ACTA FACULTATIS EDUCATIONIS PHYSICAE UNIVERSITATIS COMENIANAE

PUBLICATIO LII/II

2012

ACTA FACULTATIS EDUCATIONIS PHYSICAE UNIVERSITATIS COMENIANAE PUBLICATIO LII/II

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ISBN 978-80-223-3329-0

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ERRATA

Due to the content of the article ANALYZE OF SPORT TALENT SELECTION SYSTEMS by authors Martin Sebera and Jaromír Sedláček, published in ***ACTA FACULTATIS EDUCATIONIS PHYSICAE LII/I,*** the Editorial board had withdrawn the article from the mentioned issue.

Executive Editor

SPECIAL SWIMMING TEST DETERMINATION USING SELECTED FUNCTIONAL PARAMETERS OF SWIMMERS

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Summary: The article brings knowledge on special endurance swimming tests using functional organism response indicators, among the group of swimmers (14 – 17 yr., n = 12). We have evaluated the swimmers' performance during the annual training cycle by 5 measurements in specific preparatory periods, using the special endurance tests of 800 m, 1 500 m, 3000 m free style, and functional organism response (heart rate, maximal lactate, lactate after 20 minutes, lactate descent). The performance in various endurance tests was determined in every preparatory period by means of organism functional indicators. The highest performance was found during summer season of competitions. We found that the performance in 1 500 m and 3 000 m tests is determined by functional parameters at the level of 25 %. Sport performance in 800 m test is determined by functional parameters at the level of 11 %. During the competition period, the best indicators of the sport performance in the 3 000 m test are maximal lactate 62.41 %, (LA_{max} = 4.13 mmol.l^{-1}, swimming speed 1.17 m.s^{-1}) and heart rate 55.65 % (HR 172 bpm).

Keywords: special tests, heart rate, lactate, power swimmers

The problem definition

To achieve the best performance in competition, it is important to develop sensitively both aerobic and anaerobic energetic systems by training. Though the anaerobic lactate system is less employed by the long distance swimmer to avoid the swimming speed decrease, still it must be developed by training, as the sprint swimmer must have developed the high level of aerobic capacity. The average levels of maximal lactate in swimming disciplines are known, and help to determine the corresponding swimming speed. Madsen, Lohberg (1987) are specifying value of 12 – 14 mmol.l^{-1} for 400 m, and 10 – 12 mmol.l^{-1} for 1500 m. The anaerobic or lactate threshold is subject of studies evaluating its suitability to determine the load intensity in swimming (Weltman, 1993, Troup, 1999). The main idea of this study is the importance of lactate level interpretation in context of the swimmers' specialization, their performance, and the load intensity. Having aerobic energetic system well trained is important for swimming in all disciplines, except 50 m. The meaning of the high quality of aerobic work consists in the support and development of anaerobic load, in the speed up of the regeneration processes, it is of profound importance for the development of swim stroke

and tempo efficiency, it is the essential part for the performance tuning, and also for the ability of this system to positively affect the swimmer's overall training level (Pyne, Goldschmid, 2005). Olbrecht (2000), using various training examples, is emphasizing the fact, that if the swimmer wants to achieve excellent competition results, it is necessary to train both systems in an appropriate ratio, comparing to their age, genetic predispositions, preparatory stage, and the performance level.

Depending on the swimming speed, the swimmer can achieve the lactate equilibrium (anaerobic threshold) at various lactate concentrations. There are swimmers with anaerobic threshold more than 6 $mmol.l^{-1}$ but the highest level varies among swimmers. The anaerobic threshold of endurance swimmers is lower than the one of sprint swimmers (Olbrecht, 2000). The same author also states, that for 800 m and longer competition is the ratio of lactate and alactate energy on roughly the same level, for both sprint and endurance swimmers.

To unbiased the information on special motoric tests, used in the field of Slovak swimming, various researches have been performed, with specific results. Masarykova (2008), using intra individual evaluation of internal organism response of teenage female swimmers, found the highest heart rate in the 800 m test (within range of 178 – 186 bpm), and the highest lactate level in the 4 x 50 m test (within range of 5.5 – 9.1 $mmol.l^{-1}$). The actual training level of swimmers was researched by Ružbarsky (2010) in the 4 x 300 m test. He determined the individual anaerobic threshold by the lactate curve, using exponential approximation and mathematical interpretation of tangents intersection. By deploying intra individual approach and considering the effect of training load in time, he recommended specific ratio of aerobic and anaerobic load to swimmers.

On test rallies of the best Slovak swimmers, the aerobic capacity was measured in 800 m and 3 000 m tests (Ružbarsky et al. 2008). The authors state that the 3 000 m test is suitable to diagnose the anaerobic threshold among junior and senior swimmers. In the 800 m test, the lactate level was measured in the rage of 7.8 – 8.4 $mmol.l^{-1}$. The lactate level for senior power swimmers was lower at a higher swimming speed. They recommend the 800 m test to evaluate the critical speed, which is responding to the lactate in blood concentration within range of 9 – 12 $mmol.l^{-1}$.

A test was established to evaluate the aerobic and anaerobic capacity using the critical swimming speed (Wakayoshi, 1991). Participants were swimming the distances of 50 m, 100 m, 200 m and 400 m, at their highest power. Times, recorded in a graph, were determining the critical speed and anaerobic capacity of the swimmer.

Záhorec, Rouš, Řezníčková (1987) were doing extensive research to determine the swimming performance by somatic, functional, and motoric characteristics of top swimmers. They longitudinally followed a group of 58 swimmers (representatives of Czechoslovakia) during 4 years, and a group of 250 Slovak swimmers during 5 years. They focused on parameters of aerobic capacity (VO_2 max, maximal pulse oxygen, W170), and factors limiting anaerobic performance (O_2 debt). Motoric abilities were evaluated by 28 tests. In the set of swimmers, a relatively high level of functional dispositions was found, both endurance-(aerobic capacity), and speed oriented (anaerobic capacity) at a balanced rate (50 %). From among special swimming tests, most suitable for the sport performance were 800 m and 4 x 50 m tests.

The main purpose of this article is to find and offer to the practice concrete information on involvement of functional parameters in the performance description through tests evaluating differing quality of endurance abilities.

Methodology

The goal of the research was to find the level of determination of sport performance in three endurance swimming tests by means of functional indicators.

The test set consisted of 12 swimmers (14 – 17 years old) of second power class, who were involved in training process for 6 – 8 years. All of them are specialized on medium- to long distance swimming. Tests were performed during an annual training cycle in 5 measurements. The first measurement was performed in October (preparatory season), the second measurement in December (winter competition season), the third in March (preparation for summer season), the fourth in May (beginning of competition season), the fifth in July (competition season). The functional organism response was measured in tests evaluating endurance abilities:

3 000 m free style [s] – start from water,

1 500 m free style [s] – start from water,

800 m free style [s] – start from water.

Evaluated functional organism parameters were: average heart rate (HR) [bpm] and lactate level, maximal lactate level (LA_{max}), taken from records in 1^{st}, 3^{rd}, 5^{th} minute; lactate in 20th minute (LA20), lactate descent (Las %, percent calculated from maximal lactate and 20^{th} minute lactate).

Lactate level was measured by Biosen 5130. This device allows samples with constant volume of 20 µl of capillary blood with an error less than 3 % at 12 $mmol.l^{-1}$.

The main evaluation method was inter individual using nonparametric methods with regard to the situation and tested set size. The relation between sport performance in special swimming tests (secondary parameter) during preparatory stages, and functional parameters (primary parameters) was expressed in percentage coefficient of determination ($R^2.100$).

The share of functional parameters in the performance in special tests was evaluated in each of 5 measurements. At the same time, the level of determination of three special tests during the annual cycle was examined, taking into account median of all measurements.

Results and discussion

Changes in performance level during the measured period are of different dynamics in individual tests. We have found statistically significant changes of swimming performance during the annual preparatory cycle in 800 m test between 2nd and 3rd measurement ($p < 0,05$), and in 1 500 m test between 1^{st} and 5^{th} measurement ($p < 0,05$) (Fig. 1). Gradual performance raise in 1 500 m test was recorded only during summer season, i.e. from March to July. The winter season has longer preparatory period, unlike the competition season, and typical for it is the big volume of kilometers they have swum, which are mainly in first 6 weeks of aerobic character. Typical load in this period is shown in the highest performance in 3 000 m test at the end of winter season in 2nd measurement; on the other hand, the lowest swimmers' performance is in 800 m test (Fig. 1). 800 m test has proved to be sensitive to the training

stimulation, comparing to other special tests. The performance in 800 m test is the best reflection of the change of training stimulation quality during the specific preparatory season. The results are big changes in performance in individual measurements. Lower performance in 2nd and 4th measurement in 800 m test can show rapid anaerobic training stimulation (speed-power).

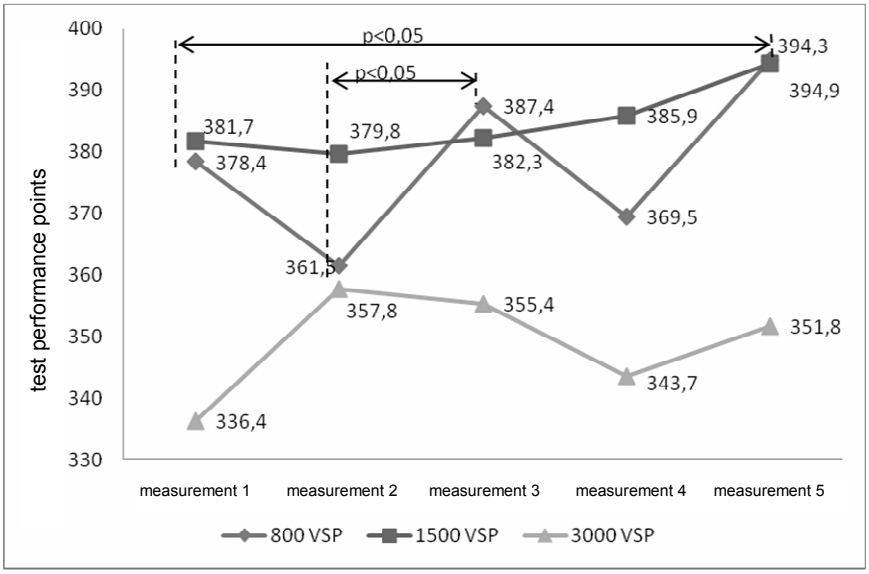

Figure 1

Performance changes in special swimming tests and individual measurements

In all three special tests different explanation of performance during all periods of the annual cycle was found by functional parameters (Fig. 2 – 6).

