make only 6 effective passes on the average,
- also the worth of passes capturing the play space made by offensive and defensive players is twice as high (on the average 80 scores) than worth of passes by defensive players (on the average 36 scores) and three times higher than worth of passes by offensive players (on the average 26 scores),
- outstanding accuracy of passes to partners made by Xavi (112 scores) is worth highlighting.

The data presented in Table 4 allow formulating of the following conclusions:

- the players fulfilling mainly offensive tasks receive three times more passes capturing the play space i.e. on the average 20, than defensive players (on the average 7) and twice as much as offensive and defensive players who receive 12 passes on the average,
- particularly frequently the passes are received by the offensive player Messi i.e. on the average 28 passes in the game,
- similarly, offensive players dominate with respect to effectiveness and worth of received passes, with the differences which are lower, and they are equal in the case of effectiveness: 15 to 7, with respect to defensive players, and 15 to 11, with respect to offensive and defensive players, and in the case of worth: 55 scores to 25 scores with respect to defensive players, and 55 scores to 31 scores with respect to offensive and defensive players,
- in this area, the actions of Eto'o (66 scores) and Messi (75 scores) are particularly valuable,
- similar differences in activity and worth of making passes to individual players indicates a similar level of undertaken risk that is receiving similarly difficult passes.

The data included in Table 5 indicate certain regularities in play positioning by the players of FC Barcelona team:

Table 4. Quantitative indices of effectiveness for ball passes from partners used in football positioning

Indices / **Players – tasks**		**Pass performance activity (A)**	**Pass effectiveness (Sk)**	**Pass worth (C)**
Dominance of defensive tasks	Pugol	3	3	13
	Zambrotta	9	7	33
	Touré	8	8	29
mean values		7	7	25
Balance of offensive and defensive tasks	Deco	13	12	41
	Iniesta	12	11	37
	Xavi	12	11	44
mean values		12	11	41
Dominance of offensive tasks	Ronaldinho	9	7	24
	Eto'o	23	18	66 !
	Messi	28	19	75 !!
mean values		20	15	55

Table 5. Qualitative indices of effectiveness for ball passes *to* partners used in football positioning

Players – tasks / Indices		Pass reliability (N=Sk/A)	Pass synergy S = CxN/100
Dominance of defensive tasks	Pugol	0.89	0,19
	Zambrotta	0.80	0,26
	Touré	0.88	0,48
mean values		0,86	0.31
Balance of offensive and defensive tasks	Deco	0.75	0.53
	Iniesta	0.86	0.49
	Xavi	0.90	1.01 !
mean values		0.84	0.68
Dominance of offensive tasks	Ronaldinho	0.85	0.22
	Eto'o	0.63	0.13
	Messi	0.67	0.20
mean values		0.72	0.18

- the highest reliability of passes capturing the play space made to partners was achieved both by defensive players (0.86) and offensive and defensive players (0.84), lower reliability in this action was achieved by offensive players i.e. 0.72 who more often make passes with a higher risk of losing the ball,
- particularly low reliability in this action was presented by specifically offensive players i.e. Eto'o and Messi, 0.63 and 0.67 respectively.
- the highest mean value of synergy indices, taking into account both worth and reliability of passes to partners used in capturing the play space, was achieved by offensive and defensive players i.e. 0.68 and it is twice

Table 6. Qualitative indices of effectiveness for ball passes *from* partners used in football positioning

Players-tasks / Indices		Pass reliability (N=Sk/A)	Pass synergy S = CxN/100
Dominance of defensive tasks	Pugol	1.00	0.18
	Zambrotta	0.77	0.25
	Touré	1.00	0.29
mean values		0.92	0.24
Balance of offensive and defensive tasks	Deco	0.92	0.38
	Iniesta	0.92	0.34
	Xavi	0.92	0.40
mean values		0.92	0.37
Dominance of offensive tasks	Ronaldinho	0.77	0.18
	Eto'o	0.78	0.51
	Messi	0.86	0.64 !
mean values		0.80	0.44

as high as the value of indices obtained by defensive players (0.31) and as much as four times higher than the synergy index of offensive players (0.18),
- a particularly high synergy index for passes to partners was achieved by an offensive and defensive player i.e. Xavi – 1.01.

The data presented in Table 6 allow formulating of several conclusions:
- high reliability of ball passes from partners at the level of 0.92 was achieved both by defensive players as well as by offensive and defensive players, a slightly lower value of this index i.e. 0.80 was achieved by offensive players,
- the highest value of synergy index for passes from partners was achieved by offensive players (0.44), it was slightly higher than the index for offensive players (0.40) and as much as twice as high as for defensive players (0.24)
- a particular high value of this index was achieved by an offensive player i.e. Messi (0.64).

1.2. Interpersonal synergy in positioning of the offensive play

Interpersonal synergy in positioning of the offensive play was identified on the basis of:
- personal flexibility determined by the number of partners with whom the analysed player cooperates and
- differentiated cooperation intensity, determined by the number of passes made to individual players and received from them.

Players showing higher personal flexibility have a bigger range for choosing solutions for situations in the play and the differentiated cooperation activity increases the possibility of surprising the opponent with a solution. The differentiation of cooperation for selected players will be illustrated using synergiograms. Comparison of the synergiogram illustrating cooperation in capturing the play space by passing the ball allows identification of a scope and intensity of using synergy in the aspect of the position in the game occupied by individual players and functions fulfilled by them.

The synergiograms in Figure 1 illustrating the degree of utilizing synergy in positioning of the offensive play by the players fulfilling mainly offensive tasks indicates that both Messi and Eto'o receive passes from a considerable number of partners fulfilling both defensive, offensive and defensive, and offensive tasks, with Messi cooperating with 8 partners and Eto'o with 6. Messi especially intensively cooperates with Xavi and Deco, and Eto'o with Xavi, Deco and Touré.

The synergiograms presented in Figure 2 indicate that the degree of utilizing the scope of synergy by offensive and defensive players in positioning of the play is similar and for Deco it is five players to whom he passes the ball and six players to whom the ball is passed by Iniesta.