In the first measurement during the preparatory period of the annual cycle, the 1 500 m test was remarkably determined by functional parameters, and the biggest influence was found in the $1LA_{max}$ parameter (27.98 %, Fig. 1). The swimmers were swimming in the test at the speed of 1.23 $m.s^{-1}$, the LA_{max} level 7.18 $mmol.l^{-1}$, and HR 180 bpm. In the first measurement, the heart rate share was highest (17.9 %, HR 183 bpm) in 800 m test at the swimming speed of 1.29 $m.s^{-1}$, the lowest share was in 1500 m test. Lactate descent was most remarkably determining the 1 500 m and 3 000 m tests (swimming speed 1.15 $m.s^{-1}$). The LA_{max} parameter at the level of 7.18 $mmol.l^{-1}$, was most influencing the performance in 1 500 m test, and least in 800 m test with its level at 9.66 $mmol.l^{-1}$ (Fig. 2).

In the second measurement during the winter competition season, we have found the highest determination by functional parameters among the swimmers in 3 000 m test and 1 500 m test. The highest share (51.41 %) in 3 000 m test had the $LA_{max.}$ parameter at the level of 4.24 $mmol.l^{-1}$ and the swimming speed 1.16 $m.s^{-1}$. The second highest share had the lactate descent parameter in the same test (38.07 %). Heart rate was most influencing the

performance in this test. The lowest determination by functional parameters in the second measurement was in 800 m test (swimming speed 1.23 $m.s^{-1}$) (Fig. 3). At the end of the winter season, after highly intensive training stimulations, the swimmers had the highest performance in 3 000 m test.

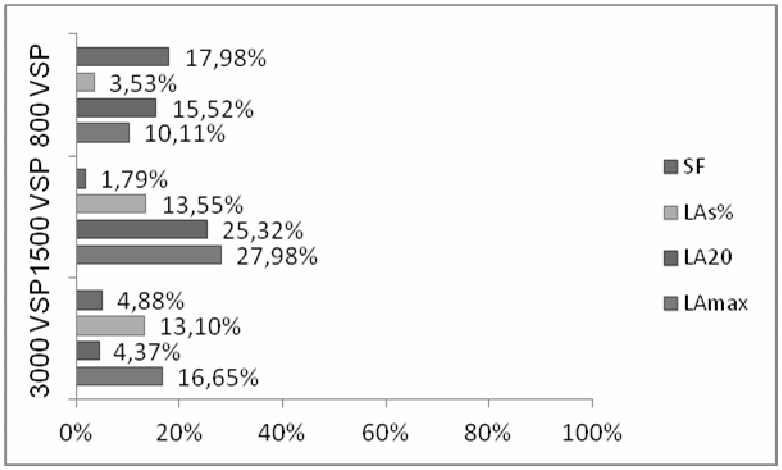

Figure 2

Determination of special tests by functional parameters (1st measurement)

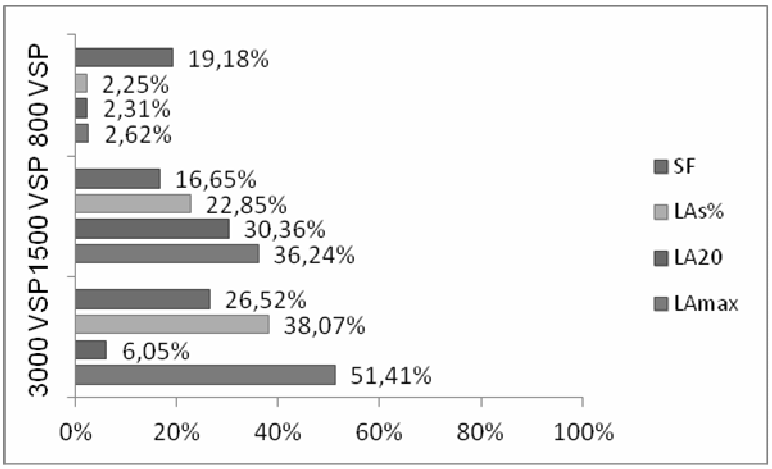

Figure 3

Determination of special tests by functional parameters (2nd measurement)

In the preparatory period for summer season (3rd measurement), was the highest determination by functional parameters found in 1 500 m test (Fig. 4). Like in previous two periods, also in the third measurement was the highest share of the LA_{max} parameter in 1 500 m test VSP (26.83 %, LA_{max} 6.65 mmol.l^{-1}, swimming speed 1.21 m.s^{-1}) and 3 000 m test (21.72 %, swimming speed 1.18 m.s^{-1}, LA_{max} 3.86 mmol.l^{-1}). The performance was determined equally by the heart rate. There was minimal determination of performance by functional parameters in 800 m test (swimming speed 1.31 m.s^{-1}) (Fig. 4).

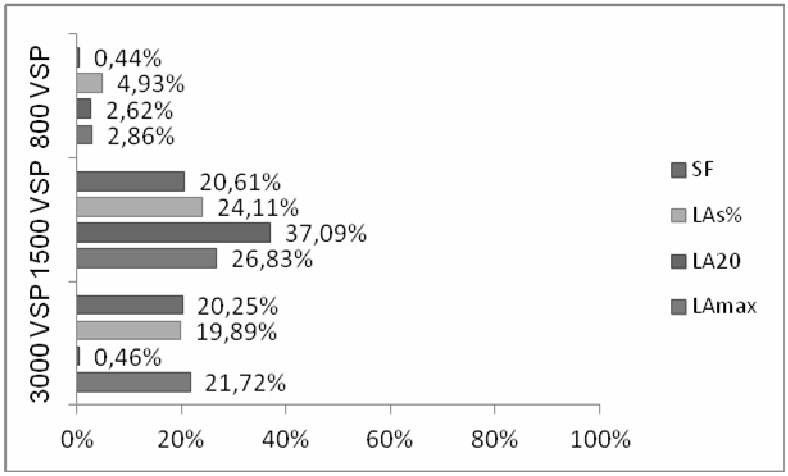

Figure 4

Determination of special tests by functional parameters (3rd measurement)

In the fourth measurement at the beginning of summer competition season, the performance highest determination in 3 000 m test (swimming speed 1.17 m.s^{-1}) was by heart rate (41.60 %, 174 bpm), lactate descent (41.09 %, Las % 72,56), and LA_{max} (4.38 mmol.l^{-1}). In 1 500 m test (swimming speed 1.23 m.s^{-1}) and 800 m test (swimming speed 1.26 m.s^{-1}) was the performance determination by functional parameters negligible (Fig. 5).

Growing training level and load intensity share in swimming trainings during May and June have brought adaptation changes. These were proved to more determine the performance in all tests evaluating different quality of aerobic abilities. At the end of annual training cycle, during competition period of summer season, functional parameters were best determining the performance in tests, predominantly focused on aerobic abilities. The highest share of functional parameters in the performance determination was in 3 000 m test (swimming speed 1.17 m.s^{-1}), where the LA_{max} share was (62.41 %, value of 4.13 mmol.l^{-1}). Heart rate was best determining the performance in 800 m test (55.65 %, HR 183 bpm, swimming speed 1.29 m.s^{-1}), and 3 000 m test (55.65 %, HR 172 bpm). It had also high share in 1 500 m test (swimming speed 1.25 m.s^{-1}). Lactate descent, which is an indicator of training level of the swimmer, was more significantly determining the performance in 3 000 m test and 1 500 m test (Fig. 6).

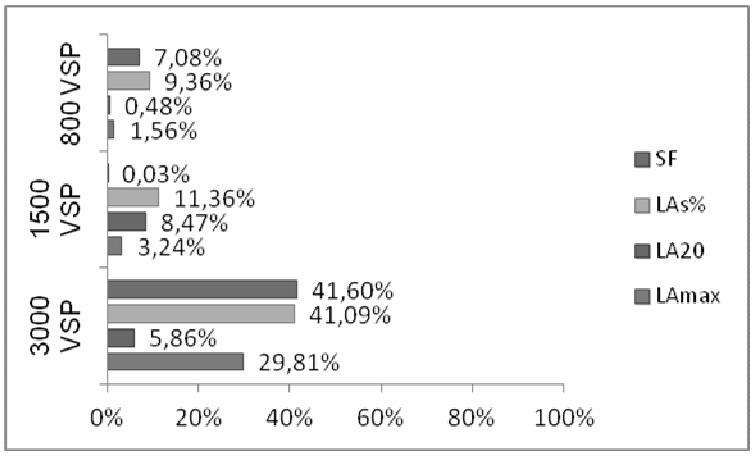

Figure 5

Determination of special tests by functional parameters (4th measurement)

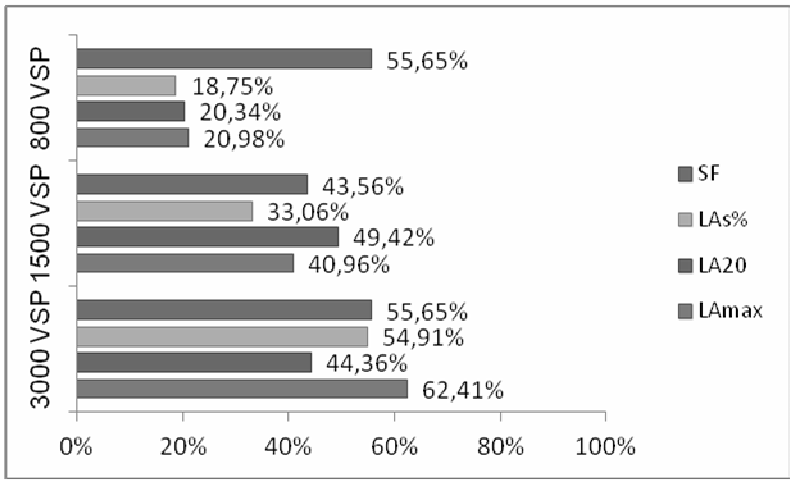

Figure 6

Determination of special tests by functional parameters (5th measurement)

Finishing the analysis of the performance determination in special tests by functional parameters, we have generalized the relation of functional indicators and special tests during the whole annual cycle (Fig. 7). We have found, that the determination degree in 1 500 m and 3 000 m tests by functional parameters is on average level of 25 %. In 800 m test, the determination is on average level of 11 %. The summary is reflecting results from individual measurements. In our set of swimmers, the performance in 800 m test was least determined by functional parameters in all measurements. Functional parameter Maximal lactate was

determining the performance at the highest degree in endurance test of 3 000 m free style (Fig. 7).

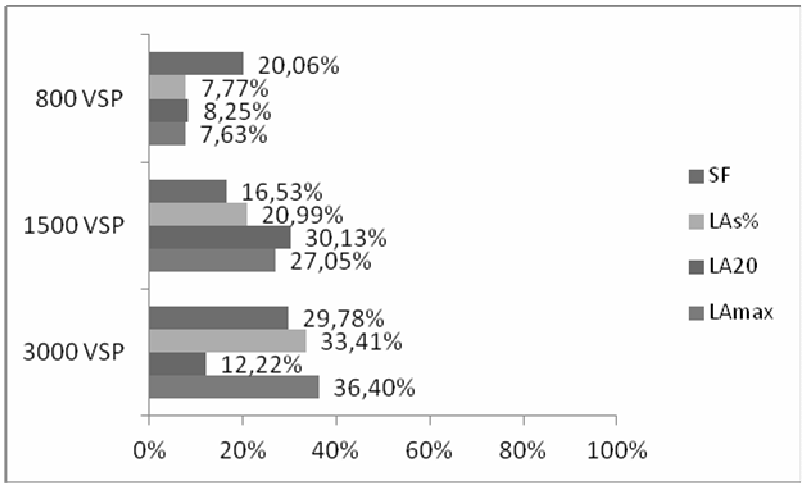

Figure 7

Determination of special tests by functional parameters during the annual preparatory cycle

Percentage degree of determination of sport performance by functional parameters was on the level of 11 % – 25 %. Other significant indicators, determining the sport performance, are efficiency of stroke cycle and dynamic strength.

Based on results describing high determination of performance in endurance tests by the LA_{max} indicator, we want to emphasize, that in 1 500 m and 3 000 m tests, the values of maximal lactate are not a manifestation of anaerobic performance. They represent maximal lactate equilibrium, anaerobic threshold, what explains also the high determination of performance in tests. Higher percentage determination of sport performance was found during competition period of winter (2nd measurement) and summer season (5th measurement).

Different results about the degree of determination of sport performance in individual preparatory periods, expressed by functional parameters in the swimming test, can be generalized as follows. At the higher training level, the functional parameters were determining the sport performance in tests to higher percentage degree. Considering the swimmer's aerobic endurance in their teenage, the most suitable are the 1 500 m and 3 000 m tests. At the specific swimming speed in 3000 m test (with an average speed 1.17 $m.s^{-1}$ in 5 measurements), the LA_{max} parameter values were ranging from 3.86 $mmol.l^{-1}$ to 4.38 $mmol.l^{-1}$. This test is suitable to evaluate the training level close to the anaerobic threshold. In the 1 500 m test, at the average speed of 1.227 $m.s^{-1}$, we have found lactate level ranging from 6.39 $mmol.l^{-1}$ to 7.83 $mmol.l^{-1}$. This test is suitable to evaluate the training level above anaerobic threshold. Higher level of aerobian capacity speeds up lactate removal, which is important during and after the load. The shortest endurance test of 800 m (average swimming speed of 1.28 $m.s^{-1}$,

lactate level ranging from 7.6 mmol.l^{-1} to 10.56 mmol.l^{-1}) is suitable to evaluate and to develop the VO_2max.

It is important to develop the diverse quality of endurance abilities, in spite of its complex nature, but also to evaluate it by diverse load character in term of length and intensity. In sport practice, the trainer is often working with concrete data, which is important to understand in specific circumstances. Higher lactate level at higher average speed in endurance tests during specific preparatory period are a sign of higher swimmer's training level, manifested by the higher ability of the organism to tolerate the lactate. In practice this means, that the closer the swimmer is with their swimming intensity at 1 500 m and 3 000 m distance to the swimming intensity at 800 m without remarkably higher acidosis, the higher is the quality of their "endurance" training level.

Conclusion

The duration of the load is significantly influencing the share of functional parameters in the performance determination in concrete special endurance test. Each of the endurance tests is evaluating different quality of endurance abilities. The 800 m test is evaluating level of VO_2max, the 1 500 m test is evaluating quality of endurance abilities above the anaerobic threshold, and the 3000 m test is evaluating the quality of anaerobic threshold. The highest share in sport performance determination has the La_{max} functional parameter in the 3 000 m and 1 500 m tests, during the competition period of summer and winter season.

References

1. MADSEN, O., LOHBERG, M. 1987. The lowdown on lactates. *Swiming Technique,* 1987, 24, 1, s. 21-26.
2. MASARYKOVA, D. 2008. *Účinnosť obsahu tréningového zaťaženia na športovú výkonnosť plavkýň.* Bratislava : FTVŠ UK, 2008, 96 s. Dizertačná práca.
3. OLBRECHT, J. 2000. *The Science of Winning; Planning, periodizing and optimizing swim training.* Belgium : Luton, 2000, 282 s.
4. PYNE, B. D., GOLDSMITH, M. W. 2005. Training and testing of competitive swimmers. In*: Swimming – Handbook of Sport Medicine and Science*. Blackwell Science Ltd. 2005, s.128-143, ISBN 0-632-05914-1.
5. RUŽBARSKÝ, P., HLAVATÝ, R., PROCHÁZKA, K. 2008. Možnosti diagnostiky aeróbnej kapacity starších žiakov a juniorov v plávaní. In: *O výskume pohybových aktivít vo vodnom prostredí.* Bratislava : Peter Mačura – PEEM, 2008, s. 121 – 127. ISBN 978-80-89197-94-1.
6. RUŽBARSKY, P. 2010. *Závislosť intraindividuálneho adaptačného efektu na štruktúre zaťaženia v plávaní.* Prešov : PU v Prešove FŠ, 2010. 113s. Habilitačná práca.
7. TROUP, J.P. 1999. The physiology and biomechanics of competitive swimming. *Aquatic Sports Injuries and Rehabilitation.* 1999, 18, s. 267-285.
8. ZÁHOREC, J., ROUŠ, J., ŘEZNÍČKOVÁ, M. 1987. Somatická, funkčná a motorická charakteristika vrcholových športovcov v plávaní. In: HAVLÍČEK a kol.: *Športová príprava talentovanej mládeže.* Bratislava: Šport, 1987. s. 278 - 294.
9. WAKAYOSHI, K. et al. 1992. A simple method of determining critical speed as swimming fatigue threshold in competitive swimming. In *International Journal of Sports Medicine* 1992, vol. 13 (5), s.367-371.

10. WELTMAN, A. 1993. *The Blood Lactate Response to Exercise.* Champain : Human Kinetics, 1993, s. 85-92.

RESUMÉ

DETERMINÁCIA ŠPECIÁLNYCH PLAVECKÝCH TESTOV VYBRANÝMI FUNKČNÝMI PARAMETRAMI PLAVCOV

Karel Procházka, Yvetta Macejková, Marián Hrabovský

Príspevok prináša poznatky o determinácii výkonnosti v špeciálnych vytrvalostných testoch v plávaní ukazovateľmi funkčnej odozvy organizmu v súbore plavcov (14 – 17 r., n = 12). V ročnom tréningovom cykle sme v jednotlivých obdobiach prípravy v piatich meraniach hodnotili výkonnosť v špeciálnych vytrvalostných testoch 800 m, 1 500 m, 3 000 m voľný spôsob a funkčnú odozvu organizmu (srdcovú frekvenciu, maximálny laktát, laktát v 20. minúte, laktátový spád). V jednotlivých obdobiach prípravy bola výkonnosť v rozdielnych vytrvalostných testoch diferencovane určovaná funkčnými ukazovateľmi organizmu. Najvyššiu sme zistili v pretekovom období letnej sezóny. Zistili sme, že výkon v testoch 1 500 m a 3 000 m určujú funkčné parametre na úrovni 25 %. Športový výkon v teste 800 m bol vysvetlený funkčnými parametrami na úrovni 11 %. V súťažnom období športový výkon v teste 3 000 m v najvyššej miere určovali maximálny laktát 62,41 %, (LA_{max} hodnota 4.13 $mmol.l^{-1}$, rýchlosť plávania 1.17 $m.s^{-1}$) a srdcová frekvencia 55,65 % (SF 172 bpm).

STUDY OF THE PERCEPTUAL SENSIBILITY IN SPORT

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Summary: This study has as its main object to show the effect of categorization of the configurations of play in Soccer. According to Mervie, Rosch (1981), the category is an organization which makes it possible to gather various physical objects or concepts in the same class. This many make us suppose that the elements (i.e., specimens) of the same category have physical features (perceptual) or conceptual (concept) similarities. The main results of this study show, on the one hand, that the experts acquire a rich person repertory of conceptual knowledge by the practice and the experiment and the other hand, through the process of the activity that facilitates the visual data. This operating process of the expert system reduced considerably the space of research. This generally results in an perceptual sensibility and a rapid cognitive performance.

Keyword: Perceptual Sensibility; Perceptual Categorization; Expert; Sport

Introduction

The capacity of human to recognize tens of thousands of objects appearing in rich and complex environments is probably one of the more surprising. It remains unmatched by the most powerful algorithms developed in artificial vision (Thorpe et al., 1989). Indeed, it appears that the perceptual system may acquire very early selective sensitivity to Visual information to which it is subject. The perceptual system would be a dynamic system that can adapt to the needs and requests of categorization faced by each individual. This effect can be similar to a sensory modulation would be function of the categories in which are organized our knowledge of the world.

According to Goldstone, Barsalou (1998), the data obtained in categorical perception and perceptual learning allow to presume the existence of a continuum between the perceptual and conceptual level. It is important to explain that we are talking about "perceptual categories" and not "semantic categories". Semantics includes all of the information that describes the nature and function of the information in the environment. The perceptual level is only the form of the information. What interests us in this study; it is to show that football players of different levels of expertise are also sensitive to forms of game without taking into account the semantic characteristics.

Methods and Materials

Hypothesis

The task of evocation requires knowledge of a lexical repertoire, characterizing the various systems of game, under a conventional type football concept digital (4-3-3; 4-4-2; 3-5-2) or a directory image, also conventional, when it comes to represent the game in schematic form systems. The fact that non-practitioners do fail where can, might simply mean that this population does not control these lexicons. If that were the case, including where the practice would emerge forms corresponding to the systems, untrained players should be able to recognize these forms and classifies them. We offer the following hypothesis: If the game systems match productions resulting from practice, then, untrained players should be sensitive to the representatives' forms. This, to a greater degree than non-observant and to a lesser extent than the coaches and the players trained.

Participants

Four populations of 12 participants (coaches, players trained, untrained players and non-practitioners) participated in the experience:

Population 1: coaching (CP) in the Division 2 Championship with more than 15 years of practice as footballers and more than 15 years of practice as a coach (mean Age = 43); (SD = 5.6);

Population 2: players trained (PT) engaged in teams of 2, and 3 divisions with more than 15 years of practice (Age = 26); (AND = 3.6);

Population 3: players not trained (PNT) does not practise the football club and having never framed by football experts (Age = 25); (AND = 4.03). Their experiences are a regular practice, at least weekly.

Population 4: non-practitioners (NP), students in architecture and chemistry having never practised collective sports (mean Age = 21); (AND = 1, 3);

This experience was programmed and conducted on a PowerBook G4 Macintosh computer via a program developed in the language (C+). Game configurations were presented on the computer screen. The size of the images on the screen was (32 cm x 21.5 cm) with a resolution of 980 x 750 pixels (width x height). Six types of categories of configurations were used in this second experience.