On the other side, considerable differences appear with respect to the degree of intensity for cooperation with partners, for the benefit of Deco who intensively, by making more than 3 passes, cooperates with

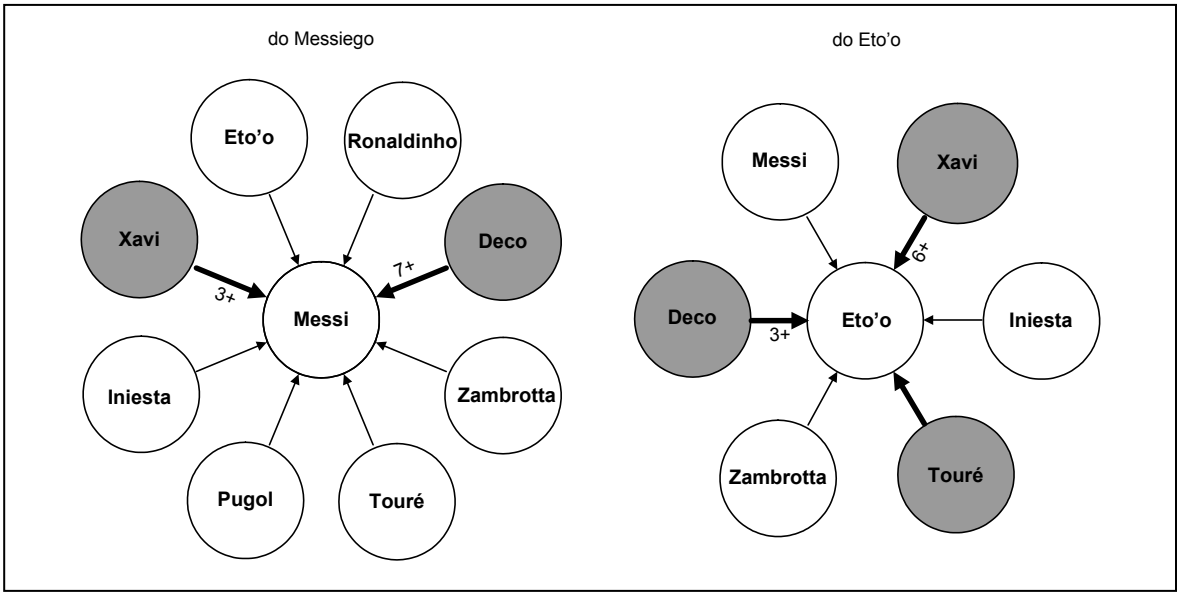

Figure 1. Synergiograms of ball passes from partners to offensive players

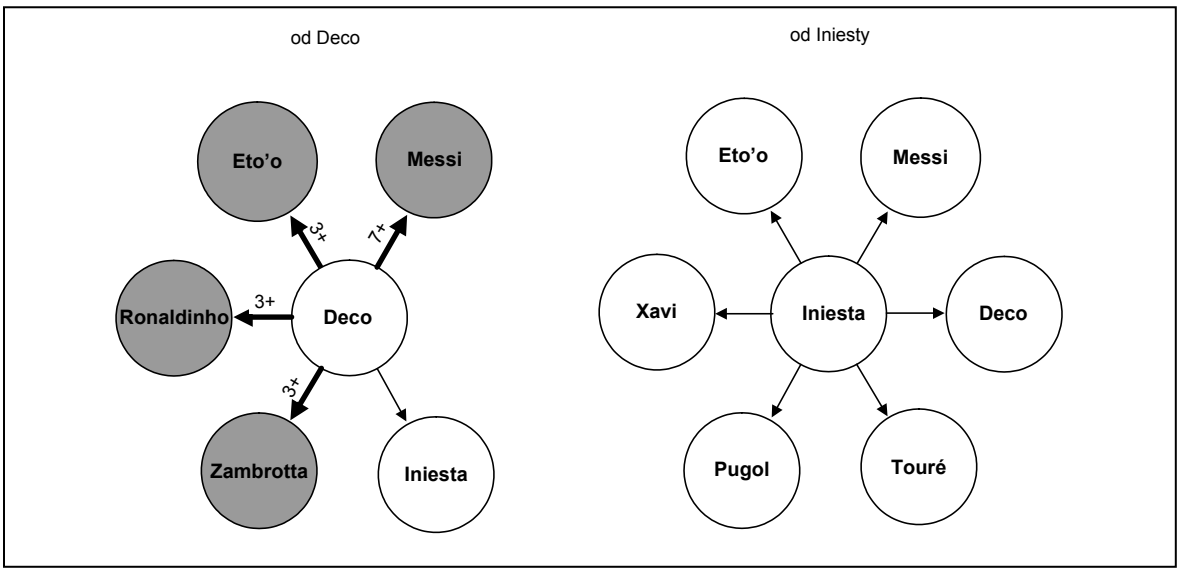

Figure 2. Synergiograms of ball passes to partners from offensive and defensive players