The five first categories of offensives game systems evoked by the coaches. For each category of game system, five copies were used. Each copy was view outerwear a variant which corresponded to a space of players in attack, the same organization or belonging to the set of reference system. Each copy was thus composed of 10 players' attackers and 10 players' defenders. These configurations were developed from selected by the coach's game systems. To closer to the conditions of game and therefore to increase the informational wealth of conventional schematic stimuli, we replaced the representative cross players by humanoid shapes in 2D, representing players of football via (Mavromatis, et al., 2003) 3D reconstruction software.

The sixth category of coherent attack game configurations to be developed by three coaches did not participate in the first experiment. For this category, each coach was to build five copies of consistent configurations of attack in football (i.e., spatial organization of

players on the ground that respects the rules which govern football in situation of attack activity), but is not a taught game system.

Thus, fifteen copies have been made. Among these configurations, five copies, only were considered as copies typical of offensive configurations corresponding to coherent configurations but cannot let appear the membership to no conventionally taught system have been selected. Total 30 configurations (6 categories * 5 copies) have thus been carried out.

The task proposed to the participants was a perceptual categorization task. The task was to recognize the appropriate label placed bottom of the screen corresponding to the image that appears at the centre of the screen, the faster and more precisely. The participants were to give their answer by a "click" on the appropriate label. Data collection program was used as an interface developed with a (C) language. The labels represented five categories of attack in football game system, conventionally known, form digital (4-3-3; 4-4-2 3-5-2 3-4-3; 3-3-4).

A coherent category of game configurations of type "Other" which does not match any labels characterizing the game system. The experimental set up took place in three phases:

1. Participants begin by familiarize themselves with the material and images by viewing. In this way they have an idea of the type of images they have associates. This familiarization time is left to the discretion of each subject;

2. Subsequently, the participants begin a phase of learning that is, a series of twelve trials whose results are not harvested. This phase allows them to get used to the task;

3. They then pass phase test during which thirty configurations are presented in random order. When the participant associated with the label to an image, a new image appears. The subject will need to categorize the images more quickly and efficiently as possible. We measure the relevance of answers (correct answers) and the response times.

Variables and statistical analysis

For experiment 2 dependent variables are:

- The nature of responses (correct answer %);
- Response time (ms).

The data were processed in several analyses of variance analysis results focused on the effect expertise. The analysis of significant effects was followed by further analysis (post-hoc test). The level of significance was set at $p < 05$ for all of the tests).

Results

The analysis of the percentage of correct answers show a performance of superior categorization in (M = 96 %, and = 3.62) coaches from trained players (M = 92 %, and = 3.62). Similarly the performance of categorization of untrained players (M = 87 %, and = 5.56) is superior to the performance of non-practitioners (M = 67 %, and = 11, 17).

Table 1

Percentage of correct answers and response times in the task of perceptual categorization according to the level of expertise

Population	**CP**	***PT***	***PNT***	***NP***
% Correct Answers	96	92	88	67
Response Time (ms	359	418	516	982

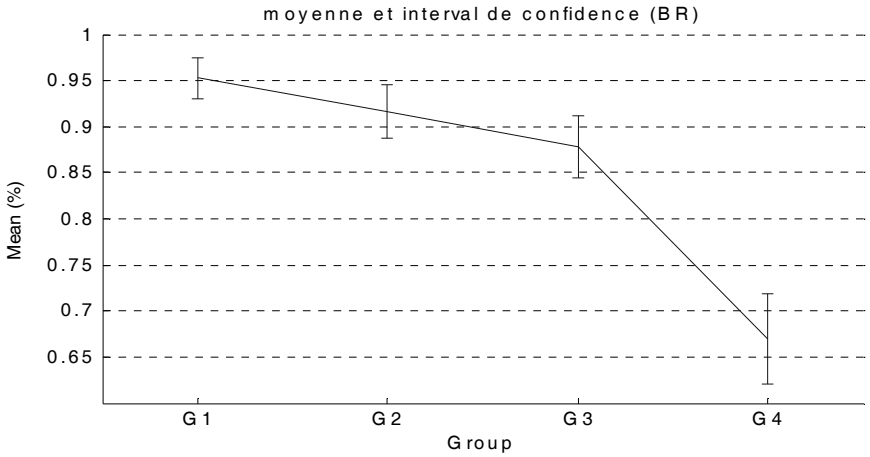

Figure 1

Percentage of good answers according to the level of expertise

The results of the analysis of variance showed a significant effect of the level of expertise [F (3.16) = 38.06, MSe = 68, 78 , p < 0.000]. The supplementary analysis (test Dunett) shows a significant level of expertise between:

- Coaches and players non-trained (p < 0.014);
- Coaches and non-practitioners (p < 0.000);
- Trained players and the non-pratiquants (p < 0.000);
- Players not trained and non-practitioners (p < 0.000);
- However, no significant effect of the level of expertise was revealed between:

  The coaches and players trained (p < 0.252)

  Trained players and players non-trained (p < 0.181);

Average time of responses shows that coaches, the players trained and untrained players have response times of shorter, respectively (M = 359 ms, and = 60.49;) M = 418 ms, and = 80.71; (M = 515 ms, and = 124.19) the average response of non-practitioners (M = 982 ms, and = 278.35) (Figure 2).

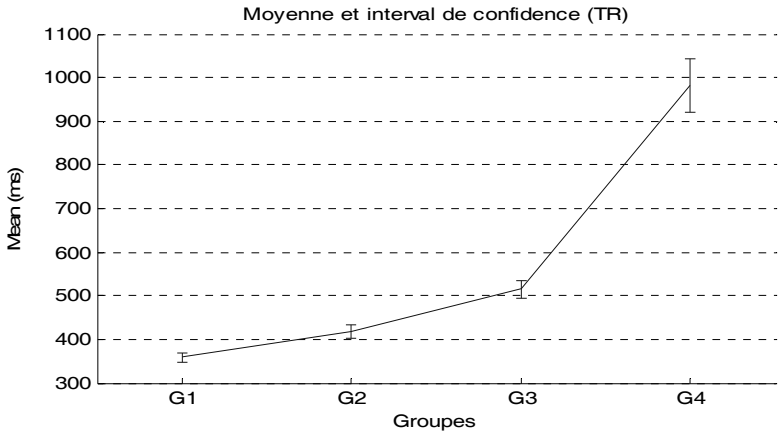

Figure 2

Latency time (ms) responses depending on the level of expertise

The analysis of the variance in response time results show a significant effect of the level of expertise [F (3.16) 214,622, MSe = 3, 654E8, p = < 0.000]. The analysis results show a significant effect between:

- Coaches and non-practitioners ($p < 0.000$);
- The players trained and non-practitioners ($p < 0.000$);
- Non-trained players and the non-pratiquants ($p < 0.000$);
- However, there is no significant effect of the level of expertise
- Between coaches and trained players (P, Lt;.42);
- Coaches and players non-trained ($p < 0.02$);
- Trained players and players non-trained ($p < 0.14$);

Discussion

In categorization, the objective of this study was to investigate the process of perceptual categorization among football players of different levels of expertise. Indeed, in the field of categorization, many works which have defended the idea that the attributes which underlie the categorization process are flexible and that flexibility is guided by these information as well as the category history of the individual (previous knowledge). The phenomenon of categorical perception illustrates this (Goldstone, 1998) interaction between processes of low level (perceptual knowledge) and high-level (conceptual knowledge) process. Moreover, the work related to the study of cognitive expertise widely highlighted the importance for any theory of the expertise of formalizing the interaction between perceptual knowledge and conceptual knowledge. Indeed, one of the few studies in the field of the categorization of sporting scenes (Laurent, et al. 2006) has shown that Visual discrimination of situation of basketball game is done on the basis of category membership. Experts distinguish more easily two different perceptual descriptions when these stimuli belong to different categories.

This perceptual sensitivity facilitates very fast extraction of relevant information of a game situation and rapid access to information which set the boundaries of the category (Goldstone, 1998). Also, different empirical work in the field show that experts have more categories than the novices (French, 2003) and that they have a remarkable ability to categorize natural scenes (Torpe et al., 2001). These authors have shown that 100 to 150 ms of treatment are sufficient to decide whether or not an image that has never been seen previously contains an object. In line with this work, our coaches and trained players results confirm the results achieved in the area of categorization. Indeed, experts are very sensitive to familiar and consistent game configurations.

This sensitivity of experts in their domain familiar information facilitates, the interaction between the perceptual and conceptual knowledge. These, translates into faster and more effective categorization performance. Moreover, results also reveal a performance of the untrained players above the threshold of the chance. This result seems very relevant to us. Indeed, untrained players participating in the activity through free practice, which does not allow the acquisition of a rich repertoire of (declarative) conceptual knowledge as it has been shown in the task of evocation (experiment 1) have become as sensitive as experts to forms of game. This result reflects that the perceptual categorization process is a product of the activity which facilitates the processing of environmental information. In other words, the same free participation in a form of game is enable productions resulting from the practice. This activation leads to identification of a particular shape and its discrimination among a set of game form. However, the results of non-practitioners do not show a perceptual sensitivity to forms of game. Exposure to television retransmissions attests that only practice is essential for the acquisition of perceptual knowledge to facilitate the categorization process.

References

1. FRENCH, K. E., McPHERSON, S. L. 2003. Development of expertise in sport. In M. R. WEISS Ed, *Developmental sport and exercise psychology* : *a lifespan perspective.* Fitness Information technology, 2003, pp.402-423.
2. GOBET, F. 2001. Réseau de discrimination en psychologie : L'exemple de CHREST. *Journal Suisse de psychologie*, 2001, 60, 264-277.
3. GOLDSTONE, R. L. 1998. Apprentissage perceptif. *Annual Review of Psychology*, 1998, 49, pp. 585-612.
4. THORPE, R., et al. 2001. A changing focus in games teaching. In ALMOND, L. Ed. *The place of physical education in schools*. London, 2001.
5. LEMAIRE, P. 1999. *Psychologie cognitive.* Ed de Boeck, 2-3-4, pp. 53-29.
6. MERVIS, ROSCH 1981. Categorization of natural objects. In M. R. ROSENZWEIG , L. W. PORTER Eds., *Annual Review of Psychology, 1999,* Vol. 32.
7. WILLIAMS, M. 2002. Perceptual and cognitive expertise in sport. *The Psychologist*, V15, N°8.
8. WILLIAMS, A., DAVIDS, K., WILLIAMS, J. G. 1999. Perception visuelle et l'action en sport. *Sports Science, Sports Studies psychology,* 1999.

RESUMÉ

SLEDOVANIE PERCEPČNÉHO VNÍMANIA V ŠPORTE

Mohamed Sebbane, Hadj Mohamed Benkazdali

Hlavným cieľom predkladanej štúdie je poukázať na vplyv konfigurovaných kategórií vo futbale. Podľa autorov Mervie a Rosch (1981) termín kategória znamená určitý druh organizácie, ktorá umožňuje zatriediť rôzne predmety alebo pojmy do rovnakej skupiny. Takéto chápanie nás vedie k domnienke, že prvky rovnakej kategórie majú zhodné fyzické vlastnosti. Výsledky štúdie poukazujú najmä na to, že odborníci získavajú potrebné dáta experimentom v praxi, ale na druhej strane ich možno získať aj vizuálne v procese činnosti. Takýto proces expertného systému vo všeobecnosti vedie k rýchlemu poznaniu úrovne percepčného vnímania.