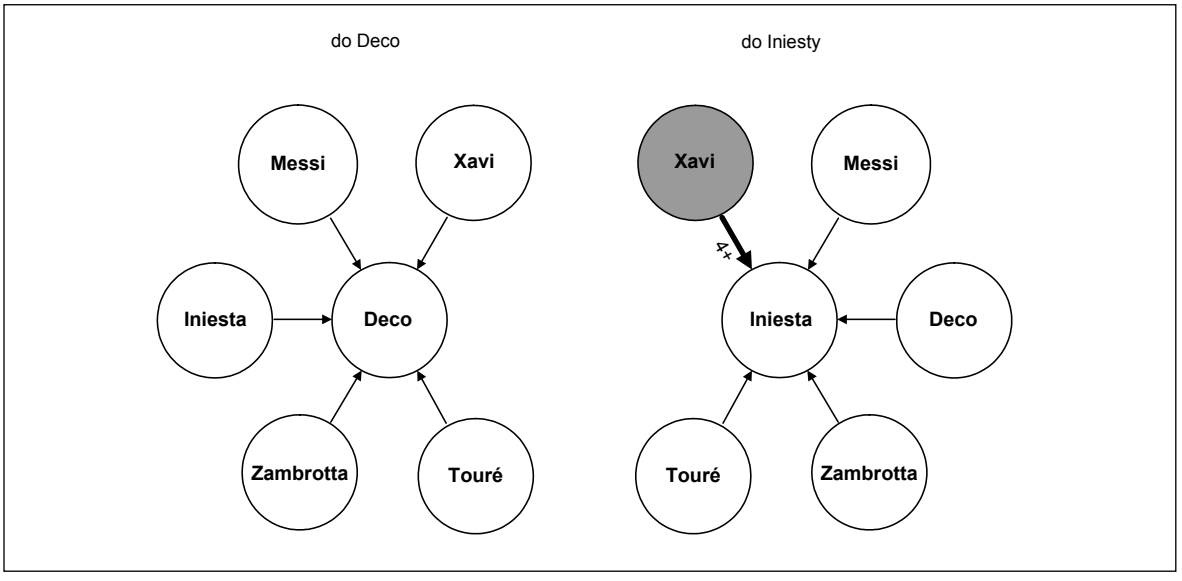

Figure 3. Synergiograms of ball passes from partners to offensive and defensive players

Zambrotta, Ronaldinho, Eto'o and Messi in the game, while Iniesta does not cooperate in a particularly intensive way with any partner.

The synergiograms from Figure 3 show that both Deco and Iniesta receive passes from five partners performing various tasks in the game. For Iniesta, only cooperation with Xavi is more intensive and is carried out at the level of more than four passes capturing the play space per one game.

The synergiograms in Figure 4 indicate that Zambrotta to a much higher degree cooperates with the partners in preparation of the offensive play because he makes passes to four partners fulfilling offensive, offensive and defensive tasks, while Pugol cooperates only with Iniesta. Both Pugol and Zambrotta make not more than three passes to individual partners in the game.

In order to summarize the issue of synergic potential of the player and interpersonal synergy, the examples of outstanding effectiveness of cooperation in positioning of the offensive game are presented.

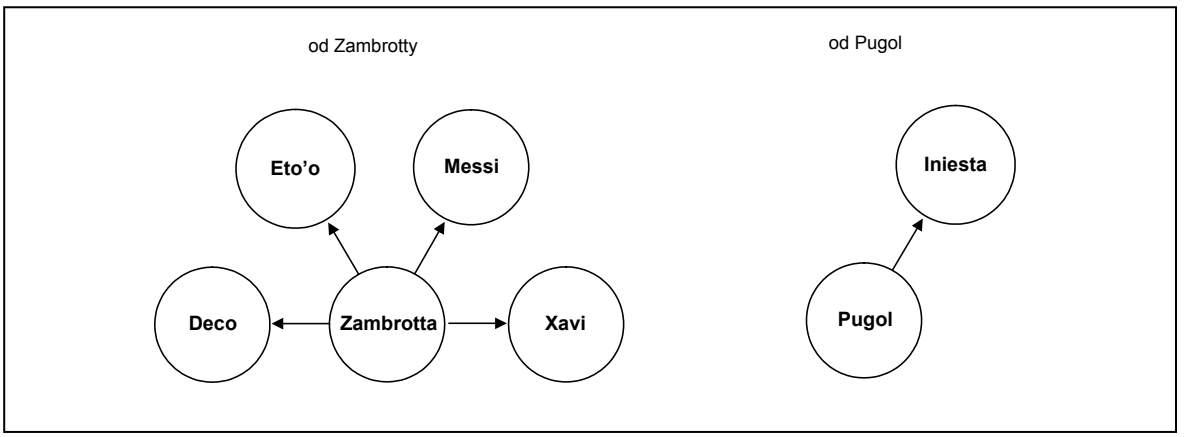

Figure 4. Synergiograms of ball passes to partners from defensive players

1. Xavi – capturing the play space by passes to partners.

Table 7. Indices of effective cooperation in the offensive play

Index	Value
Pass activity (A)	31
Pass effectiveness (Sk)	28
Pass worth (C)	112 scores
Pass reliability (N)	0.90
Pass synergy (S)	1.01

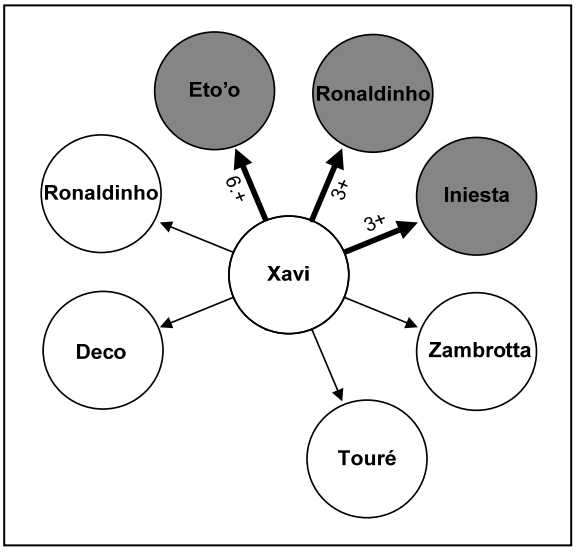

Figure 5. Synergiogram of effective cooperation in the offensive play

The data included in Table 7 indicate outstanding effectiveness of Xavi in capturing the play space by ball passes to partners and they can provide a determinant for development of players fulfilling similar tasks to Xavi in the game. The synergiogram in Figure 5 also shows that the player effective in sport fulfilling offensive and defensive tasks makes passes to most partners, performing various tasks in the game, and particularly intensifies his cooperation with offensive players.

2. Messi – capturing the play space by passes from partners.

Table 8. Indices of effective cooperation in the offensive play

Index	Value
Pass activity (A)	28
Pass effectiveness (Sk)	19
Pass worth ©	75 scores
Pass reliability (N)	0.86
Pass synergy (S)	0.64

The data presented in Table 8 show outstanding effectiveness of Messi in capturing the play space receiving passes from partners and they can provide a determinant for sporting development of players fulfilling tasks similar to Messi in the game. The synergiogram presented in Figure 6 shows also that an effective offensive player cooperates with all partners from the team, and it particularly intensifies this cooperation with offensive and defensive players.

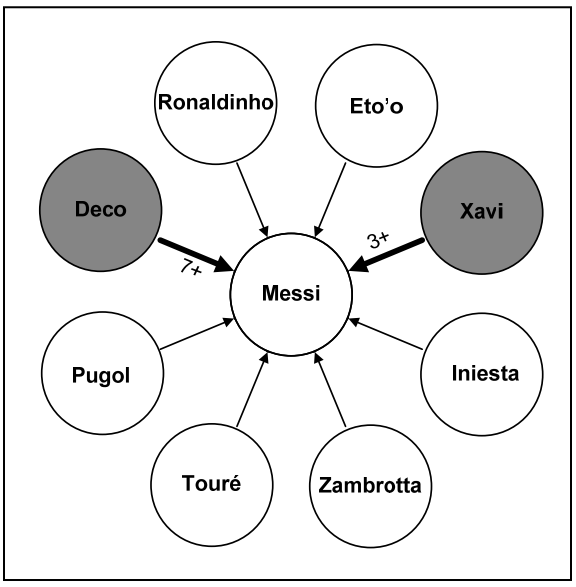

Figure 6. Synergiogram of effective cooperation in the offensive play

2. Positional dimensions of synergy in creating score-gaining situations

Creating of a score-gaining situation is a relatively or absolutely dependent action (the last pass and last but one pass) allowing performing of an action (ball throw or shot) the goal of which is to get a score. In the publication, absolutely dependent actions used in creation of score-gaining situations were analysed. The analysis covers passes made from various positions, in situations with a various level of difficulty. Positions appearing in basketball games by teams representing the clubs Orlando Magic and Los Angeles Lakers, playing in the league organized by the National Basket Association in the United States, will be described in a synergic way. The identification will be presented in a positional dimension as a specific synergic potential of the position, and also in interpositional dimension. Passes of the ball, including those made and received by the players occupying five positions in the game and therefore fulfilling various functions, were registered.

Position number one is occupied by a player positioning the offensive play and creating score-gaining situations, and in the defence counteracting positioning of the play by the opponent. The throwing defender occupies position number two, in the offence he creates score-gaining situations by relocating himself with the ball under the basket, he gets scores using throws from so called distance and half distance, in the defence he counteracts positioning of the play by the opponent. Position number three is occupied by so called winger who in the offence creates score-gaining situations playing in the position with his back to the opponent's basket and gets scores mainly using throws from so called half distance, in the defence he counteracts both positioning of the play by the opponent and creating of score-gaining situations. A strong winger is a player playing in position number four, in the offence he stands mainly under the basket, from this position he creates score-gaining situations and gets scores, in the defence he counteracts creation of score-gaining situations by the opponent. Player number five, so called center, is a person playing in the offence under the basket where he gets scores and collects balls bouncing from the board, in the defence he blocks throws made from under the basket and collects balls bouncing from the board.

2.1. Positional synergy in creation of score-gaining situations in the team game

Positional effectiveness of players' cooperation will be presented as a specific synergic potential resulting from position occupied in the game. This potential will be analysed in the aspect of activity in making and receiving of ball passes during creation of score-gaining situations in the offensive play.

Table 9. Positional synergic activity in creation of score-gaining situation (using the example of Orlando Magic and Los Angeles Lakers teams) – number of passes

Direction of passes / Position in the game		To partners creating positions for thrown into the basket		From partners creating positions for throw into the basket	
„1"	OM	16	15	3	4
	LA	15		5	
„2"	OM	6	12	10	15
	LA	19		20	
„3"	OM	15	13	13	13
	LA	12		14	
„4"	OM	17	16	12	13
	LA	16		14	
„5"	OM	7	7	19	15
	LA	7		12	

When analysing positional activity of players in Orlando Magic and LA Lakers teams presented in Table 9, we notice the following:

– passes to partners creating score-gaining (throw) situations are made in the number from 12 to 15 by players playing in positions „1" to „4", the exception is position „5" from which half of the passes creating score-gaining situations are made.
– passes from partners also creating score-gaining (throw) situations are made also in the number from 13 to 15, while in this case they are received by players from position „2" to „5", the exception is position „1" which receives four times fewer passes allowing a throw into the basket,
– the obtained data indicates the fact that effective basketball play requires involvement in creation of score-gaining situations of all players, regardless of the position occupied by them.

2.2. Interpositional synergy in creation of score-gaining situations in the team game

Interpositional synergy in creation of score-gaining situations on the basis of:
– positional flexibility determined by the number of partners with whom the analysed position cooperates and
– differentiated intensity of cooperation determined by the number of passes made from individual positions and received from them.

The differentiation of cooperation for chosen players will be illustrated using synergiograms.

The data resulting from the synergiogram in Figure 7 indicate that „1" both in OM and in LA cooperate with

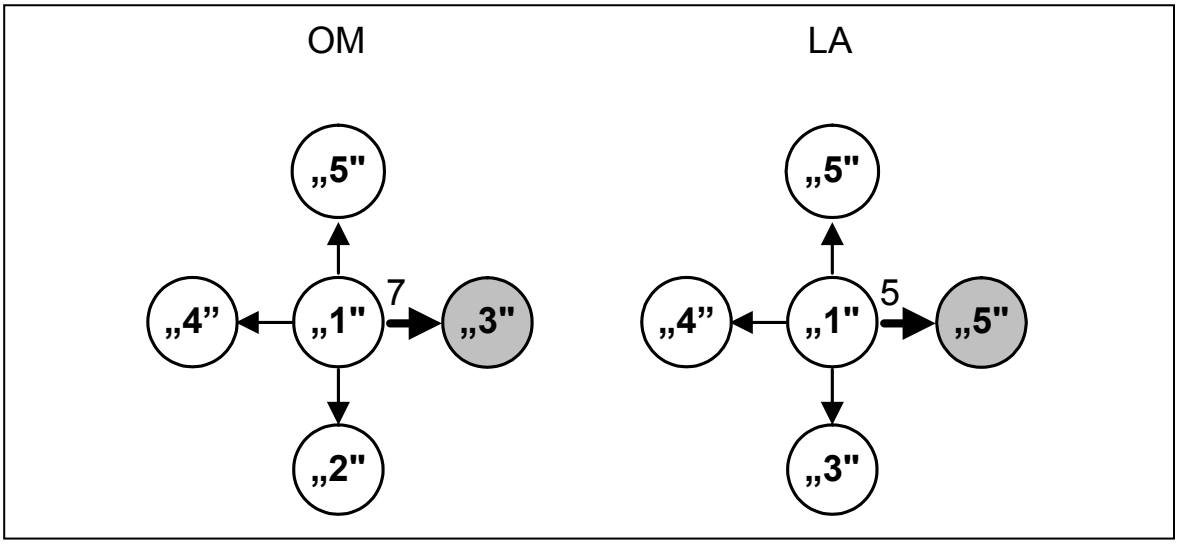

Figure 7. Synergiograms of ball passes creating score-gaining situations made from position „1" in OM and LA teams