SPORT AND RECREATIONAL FACILITY AQUACITY POPRAD AND VISITORS´ OPINIONS TO ITS SERVICES

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Summary: In our paper we describe the problems of recreational sports facilities. The aim of our research is to obtain knowledge based on opinions of the visitors of Aquacity Poprad, to assess its functionality in recreational sports and to note satisfaction with the services offered. Based on the research results, we present recommendations for correcting services in sport activities. With a questionnaire method we obtained opinions from 120 respondents. Results of the questionnaire document satisfaction with the services and reasons of the visit which were differentiated by gender and sport activities. In the male part of respondents sports activities dominated, for women it was health effect as a decisive element. For active athletes sports activities were crucial, respondents, who do not play any sports it was relaxation effect.

Keywords: recreational sport, management, Aquacity Poprad, motives, visitors´ opinions

Introduction

The concepts of health, physical activity and hypokinesia are closely related and are now increasingly discussed. This issue deserves more attention, as the statistical data and numerous studies warn and point out to unsatisfactory long-lasting health condition of the population. Health is a prerequisite for life quality of individual and society and expresses its positive value as well. One of effective means of retaining health is to initiate people to take part in sport activities and thereby influencing their way of life in a positive way. This is the way how to contribute to the reduction of the incidence of disease in the population (Labudová et al., 2002). This is confirmed by the results of many studies. Non-infectious diseases account for over 70 % of the causes of premature death in our population (www.uvzsr.sk).

The other negative consequences of health population deterioration in the context of the potential of physical activity we can point out to heart and vascular diseases and cerebrovascular diseases, which are dominant diseases of the circulatory system (DCS). Because of severe clinical course and multiple occurrences in a population DCS is the most common cause of death. This is mainly conditioned by high prevalence of the risk factors in population and most of them are preventable. According to the World Health Report (2003), nearly 17 million people worldwide dies because of DCS. From this number the coronary heart diseases (CHD) cause 40 % of deaths, high arterial pressure 20 % and cerebrovascular diseases cause 33 %. Despite the overall effect of higher intervention measures to prevent these

diseases, today more people die of DCS than for all types of tumours. Implications of socio-economic impact of diseases of the circulatory system is extremely important due to reduced quality of life, chronic course and the high cost of long-lasting treatment. The incidence of major risk factors in the Slovak population aged less than 65 years, has been alarming in the last years. World Health Organization said that 60 % of all deaths worldwide and 43 % of all illnesses were caused by non-infectious diseases (www.uvzsr.sk).

Results of CINDY and MONIKA projects document that men in the age group of 25 – 64 years 1/5 is without any risk, and the remaining 4/5 require intervention, primary and preventive care, or treatment. For women in the same age group 1/3 is without the risk and slightly less than men, 2/3 require already mentioned professional care (www.uvzsr.sk). And therefore a significant factor is to provide physical activities as factors preventing these types of diseases and to promote healthy lifestyle (Labudová, 2002). The way of life of the current population can be characterized as predominantly hyperkinetic. Modern science provide us with sufficient evidence that health complications arising from lack of exercise can be prevented by adequate physical activity, properly chosen sports-recreational activities (Hrčka, 2009). Thus realized the choice of physical activities must take into account a lot of factors,: age, gender, previous sports activity, and the level of health. With sufficient frequency and intensity it can be considered at the level of primary and secondary prevention of non-infectious diseases of civilization as well as a contributing factor to the quality of life.

The most natural way to help in solving this difficult problem is to increase physical activity of population through sports and recreation facilities, which should provide services at high professional level to motivate broad range of clients and offer a rich complex of movement, relaxation and regeneration means and appropriate material conditions for the use of various forms of sports and recreational activities for the general population (Hrčka, 2000).

Finally, they could be enriched by counselling the clients aimed at providing information on the positive effects of physical activity on the human body and their potential for correction of already existing diseases.

Characteristics of sports facility which offers services to the general public is important for policy formulation, based on the needs and demands of the market. Thus one of the possible solutions to this problem is cooperation between the local management and sports facilities. Management of sports facilities is a complex process of coordinating work activeties of people in order to perform effectively and efficiently (Antala, 2007).

Sport and recreation facilities should be dominant place in the local area to eliminate the negative factors affecting the health of the general population. But to create this we have to find a suitable bridge between clients and management components to create a basic precondition to change this unfavourable situation. Processes towards the creation of appropriate conditions is not a trivial matter and their efficiency is coordination of many activities and complex planning to ultimately achieve a suitable alternative approach to improving health and lifestyle.

Aim

The aim of our research is to obtain knowledge based on opinions of the visitors of Aquacity Poprad, to assess its functionality in recreational sports and to point out satisfaction with the services offered.

Methodology

The sample was comprised by 120 visitors of Aquacity Poprad facility, 50 % of women and 50 % of men aged 18 – 55 years. Respondents were differentiated by sex and divided them into two main groups; the first group consisted of clients who are recreational athletes, or performance athletes and the second group, those who reported that they do not perform any sport regularly or do not do any sports at all.

The main methods of data collection were: a questionnaire method and study of materials. For the collection of empirical data, we used structured questionnaire with closed and open questions aimed at gathering the views of customers on satisfaction with the services offered and motives (reasons) to visit Aquacity. The data were processed and analyzed using standard mathematical and statistical methods and the results are shown graphically in charts and tables. We used the basic logical method (analysis, synthesis, and comparison). The obtained empirical results have been processed on the level of percentage and relational analysis, and context variables were assessed by chi-square.

Results and discussion

Aquacity Poprad is a leading resort offering world class attractions and many additional services. The company was founded in 2003 near to geothermal well, which has not been examined up to now and its potential has not been properly used. Technology was damaged after years of erosion, and it was necessary to invest considerable funds in this valuable well. The most significant development was in the years 2003 to 2006, when the whole area was built to the present form. Cat present the company is making continuous progress, it won numerous awards and its position in the market is not just an important element of the regional economy, but is also a factor with a high potential to recover their lifestyle – not only for locals. The facility maintains a relatively constant number of annual visits. Progress in it is also used for the benefit of young people, they cooperate with the management of sports clubs in football, hockey and, of course to support the swimmers. Next stage is to build and expand more complex areas. The company has not stopped the construction of the basic complex, it is expanding its field of operation, and it combines comfort with high standards of environmental luxury (Vitková, 2010).

Our research was conducted at two-year intervals. We were interested how the determinants and reasons for the visits in expanding complex change. The question of satisfaction has not significantly altered in both years. The largest percentage of visitors expressed their satisfaction with evaluation "satisfied" (35 %) and "very satisfied" (30 %). 35 % of customers were "less satisfied“. Dissatisfaction was not expressed by any of the respondents. It can be concluded that the level of service has not changed and maintains constant high level, which can be evaluated as a positive factor.

Assessment of satisfaction with services based on gender differences documents significant relation between observed variables ($p \leq 0.10$). Diversity of gender was reflected by higher levels of woman satisfaction compared to men attitudes. Men are more demanding clients, they were more critical in their answers (fig.1).

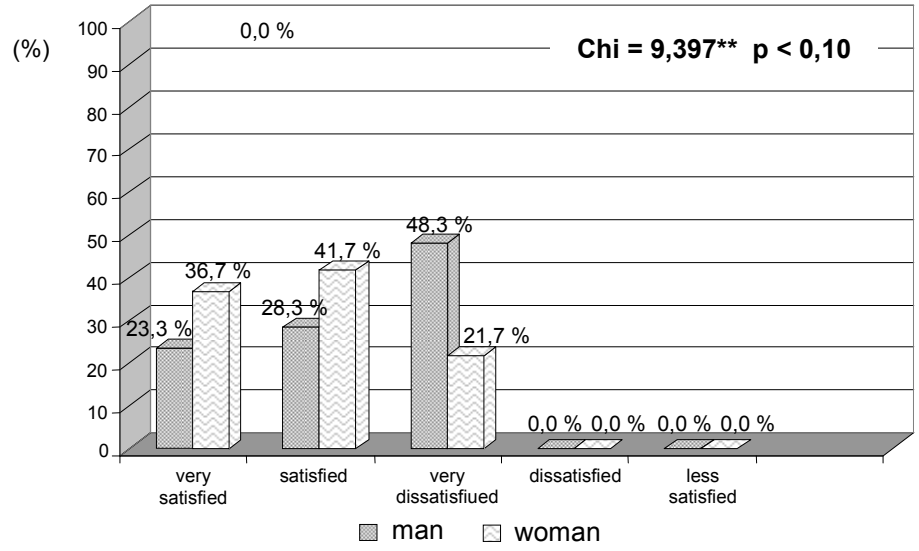

Figure 1

Satisfaction with service *based on gender* differences

In the structure of personal motives in the answers of respondents of the whole file had the largest representation in the file "sports activities", the second major motive of the visit was "health effect", the third most serious cause of respondents´ visit was the "relaxation effect". The frequency of responses can refer to the wide use of facilities to improve the health of visitors, which is pointing to health potential and importance to build sport and recreation facilities. Themes of visits in a time span of two years have not changed. Therefore we can consider that the role of Aquacity remains relatively stable and can contribute to a positive influence of visitors' health (Fig. 2). Analysis of motives to visit facilities Aquacity Poprad according to gender shows significant relation ($p \leq 0.10$). For men, it has the highest percentage of using sports activities, and on the other hand women put at the forefront the health effects.

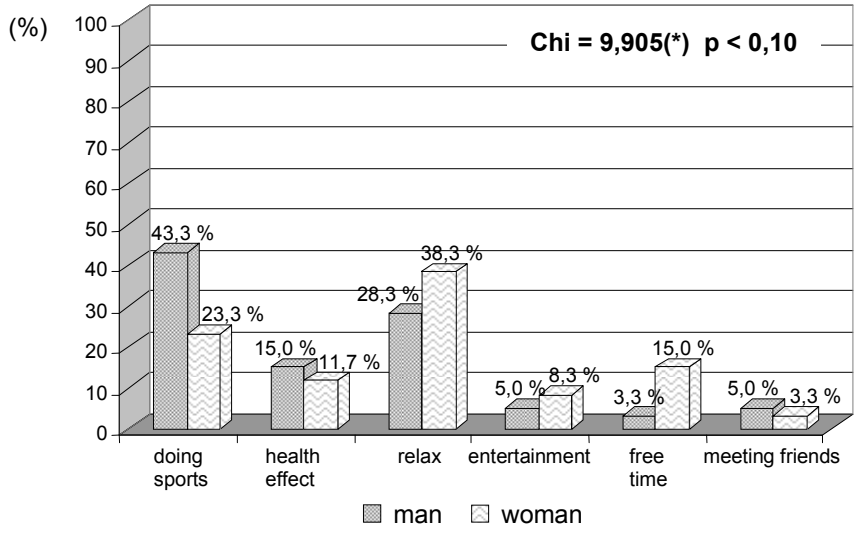

Figure 2

Themes structure based on gender differences

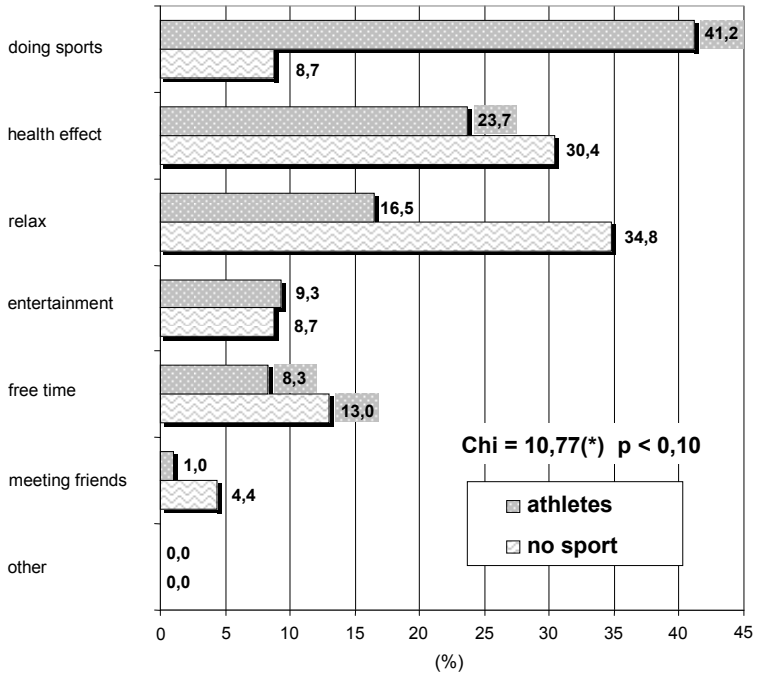

Figure 3

Themes structure based on physical activity

The question of personal motives to go to this centre the people who take active part in sports replied as we supposed. The dominant reason for the visit of Aquacity was to do sports activities (41.2 %) and also the most positive health effects in general, which was listed as the next most common reason (23.7 %). The group of non athletes was interested in relax (34.8 %), but the positive feature in this group was, an important role in the structure and motives of health effect (30.4 %). The largest impulse to go to the centre for non athletes was the opportunity to spend their leisure time effectively (13 %). The fact that the group of non athletes attends sports and recreational facilities is positively assessed. Based on the opinions it can be concluded that the facility Aquacity attracts a wide range of clients, and non athletes as well. It requires promotion aimed at positive effect on their health.

The frequency of visits did not record any change neither after two years – when comparing the results of our previous research (Vitková, 2010). The greatest percentage after two years with a small increase (54.2 % – 57 %) has the group of respondents who attended Aquacity irregularly. In this regard, we have some recommendations to management: we recommend offering benefits to regular customers that ultimately increase the frequency of visits, which should be reflected in regular physical activity and creating opportunity to support and improve the physical activity of visitors.

In the next section we analyze the views on offers. As positive point may be the fact that the majority of visitors (62 %) said that they were not missing any of services. As we have already mentioned, Aquacity offers really wide range of services. However, if it was possible, it would be desirable to extend the range of sporting activities (34 %) and rent sports equipment and sport apparatus (tools) (26 %). An important point is to consider the opinions of visitors (47 %), who are missing the possibility of cooperation with sports instructor and counselling (32 %) when changing kinetic regime, appropriate choice of physical activities in relation to the profession and lifestyle.

Visitors were able to express their criticisms. One of the most obvious disadvantages are prices. Further recommendations were the hygiene and showers quality improvement. Customers also complained about the poor technical condition of saunas. The next demand was to increase the capacity the complex and parking places. Negative views on the size of the storage space in lockers were expressed as well. We have to remember that these "minor" deficiencies may cause barrier to reuse services and visit the water park again.

All requirements were sent to Aquacity Poprad management. We think that it is important to know the negative comments and criticism of the clients. Today's increasingly demanding consumer considers the quality, which is criterion for the use of sports and recreational facilities, and it is necessary to know the opinions and change all deficiencies which were discovered.

Conclusion

Lessons we had learned point to the fact that sports and recreational facilities are an essential part of health care for the population as the highest value and improvement of lifestyle. They offer the opportunity to reach and influence a wide range of consumers, but we must take into account the standard of services offered. That is why our research was focused on the direct consumer needs.

Satisfaction with services has maintained high level within 2-years. "Doing sports" and "health effects" are the most important themes according to sex differentiation and also in the groups of athletes and non athletes. "Relaxation effect" has an important role too, which was the third crucial element. Critical comments were elaborated into proposals and were sent to the management to improve the services.

Since most customers considered the affordability as a problem, we propose to support the frequency of visits by financial advantage. Based on the results obtained, which show lack of services in counselling on selection of appropriate physical and sport activities is recommended to expand services in education, training and guidance on the positive effects of physical activities on the body and prescribing appropriate physical activity. Based on the results obtained we suggest that initiatives in this area have the potential to improve traffic system to sports and recreational facilities and thereby improving physical activity of the visitors.

Our society must be aware of the necessity to develop interest in physical activity in order to create the basis for health care as a lifelong basal condition in the process of creating, maintaining and promoting the health of the population. Sport as a social phenomenon has a significant potential to improve the economic prosperity of the country and improving our way of life. In this context sport and recreational facilities can significantly contribute to improvement healthy lifestyle. We must bear in mind that today‘s demanding consumer is not easy to satisfy and motivate him to move. If it is an incentive to improve physical activity and quality of services, it is necessary to improve it in the face of the opinions of those who are addressed to, in order to optimize and improve the conditions.

References

1. ANTALA, B. 2007. Manažment telovýchovných zariadení. In LABUDOVÁ J. a kol., *Obsahová báza v programe šport a zdravie*. Bratislava : FTVŠ UK, 2007, pp. 51–56.
2. HRČKA, J. 2000. Edukológia športu pre všetkých. In HRČKA J. a kol., *Základy športovej edukológie*. Bratislava : FTVŠ UK, 2000, pp. 36–56.
3. HRČKA, J. 2009. *Kapitoly zo športovej zdravovedy vysokoškoláka* 1. vyd.. Žilina : EDIS – vydavateľstvo Žilinskej university, 2009.
4. LABUDOVÁ, J. 2002. Podiel a možnosti športu pre všetkých pri výchove k zdravému spôsobu života. In TÓTHOVÁ, D. *Zborník 1. konferencie športu pre všetkých: šport pre všetkých a zdravie*. Bratislava : Asociácia športu pre všetkých a zdravie, 2002, pp. 52–61.
5. LABUDOVÁ, J. a kol. 2002. *Šport pre všetkých* 1. vyd. Bratislava : Slovenský zväz rekreačnej telesnej výchovy a športu, 2002.
6. VITKOVÁ, D. 2010. *Aquacity Poprad a rekreačný sport.* Diplomová práca. Bratislava : Univerzita Komenského, Fakulta telesnej výchovy a športu, 2010.
7. http://www.uvzsr.sk/index.php?option=com_content&view=article&id=216:poradenske-centrum-ochrany-a-podpory-zdravia-zakladne-informacie&catid=55:poradenske-centrum-ochrany-a-podpory-zdravia&Itemid=61
8. http://www.uvzsr.sk/docs/info/podpora/NPPOC.pdf

RESUMÉ

ŠPORTOVO-REKREAČNÉ ZARIADENIE AQUACITY POPRAD A NÁZORY NÁVŠTEVNÍKOV NA JEHO ČINNOSŤ

Dominika Vitková, Branislav Antala

V našom príspevku sa zaoberáme problematikou športovo-rekreačných zariadení. Cieľom práce je na základe názorov návštevníkov Aquacity Poprad posúdiť jeho funkčnosť v rámci ponuky rekreačného športu, poukázať na motívy návštevy a spokojnosť s ponúkanými službami. Na základe výsledkov predkladáme odporúčania na korekciu služieb v oblasti športových aktivít. Metódou dotazníka sme získali názory od 120 respondentov. Výsledky dokumentujú spokojnosť so službami a motívy návštevy, ktoré sú diferencované podľa pohlavia a športovej aktivity. U mužov dominovalo športové vyžitie, u žien bol hlavným motívom zdravotný účinok, u nešportujúcich relaxačný účinok pobytu, u športujúcich bol najfrekventovanejší motív športového vyžitia.

THE FUNCTIONAL RESPONSE TO TRAINING AND COMPETITION LOAD IN AEROBIC GYMNASTICS ATHLETES

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Summary: The aim of the study was to identify the functional responses of organism by recording and analysing the heart rates and blood lactate levels of elite female aerobic gymnastics athletes during two training sessions and competition. Six gymnasts were involved in the study (the average age of 19.2 ± 1.1 years, the average body weight of 57.1 ± 4.26 kg, the average body height of 1.66 ± 0.04 m). The necessary information was obtained by the measurement of heart rate and blood lactate levels during the training sessions and competition. Comparison of the training (14.6 ± 0.8 $mM.l^{-1}$) and the competitive (17.3 ± 2.6 $mM.l^{-1}$) format results showed significant differences between the blood lactate concentration ($p \leq 0.05$) in favour of competition load. In the contrary, the differences between the training and competitive mean values of maximal and average heart rates were not statistically significant.

Key words: aerobic gymnastics athletes, training sessions, competition, performance, competitive routine, lactate measurements, heart rate monitoring

Introduction

Aerobic gymnastics, as the youngest and progressively expanding gymnastic sports is defined an aesthetic-technical discipline. Aerobic gymnastics routine involves many traditional aerobic skills and difficulty elements with unique technical and artistic requirements. These skills load the body in a variety of ways. Development of sports performance in aerobic gymnastics requires upper body strength, power, astonishing flexibility, and coordination skills consistent with rational technique of specific aerobic movements and difficulty elements (Tibenská, Kyselovičová, 2005).

Since aerobic gymnastics performance is characterised by the dynamics of movement with fast direction changes over the competition floor, a short-term persistence has the largest representation during the routine. Gymnasts do not perform more than 105 s (duration of the routine differs according to age and competitive category). Thus, in terms of energy requirements on the body the anaerobic dominance is obvious. During the intense training sessions, aerobic gymnasts are asked to perform routines while fatigued. Additionally, they are often asked to find the best compromise among technical effectiveness, safety, and high intensity effort (Sands et al., 2003).