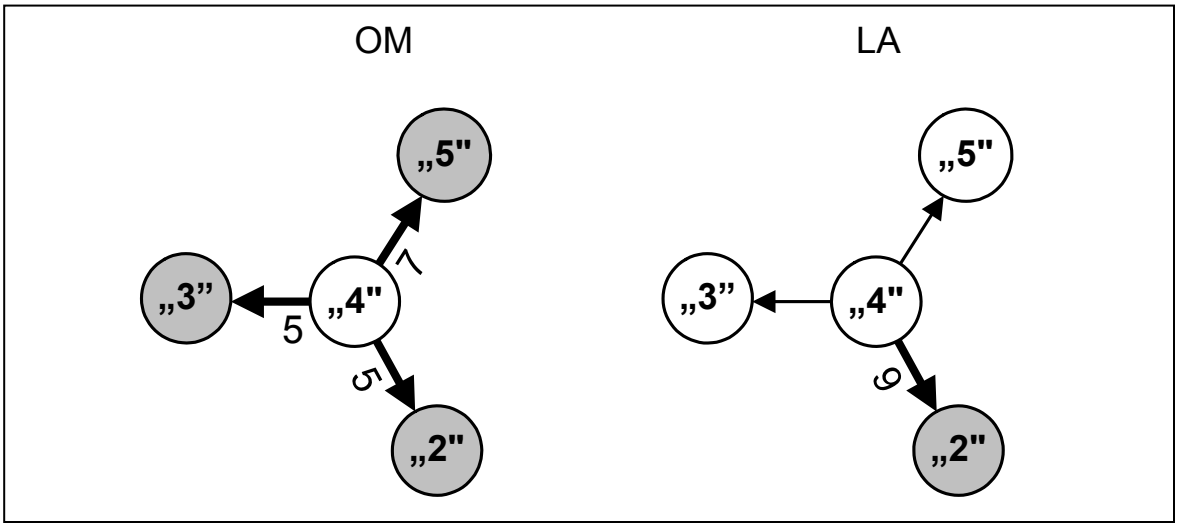

Figure 8. Synergiograms of ball passes creating score-gaining situations made from position „4" in OM and LA teams

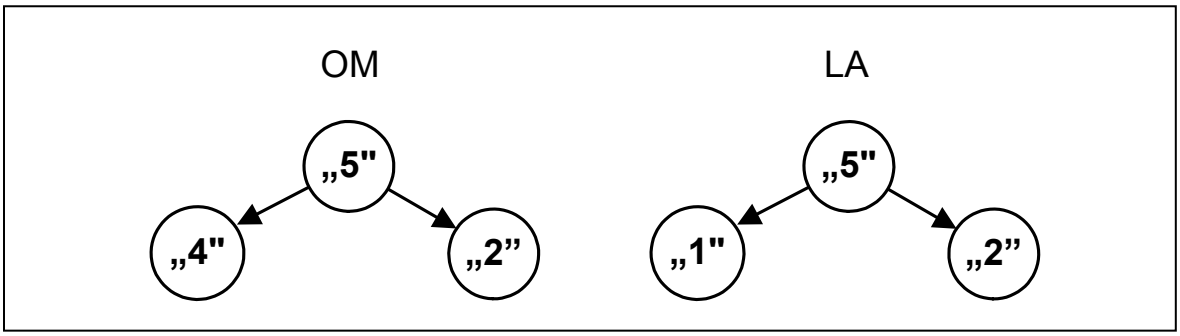

Figure 9. Synergiograms of ball passes creating score-gaining situations made from position „5” in OM and LA teams

all partners in creation of score-gaining situations, and they differ by the intensity of passes to specific players. „1” – OM cooperates at the level of 7 passes in the game with „3” and „1” – LA with „5” at the level of 5 passes creating score-gaining situations on the average.

Data obtained from the synergiograms presented in Figure 8 indicate that both in OM and LA teams, players from position „4” make passes creating score-gaining situations to players in positions „2”, „3” and „5”. “4” in LA particularly intensively cooperates with „2” (Kobi Bryant), and „4” in OM similarly intensively cooperates with all positions.

Data from synergiograms presented in Figure 9 show that positions „5” in OM and LA to a small extent create score-gaining situations by the pass and they cooperate in OM with „4” and „2”, and in LA „1” and „2”.

3. Team aspect of synergy in the sports game

In order to summarize results of the research concerning importance of cooperation in creation of score-gaining situations in the volleyball game, the indices allowing evaluation of the scope of application and utilization of synergy by the examined teams in combinations, determined on the basis of the assessment of the number of specific types of actions carried out at various tempo by individual teams, were analysed.

The research covered eighteen offensive combinations with the participation of two or three players, used to create score-gaining situations by teams representing Brazil, Russia and Serbia in international tournaments. The combinations are performed using various tempo of passes, with the participation of two or three players, using various zones of the playing field. The combinations were divided into three groups depending on their complexity, defined as performed at tempo I, II or III. Those performed at tempo III e.g. with the participation of two players and using a high free pass to zone II or IV were regarded as the least complex. Combinations performed at tempo III e.g. with the participation of three players and using a fast flat pass to zone I, V or VI were regarded as the most complex. The combinations which were analysed are described in details by Superlak [21].

Table 9. Effectiveness of combinations performed at various tempo in individual teams

Team name Cooperation tempo	Brazil			Russia			Serbia		
	Activ.	Effect.	Reliab.	Activ.	Effect.	Reliab.	Activ.	Effect.	Reliab.
1	18	11	0.65	26	16	0.63	26	15	0.65
2	61	31	0.52	49	27	0.57	47	18	0.43
3	27	6	0.24	30	10	0.35	45	18	0.31

Synergy application index (Wss) calculated on the basis of comparison of team activity (A) in carrying out of various combinations was as follows:

Brazil $Wss = \left(\frac{27}{61} + \frac{18}{61} + \frac{27}{18}\right) : 3 = 0{,}74$

Russia $Wss = \left(\frac{30}{49} + \frac{26}{49} + \frac{30}{26}\right) : 3 = 0{,}76$

Serbia $Wss = \left(\frac{45}{47} + \frac{26}{47} + \frac{45}{26}\right) : 3 = 1{,}08$

Synergy utilization indices (Wws) were determined following similar principles, adding the number of ratios for effective combinations performed at various tempo, and so:

Brazil $Wws = \left(\frac{6}{31} + \frac{11}{31} + \frac{6}{11}\right) : 3 = 0{,}36$

Russia $Wws = \left(\frac{10}{27} + \frac{16}{27} + \frac{10}{16}\right) : 3 = 0{,}53$

Serbia $Wws = \left(\frac{18}{18} + \frac{15}{18} + \frac{18}{15}\right) : 3 = 1{,}01$

The values of indices, including: synergy application (Wss) and utilization (Wws) indicate that together with the growth of sporting effectiveness the level of utilizing synergy in creation of score-gaining situations in the volleyball game increases. This is confirmed by values of indices defining both activity and effectiveness, with diagnostic capability of the synergy utilization index determined by effectiveness of combinations performed at various tempos being higher than diagnostic capabilities of the synergy application index determined by activity of cooperation.

The fact that values of the indices, both synergy application (Wss) and utilization (Wws), are coming close to zero shows bigger and bigger application and utilization of three-player combinations performed at tempo 2 with broad and deep utilization of the playing space by teams effective in sport. On the other side, the contrary tendencies, that is coming of the indices close to one or exceeding this value by teams with lower effectiveness (see the team of Serbia) indicates decreasing importance of less complex combinations performed at tempo 1, and in particular at tempo 3, at the highest sporting level in the effective play.

SUMMARY

The obtained results allowed identification of various dimensions and levels of synergism in the team game, including: effectiveness of cooperation for chosen players and utilization of combination (variants) in positioning of offensive actions and in creation of score-gaining situations. The obtained data indicate that evaluation of effectiveness for two-player and three-player cooperation may concern both the synergy dimension i.e. synergic potential of players and positions occupied in the game, synergism between players and positions, as well as synergy of the team as a whole. The obtained results allowed also identification of the level of synergy resulting from the degree of synchronization and coordination of actions absolutely dependent on each other. Synergic perception of the cooperation effectiveness, accepted by players, is favourable for development of an added value in the team, i.e. task-related coherence and as a consequence also emotional coherence, as well as a new quality i.e. combinations of actions that we cannot analyse in an individualized personal aspect.

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DISCUSSIONS
POLEMIKI I DYSKUSJE

PHYSICAL FITNESS NORMS IN CHILDREN AND ADOLESCENTS: THE PHYSICAL EDUCATION APPROACH

NORMY SPRAWNOŚCI FIZYCZNEJ DZIECI I MŁODZIEŻY Z PERSPEKTYWY WYCHOWANIA FIZYCZNEGO

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Key words: physical fitness development, evaluation, norms, children and adolescents
Słowa kluczowe: rozwój sprawności fizycznej, ewaluacja, normy, dzieci i młodzież w okresie dojrzewania

SUMMARY • STRESZCZENIE

The physical fitness development is mentioned as one of main aims, not only among short-term tasks of physical education (supporting of physical fitness development), but also among long-term tasks (lifelong physical fitness education). In both cases, the proper measurement and evaluation of physical fitness level are necessary. While we care strongly about the measurement methods (validity, reliability, standardization etc.), much less of our attention is related with evaluation of received scores of physical fitness.

The main aim of this paper was to emphasize the significance of suitable establishment and interpretation of physical fitness norms in children and adolescents. In consideration of the topic the physical education approach was applied and discussion was divided into four sections:

1. OBLIGATIONS or endorsement of physical fitness development as one of the basic aims of physical education.
2. PROBLEMS or why proper establishing physical fitness norms for children and adolescents is impossible.
3. MISTAKES or what we do wrong in establishing and interpreting norms of physical fitness of children and adolescents.
4. GOOD EXAMPLES or how to establish and apply norms of physical fitness in children and adolescents.

The additional aim of the paper was introduction and invitation professionals from various sciences to wide discussion about establishment and interpretation of physical fitness norms in children and adolescents.

Rozwój sprawności fizycznej jest zaliczany do podstawowych celów wychowania fizycznego, nie tylko doraźnych (wspieranie rozwoju sprawności fizycznej), ale również perspektywicznych (całożyciowa troska o sprawność fizyczną). W obu przypadkach konieczne jest zastosowanie właściwego pomiaru i interpretacji wyników sprawności fizycznej. Zwykle dbamy szczególnie o dobranie właściwych metod pomiaru (trafność, rzetelność, standaryzacja itp.), poświęcając dużo mniej uwagi interpretacji uzyskanych wyników sprawności fizycznej.

Celem głównym pracy było podkreślenie znaczenia odpowiedniego konstruowania i wykorzystania norm sprawności fizycznej dzieci i młodzieży. Zagadnienie jest opracowane z perspektywy wychowania fizycznego, a rozważania podzielono na cztery części:

1. POWINNOŚCI, czyli wspomaganie rozwoju sprawności fizycznej jako jeden z podstawowych celów wychowania fizycznego.
2. TRUDNOŚCI, czyli dlaczego rzetelne wyznaczenie norm sprawności fizycznej dzieci i młodzieży jest niewykonalne.

3. BŁĘDY, czyli co robimy źle w konstruowaniu i interpretacji norm sprawności fizycznej dzieci i młodzieży.
4. POZYTYWNE PRZYKŁADY, czyli jak konstruować i wykorzystywać normy sprawności fizycznej dzieci i młodzieży.

Dodatkowym celem pracy było wprowadzenie do zagadnienia i zaproszenie naukowców reprezentujących różne dziedziny nauki do dyskusji o tworzeniu i wykorzystaniu norm sprawności fizycznej dzieci i młodzieży.