Diagnostics of the workload

Gymnastics specific fitness is foundational for the success and the safety not only of the aerobic gymnasts. The relationship between the level of motor performance and the level of athletes' metabolic response is considered to be an important physiological aspect of sports performance diagnosis. Functional examination assesses the ability to endure the physical load during the athletic activities, and cardiovascular system plays dominant role. Heart rate, as one of the manifestations of cardiac activity, is considered to be one of the most suitable parameters to monitor the workload on the body. In addition, heart rate is well correlated with the load intensity in all physical activities and in this way it is used when testing performance and effort (Komadel, Thurzová, 1994; Hamar, Lipková, 2008).

After a heart rate measurement the blood lactate concentration is the second most commonly monitored parameter. The blood lactate level is given by the ratio between its production mainly of blood elements and muscles and its metabolism process (Vanderka, 2008). Accumulated lactate, acts as the deciding factor leading to premature fatigue and disruption of the intensity of the load. Endurance trained subjects will tend to have lower blood lactate values at any given running speed, or intensity, than untrained subjects; this difference owing partly to better ability to use aerobic metabolism in the trained subjects and a better ability to remove lactate from the circulation (Bielik, 2006).

The concentration of blood lactate very appropriately reflects the range of anaerobic energy metabolism (Heller, 1996) and in addition, provides information about the intensity of the load (Ozturk et al., 1998). One more reason why blood lactate is an important variable to assess is that the hydrogen ions that result from lactate production in the cell are known to cause muscle fatigue via several different mechanisms. An athlete who can perform at high intensities with minimal lactate accumulation in the circulation will be better able to avoid fatigue. On the other hand, during high intensity exercise, the ability to use anaerobic energy systems is very important. Thus, it is not uncommon to find very high maximal blood lactate values in athletes competing in high intensity events (Butios, Tasika, 2007).

The absence of studies related to physiological responses in athletes during aerobic gymnastics competition makes this the first attempt to investigate the different aspects of this relative new gymnastic sport event. Exceptionally, few studies documented particular results related mostly to training load. Selected physiological parameters (heart rate, ECG, and blood pressure have been investigated and monitored recently in the studies of Kyselovičová et al. (1999), Righetti et al. (2003), and Kyselovičová, Tibenská (2007).

Therefore the aim of this study was to identify the functional responses of organism by recording and analysing the heart rates and blood lactate levels of elite female aerobic gymnastics athletes during two training sessions and competition. We assume that the comparison of both indicators should significantly differ in favour of the competitive conditions.

Methods

Six top level aerobic gymnasts were included in the study (the average age of 19.2 ± 1.1 yr, the average body weight of 57.1 ± 4.26 kg, the average body height of 1.66 ± 0.04 m). The gymnasts competed at international (Slovak National Team members, n = 5) or national (n = 1) levels. The necessary information was obtained by the measurement of heart rates

and blood lactate levels during the international competition (National Open Championships) and two training sessions (within 1 week prior to the Championships). The format and content of two training sessions were almost identical and comparable with the competition conditions.

The gymnasts´ heart rates were continuously monitored and recorded during the whole training sessions and competition (included warm up and cool down) using a SUUNTO TEAM PACK sport tester. For the determination of the blood lactate concentration levels, blood samples were collected at the 5th minute of the recovery phase after performing the routine. Before sampling, the sample site was cleaned and treated hygienically, in order to ensure the clearness of the blood samples and to keep hygienic safety. A small incision was then made using a single-use disposable lancet. The blood samples were analyzed immediately with a portable Glucose/Lactate Analyzer ACCUTREND PLUS.

The mean heart rates and blood lactate concentration were determined for each gymnast. The empirical data were analysed and compared using Wilcoxon T-test and Mann-Whitney U-test. The level of statistical significance was set at $p \leq 0.05$.

Results and discussion

Heart rate

Average and maximal heart rates (mean and SD) are shown in *Table 1*. Intraindividual comparison of gymnasts maximal heart rates (reached at the end of the routine) showed significant differences in 4 gymnasts between the *training session 1* and the *competition*, respectively. Individual routine performances during the National Championship event resulted in higher heart rate values (mean = 179.0 ± 5.7 b.min^{-1}). The identical trend is visible between the individual average heart rate values. No statistically significant differences between mean values of either maximal or average heart rates during the whole sessions were found. However, four gymnasts have achieved the higher average heart rate values in the competitive conditions comparing to training (session 1 or 2).

Table 1

Comparison of aerobic gymnasts (AGy) individual heart rate values (average = HR_{avg} and maximum = HR_{max}) under different conditions (mean ± SD are presented)

	Average and Maximum HR [b.min.$^{-1}$]					
	Training 1		**Training 2**		**Competition**	
	HR_{avg}	**HR_{max}**	**HR_{avg}**	**HR_{max}**	**HR_{avg}**	**HR_{max}**
AGy 1	137.8±31.1	193.0	140.0±37.3	182.0	125.4±18.9	179.0*
AGy 2	115.7±25.7	157.0	110.6±32.9	184.0	114.0±26.4	177.0*
AGy 3	111.8±30.9	168.0	118.3±24.5	167.0	138.1±28.5*	188.0*
AGy 4	120.0±26.7	181.0	124.9±30.3	188.0	138.1±20.9*	188.0
AGy 5	118.9±32.9	168.0	120.9±27.5	169.0	121.5±24.6*	177.0
AGy 6	110.6±30.6	170.0	128.9±27.6	187.0	128.0±27.8*	182.0*
Mean ±SD	120.5±9.2	172.8±12.5	124.0±9.9	179.7±8.9	123.3±9.3	179±0.0*

*$p \leq 0.05$ (*vs. Training session 1*)

Since aerobic gymnastics performance is characterised by the dynamics of movement with fast direction changes over the competition floor, it is difficult to interpret heart rate energetic significance because of the lack of a steady state condition in the performance, and the short duration of the routines (1min. 30 s).

Blood lactate concentration

Due to the length and intensity of the competition routine aerobic gymnasts demonstrated an increase concentration of blood lactate during and following routine performance. Blood lactate values varied between the measurements. Comparison of two different conditions showed the high blood lactate concentration at both format *(Figure 1).* The differences between the *competition values* (17.3 ± 2.6 $mM.l^{-1)}$ were significantly higher ($p \leq 0.5$) than *training 1 and training 2* sessions' averages (14.6 ± 0.8 $mM.l^{-1}$ and 14.7±2.0 $mM.l^{-1,}$ respectively).

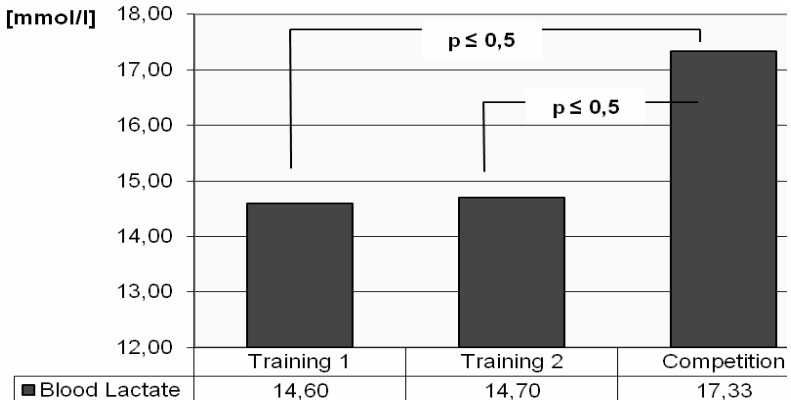

Figure 1

Blood lactate evaluation under training and competitive conditions (mean values are presented).

In addition, inter individual comparison of the blood lactate levels shows a range between the highest individual blood lactate concentration of 20.2 $mM.l^{-1}$, observed during the competitive format, and 14.0 $mM.l^{-1}$, detected in training session. Such values document clear anaerobic dominance and anaerobic energy metabolism during the investigation of aerobic gymnastics routine performance.

Higher levels of lactate may be indicative of higher energy output and increased intensity of performance (Bar-Or et al., 1980; Olbrecht, 2000). High performance is correlated to high blood and muscular lactate value during intense anaerobic exercises. Indeed, lactate production depends on age, diet, training characteristics, intensity of activities, and level of fitness (Yoshida, 1986; Gaesser and Poole, 1988; Gaul et al., 1995; Tolfrey and Armstrong, 1995;). Blood lactate values of the aerobic gymnastics routine were comparable with artistic gymnastics different events found in the recent literature (Montpetit et al., 1976; Goswami and Gupta, 1998; Lechevalier et al., 1999; Rodríguez et al. 1999).

We expected that the values of both indicators, heart rates and blood lactate concentrations, should be statistically higher under the competitive conditions. However, because of the lack of similar investigations in aerobic gymnastics it is quite difficult to compare and analyse the obtained empirical data. We were notable to find any relevant studies on the blood lactate level of competitive conditions, particularly.

Conclusion

Monitoring functional response of the organism to training and competition load in aerobic gymnastics should contribute to the empirical knowledge and information that leads to improvement of the training process in such relative young sport. Since our measurements to that extent were carried out for the first time in the Slovak Republic, it is very difficult to compare the obtained data with the results of other investigations.

Therefore, it is necessary to follow similar scientific studies that will document the concrete and accurate data. Despite of many limitations, we confirmed the physiological demands of aerobic gymnastics routine in order to provide specific information for further design and better evaluated training.

References

1. BAR-OR, O., DOTAN, R., INBAR, O., ROTHSTEIN, A., KARLSSON, J., TESCH, P. 1980. Anaerobic capacity and muscle fiber type distribution in man. *Int. J. of Sports Med.* 1, 82-85.
2. BIELIK, V. 2006. Laktát – významný medziprodukt látkovej premeny. In *Telesná výchova a šport.* roč.16, 2006, č. 1, s. 29-31.
3. BUTIOS S, TASIKA N. 2007. Changes in heart rate and blood lactate concentration as intensity parameters during simulated Taekwondo competition. *J Sports Med Phys Fitness.* Jun; 47(2): 179-85.
4. GAESSER, G. A., POOLE, D. C. 1988. Blood lactate during exercise: Time course of training adaptation in humans. *Int. J. of Sports Med*. 9, 284-288.
5. GAUL, C. A., DOCHERTY, D., CICCHINI, R. 1995. Differences in anaerobic performance between boys and men. *Int. J. of Sports Med*. 16(7), 451-455.
6. GOSWAMI, A., AND GUPTA, S. 1998. Cardiovascular stress and lactate formation during gymnastic routines. *J. sports Med. Physical. Fitness*. 38, 317-322.
7. HAMAR, D. 1989. Všetko o behu – zdravotné aspekty, výživa a možnosti rekreačného bežca. 1. vyd. Bratislava : Šport, 1989. 203 s.
8. HAMAR, D., Lipková, J. 2008. *Fyziológia telesných cvičení*. 4. vyd. Bratislava : Univerzita Komenského, 2008. 173 s.
9. KOMADEL, Ľ., THURZOVÁ, E. 1994. *Telovýchovné lekárstvo*. Regenerácia a športová masáž. 1. vyd. Bratislava : Univerzita Komenského, 1994. 112 s.
10. KYSELOVIČOVÁ, O. 1999. Zmeny srdcovej frekvencie a EKG v špecifických podmienkach tréningového procesu športového aerobiku. In *Acta Facultatis Educations Physicae Universitatis Comenianae,* 1999. s.177-184.
11. KYSELOVIČOVÁ, O., TIBENSKÁ, M. 2007. Využitie pulzovej frekvencie pri hodnotení zaťaženia počas tréningovej jednotky športového aerobiku v špeciálnej etape prípravy na MS. In *Optimalizácia zaťaženia v telesnej a športovej výchove*, 2007, s. 113-118.
12. LECHEVALIER, J. M., ORIGAS, M., STEIN, J. F., FRAISSE, F., BARBIERIE, L., MERMET, P., THOULÉ, B., COLOMBO, C., FRIEMEL, F., AND JEMNI, M. 1999. Comparaison de 3 séances

d'entraînement-type chez des gymnastes espoirs: Confrontation avec les valeurs du métabolisme enregistrées en laboratoire. *Gym Technic*. 27, 24-31.