INTRODUCTION

The present paper focuses on the issues of establishment and usefulness of physical fitness norms in physical education of children and adolescents. The usability and, in particular, correct interpretation of physical fitness normalization have been grossly neglected in physical education practice. It is, after all, an aspect of educational practice implying the efficiency of physical education. As regards the common practice of regarding results of physical fitness evaluation as the main – or sometimes even the sole – assessment school grade criterion at school, one can hardly resist an impression that it is a great waste of efforts, not only those of PE teachers. A change in teachers' attitude as well as a slightly increased teaching workload can bring about educational outcomes which can greatly affect students' current and prospective life and health. How can it be accomplished? Before providing some g o o d e x a m p l e s of actions, let us consider first the o b l i g a t i o n s of physical education related to the postulate of physical fitness improvement. P r o b l e m s with the establishment of physical fitness norms should be analyzed since the awareness of them is also necessary for interpretation of obtained results. Finally, valid conclusions must be drawn from obvious m i s t a k e s commonly made not only by PE teachers.

OBLIGATIONS

or endorsement of physical fitness development as one of the basic aims of physical education

Regardless of the way it is understood, the appropriate level of physical fitness remains a positive and much desired human "property". Taking care of proper development of physical fitness in childhood and adolescence is translated into undertaking appropriate actions as one of the basic aims of physical education. From ancient times it has been undoubtedly the most characteristic and spectacular mission of physical education. The famous quotation from *Satire X* by Juvenal: "A sound mind in a sound body" has always been and still is the leading maxim for generations of physical education teachers. It has additionally emphasized the significance of man's physicality for his spiritual development. Such a philosophical premise, justifying physical education acts, fulfilled its function quite effectively a long time ago, when life challenged man to undertake physical efforts at any age and in any profession. Physical education should be part of general education preparing man to live an independent, adult life. Today, in the face of the scope of demands of the modern world, the underlying assumptions and principles of development of physical fitness in physical education are in need of revision.

The starting point should be an analysis of the longer line from Juvenal (not only its most known fragment taken out of context): "Orandum est ut sit mens sana in corpore sano". Usually the second part of the line is quoted but, in fact, the Roman poet explicitly stated that: "I t i s t o b e p r a y e d that the mind be sound in a sound body". The line therefore is an expression of a desire rather than an automatic interrelation, which turns out to be a logical and semantic overstatement. Not always is there a sound mind in a sound body, and not always is there an unsound mind in an unsound body. Once such a deliberation is projected onto the reality and health hazards of the modern world, especially those resulting from the sedentary lifestyle, we will easily notice the obsoleteness of the aforementioned philosophical premise. Thus, a reversed way of thinking has been dominant in physical education for a few dozen years: proper education ("sound mind") causes the possession of a fit and healthy body [1, 2, 3]. How does this translate into the ways physical fitness is developed? Modern man must be prepared to a take lifelong care of his body (including maintaining a good level of physical fitness) since no amount of gathered fitness and health is enough to last for a lifetime. Physical education does not end once one leaves school. Even the most athletic body and best trained muscles will not remind us to be taken care of. The decision to take care of the body lies in human awareness and in the sphere of values, which are developed as axiological competences in the process of education.

In view of the above a question should be asked whether the traditionally exhibited biologistic trend in physical education (with its priority given to physical fit-

ness improvement) has lost its significance? Certainly not, and in the face of modern civilizational threats, it has actually gained in significance [3]. However, we should not be satisfied with the current state of affairs. The physical development of the young generation must be endorsed even more strongly than before because life no longer provides the necessary stimuli for it in sufficient quality and quantity. Concurrently, stimulating actions should be included in the process of proper education as it must ensure students develop proper behaviors in their adult life. In this way, short-term and long-term educational tasks will be fulfilled.

PROBLEMS

or why proper establishing physical fitness norms for children and adolescents is impossible

If sustaining the development of physical fitness is one of the fundamental objectives of physical education, then assessment of physical fitness must also be its integral part. The normalization of physical fitness is a complex issue and any comprehensive discussion of its intricacies is clearly beyond the scope of this paper. Is establishing norms of physical fitness necessary at all? It is a rhetorical question. Without normalization, assessment and interpretation of results seem impossible.

Considering the importance of improvement of physical fitness development, physical education may be referred to as "health-related fitness education". The attainment of desired educational goals also depends on properly established norms of physical fitness that must account for specific needs and determinants. This may involve problems that must not be ignored.

It is a truism to repeat constantly (but is nevertheless necessary to repeat) that the range of ontogenetic variability, including the level of physical fitness, is determined simultaneously by genetic and environmental factors. Additionally, in the case of children and adolescents, also the pace of physical maturity must be taken into consideration [4]. The establishment of norms of physical fitness must account for all the above factors. Individual differences resulting from genetic and environmental variations are particularly visible in a comparison of morphological traits, which also significantly determine physical fitness effects. With such significant differences, the use of population norms, based on the average value of given characteristics in particular populations, is an oversimplification. Such procedures are not only wrong but also harmful [5]. Szopa [5] notes that if the process of setting population norms involved only the basic categories of variability resulting from genetic and environmental factors as well as the pace of maturity, the number of possible combinations would lead to 243 distinct classifications. He admits, however, that such research would be impossible for the lack of representative samples.

Having considered all these problems, is the establishment of logically explained norms of physical fitness of children and adolescents an unfeasible task? Unfortunately yes, however, facing the necessity of existence of some sort of frame of reference, we must undertake such procedures that will be of lesser evil.

MISTAKES

or what we do wrong in establishing and interpreting norms of physical fitness of children and adolescents

One of the most common mistakes is nearly thoughtless application of physical fitness assessment. According to Osiński [6], mere learning of standard procedures and routine interpretation of results are not sufficient. A physical fitness test without its proper place in a specific conception of physical fitness "is only a senseless and random collection of jumps, throws or strength or coordination exercises" [6].

The fundamental mistake in establishing and applying norms of physical fitness of children and adolescents is the use of population norms with reference to calendar age in which individual scores are evaluated against a normative reference scale for a population. Simple statistical calculations based on arithmetic means and standard deviation contain a serious error because they fail to account for the lack of homogeneity of the population and frequent non-normal distribution of results [7]. Besides, scores calculated in this way are only of descriptive character, and the information "what is", but for some reason, they are regarded as "prescriptive" or "normal". Such norms may not constitute a biological frame of reference [5]. The only explanation for such erroneous treatment is probably the deeply rooted belief in the "fairness" of norms [8]. Teachers are often convinced about the validity of assessment based on "objective" criteria, whereas from the standpoint of efficiency of fitness education such criteria may be highly discouraging [9]. Differences in biological age may render attainment of an appropriate physical fitness level impossible and thus discourage a student from performing an exercise [10, 11].

Additionally, the averaging of scores in cross-sectional studies makes the population norm useless for tracking the dynamics of a child's individual development. On the other hand, results of longitudinal studies can only pertain to the studied population [5].

By the way, another common mistake worth mentioning here is the use of well known WHO adult categories of overweight and obesity in the assessment of body build in children and adolescents. Apart from serious doubts about the usefulness of BMI for obesity assessment, we must remember that a child is not simply a miniature of an adult. As Cole et al. [12, 13] observe the BMI ranges in children differ substantially from the categories of underweight, overweight and obesity in adults.

GOOD EXAMPLES

or how to establish and apply norms of physical fitness in children and adolescents

In the opinion of many authors [5, 9, 10, 14, 15] the assessment of development of functional traits must account for the purpose of norm setting and somatic development (in the case of motor fitness assessment).

To precisely determine the purpose of establishing norms the concept of physical fitness and the role of fitness education must be first defined. Present-day physical education stresses the importance of those components of fitness education which constitute the notion of positive health and determine a low risk of health problems [16]. It is referred to as "health-related fitness" (H-RF), which does not defy but remains clearly distinct from the so-called "performance-related fitness" [17]. Such an understanding of physical fitness fully relates to the mission of physical education discussed earlier.

The first and foremost aim of assessment tests (and corresponding assessment norms) within the concept of H-RF is health promotion and care for functional efficiency and wellbeing. Tests play an important educational role [18], and they should be integrated in school curricula and used as pedagogical tools [14]. Apart from its important (but not primary) diagnostic function a physical fitness test should be an aid in the propagation of knowledge about the significance of physical fitness and support the development of appropriate attitudes towards it. Thus, there should be premises to undertake specific actions in the future, especially aimed at promoting appropriate physical activity. The presentation and interpretation of test results should not be based on biological heredity only but on encouragement of an active lifestyle [10]. In this way, tasks traditionally associated only with performance of physical exercises become part of proper education.

The diagnostic function of physical fitness norms must provide the answer to the important question "How much fitness needs good health"? [11]. The complexity of this issue has made any comprehensive, mathematical and theoretical establishment of criteria impossible [19]. The standards are usually set arbitrarily. The level of achievement corresponding to the state of complete health is estimated by means of "criterion values" [11], "criterion-referenced standards" [14] or "criterion health status" [16]. Similarly, years ago Wolański [20] considered a "target norm" (desired standard) in reference to biological development. An individual must realize whether he or she has achieved a desired standard (from the standpoint of health), not only how it contrasts with the rest of population [21]. A good example may be also the "healthy fitness zone" used in "FITNESSGRAM" developed by "The Cooper Institue" [22], that focuses on the range of desired physical fitness standard from the perspective of health needs. An exerciser must be made aware of his or her needs and encouraged to adopt desired attitudes [15]. The aims should be useful, attainable, and each next measurement and evaluation should verify their attainment [14, 21]. The present level of physical fitness is important, but it is much more important what it will be in 15 or 20 years [21].

Accounting for the level of somatic development in the assessment of such functional traits as physical fitness is a relatively easy task. It involves simultaneously the impact of genetic and environmental factors and the level of body's maturity. There are many indices that can be used in such a comprehensive evaluation, however, their measurement and interpretation in physical education can be often difficult due to the unavailability of appropriate research methods and tools, lack of specialist medical knowledge or problems with processing and simple interpreting complex research results. Body height may appear to be a parameter that can be easily measured and yield sufficient data. It is certainly not the best index of genetic and environmental influences, as well as the level of somatic maturation, but nevertheless quite useful in physical education. This was noted, for example, by the authors of national norms of physical fitness for children and adolescents in Poland [23, 24], who proposed two categories of physical fitness

assessment: calendar age and body height age. In the case of the latter, if a child's body height differs significantly from that of its peers, the so-called "calendar age correction" should be calculated and the child's level of physical fitness should be evaluated according to the norms of a younger or older age category.

The subject of this paper is not new. Arguments for and newly proposed approaches towards the establishment and application of physical fitness norms in physical education have been around for a long time. Why then outdated and harmful stereotypes can be still encountered in physical education? Perhaps, it is because PE teachers at school are more often training instructors than physical educators in the full sense of the word? The education of PE teachers still leaves much to be desired. There is too much stress on knowledge and skills rather than on what a human being the student becomes. Development of the student's axiological competences is still wishful thinking. In education of PE teachers biological aspects of physical education are often considered in separation from pedagogical aspects, without pointing to any mutual interactions. The knowledge of physical education is treated too analytically. We concentrate on sophisticated research investigations, hoping students will somehow figure them out as a whole. Not everyone will be willing and ready to adopt such a synthetic approach. The norms of physical fitness of children and adolescents required such an approach. This should be done in a systematic way, and prospective PE teachers should be constantly reminded of this approach as the danger of stereotypical proceedings and misinterpretation is still high.

What is interesting, arguments for the educational approach postulated in this paper can be found long time ago in the views of Jędrzej Śniadecki, a famous Polish physician with great pedagogical aspirations, who wrote more than 200 years ago that: "Man is never cast into the same, uniform mold, but his existence features unbound variability (…) there is no one uniform but multiple patterns of perfection…" This was Śniadecki's biological argument. And if someone still insists on uniformization in physical education in the name of apparent equality and fairness, let them remind of Śniadecki's pedagogical argument: "Physical education, designed to make man happy, should be made accessible to all (…). After all, even the crippled and the infirm have their health and their happiness." Can there be anything more important than that?

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