13. MONTPETIT, R. 1976. Physiology of gymnastics. In J. H. SALMELA (Eds.), *The advanced study of gymnastic*. Springfield : C. Thomas Publisher, pp. 183-214.
14. OLBRECHT, J. 2000. *The science of winning*. Swimshop, Lutton, England.
15. RODRÍGUEZ, F. A., MARINA, M., AND BOUCHARIN, E. 1999. Physiological demands of women's competitive gymnastic routines. *4th Annual Congress of the European College of Sport Science*. (pp. 430). Rome.
16. SANDS, B., CAINE, D. J., BORMS, J. 2003. Scientific Aspects of Gymnastics. *Medicine and Sports Science*, Vol. 45.
17. TIBENSKÁ, M., KYSELOVIČOVÁ, O. 2005. Úroveň a zmeny vybraných motorických parametrov pretekárok športového aerobiku v ročnom tréningovom cykle. In *Telesná výchova a šport,* roč. 15, 2005, č.3 - 4, s.33-38.
18. TOLFREY, K., ARMSTRONG, N. (1995). Child-adult differences in whole blood lactate responses to incremental treadmill exercise. *British J. of Sports Med.* 29(3), 196-199.
19. VANDERKA, M. 2008. *Silové a rýchlostno-silové schopnosti v kondičnej príprave športovcov*. Bratislava : Fakulta telesnej výchovy a športu UK, 54-56 s.
20. YOSHIDA, T. 1986. Effect of dietary modifications on anaerobic threshold. *Sports Med. 3*, 4-9.

RESUMÉ

FUNKČNÁ ODOZVA ORGANIZMU NA TRÉNINGOVÉ A SÚŤAŽNÉ ZAŤAŽENIE V ŠPORTOVOM AEROBIKU

Oľga Kyselovičová, Karina Danielová

Cieľom štúdie bolo rozšíriť poznatky o zaťažení organizmu pretekárok v športovom aerobiku prostredníctvom sledovania srdcovej frekvencie a koncentrácie hladiny laktátu v krvi počas súťažnej zostavy, a to v podmienkach súťaže a tréningu. Výskumu sa zúčastnilo šesť vrcholových športovkýň, 5 bolo zaradených do reprezentácie SR v športovom aerobiku (priemerný vek 19,2 ± 1,1 roka, priemerná hmotnosť 57,1 ± 4,26 kg, priemerná telesná výška 1,66 ± 0,04 m). Potrebné údaje sme získavali prostredníctvom meraní pulzovej frekvencie a hladiny laktátu v krvi v tréningových a v súťažných podmienkach. Porovnaním výsledkov hladiny laktátu v krvi v tréningu a v súťaži sme zistili štatisticky významné rozdiely medzi koncentráciou laktátu v krvi ($p \leq 0,05$) v prospech súťažného zaťaženia. Naopak, rozdiely priemerných hodnôt a maximálnej srdcovej frekvencie neboli štatisticky významné.

INFLUENCE OF STRENGTH WORKOUT PROGRAM FOR DEVELOPMENT OF STRENGTH ABILITIES WITHIN SCHOOL PHYSICAL EDUCATION

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Summary: The objective of the study was to demonstrate the positive impact of body strength workout program on the development of strength abilities at middle school aged girl (11 – 12 years). During the twelve weeks on selected group of girls (N=31) has been applied an exercise program, which included a diagnosis of power abilities. The results of this pilot study show that the inclusion of regular ten-workout program in school physical education has a positive effect on the level of the strength abilities of girls 6-grade. The program is most useful in the context of thematic whole gymnastics.

Key words: physical education, artistic gymnastics, strength abilities, gymnastic skills.

Introduction

Gymnastics is included in the curriculum of physical education at all school levels, in the scope corresponding to the possibilities of school teaching. Low physical fitness, caused by insufficient exercise load and the level of strength abilities of most school youth does not allow acquiring the contents of gymnastics in school physical education. It is well known that additionally to strength abilities, also further exercise abilities like agility, speed and endurance are important to perform the relevant exercises. But strength abilities are included among the limiting factors.

The sensitive period of girls for the development of dynamic-strength abilities takes place at 11 – 12 years of age and for that of speed-strength abilities at 7 – 11 and 13 – 14 years of age (Guželovskij, 1985, in Havel, Hnízdil, et al., 2009). According to Bukač (2008), the period of "growth spurt" is most convenient period for the development of muscle strength of girls. If strength is not developed, it slowly grows weaker and fades away after 6 – 10 weeks. Guz (2009) demonstrated that strength training respecting the individual's age and development has influence on the development of endurance and of functional body systems and that it should be included in childhood already, as well as in the period of adolescence. As they write Máček, Radvanský (2011), the results of strength training are lower before puberty than after. Yet at the age of 12 – 13 years was an increase in muscle strength due properly conducted resistance training for 13 to 30 %. Specialized literature pays great attention to the development of strength. The strength training for children is based on

general rules and principles for strength workout, described for example by Kalabis (1997); Perič (2004); Tvrdá-Gottvaldová, Gottvald, Tománková (2005); Willardson (2007); Grasgruber, Cacek (2008); Dovalil a kol. (2009); Tlapák (2010); Hamar, Kampmiller (2009); Buben (2012) and others.

Our goal was to find out whether it is possible to affect the level of strength abilities by applying a strength workout program in the lessons of compulsory physical education of 6th grade girl and thus possibly enable them to reach better gymnastic skills. When putting together the program, we based our work on the studies published by Proskurov (2011) who tested 15-minute jogging in the course of 19 hours of physical preparation within school physical education and by Hatiar (1997) who recommended performing of 5 – 6 minute fitness training during the whole school year in each physical education (PE) lesson to improve the exercise performance of the pupils.

The objective of the study was demonstrating the positive impact of the workout program within the school physical education on the development of strength abilities in girls middle school age (11-12 years). In connection with the goal set, we formulated the following hypothesis of the work.

H1: Due to integration of strength workout program into the lessons of compulsory physical education, the level of the observed strength abilities of 6-grade girls will significantly increase.

H2: Due to integration of strength workout program into the lessons of compulsory physical education there is a significant increase in the rate of improvement in the monitored strength abilities of girls aged 11 – 12 years.

Methodology

Research strategy

The research was focused on the level of efficiency of the development of strength abilities through strength workout program (P_E) integrated into lessons of physical education at elementary schools during a twelve-week cycle (Δt). Therefore it was approached as a pilot two-group pedagogical experiment with parallel arrangement (Figure 1). The influence of the above stated workout program was assessed based on the results achieved by the girls in motor tests (MT) at the beginning (t_0) and at the end (t_1) of the intervention.

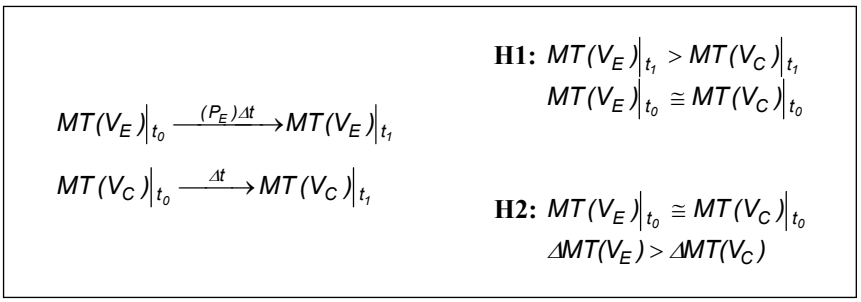

Figure 1

Diagrammatic expression of the research situation and hypotheses

Legend: E – experimental group, C – control group, $MT(V_i)\big|_{t_j}$ – results level in motor test reached by selection Vi *at time* t_j, $\Delta MT(V_i)$ – difference in results level in motor test at time t_0 and t_1 reached by selection V_i ($\Delta MT(V_i) = MT(V_i)\big|_{t_1} - MT(V_i)\big|_{t_0}$).

Characteristics of the set

The research sample consisted of 61 girls aged 11 – 12 year of birth 1998 – 1999. The research took place from September of school year 2010/2011 at three elementary schools of Liberec Region, with focus on 6-grade girls. Girls have been divided by deliberate choice (by classes) into experimental (V_E) and control (V_C) group. All girls have been taken their basic anthropometric parameters at the beginning and at the end of the experiment (Table 1).

Table 1

Anthropometric parameters

	Experimental group (N_E = 31)						**Control group** (N_C = 30)					
	Height (cm)		**Weight** (kg)		**BMI** (kg.m^{-2})		**Height** (cm)		**Weight** (kg)		**BMI** (kg.m^{-2})	
	t_0	t_1	t_0	t_1	t_0	t_1	t_0	t_1	t_0	t_1	t_0	t_1
$\bar{X}$	157.5	159.4	43.8	44.8	17.6	17.6	157.5	159.4	44.9	45.8	18.1	18.0
σ	7.5	8.1	8.4	8.4	3.1	3.1	5.1	5.6	8.5	8.6	3.2	3.2
X_{med}	158.0	159.0	42.4	43.5	16.9	16.8	157.5	159.5	43.3	44.4	17.7	17.6
$X_{\min}$	139.0	140.0	32.5	33.5	14.2	14.3	148.0	149.0	35.0	35.8	14.8	15.3
$X_{\max}$	179.0	181.0	72.2	72.7	30.1	29.9	169.0	171.0	70.2	71.2	28.9	28.5

Legend: $\bar{X}$ – arithmetic average, σ – standard deviation, X_{med} – median, X_{min} – minimum, X_{max} – maximum

When comparing both groups, it can be stated that the experimental and control group does not differ significantly in the observed anthropometrical parameters at the beginning and at the end of the experiment. The difference between the groups is statistically inconclusive at □ < 0,05 significance level. The same can be stated also from the perspective of factual significance where the greatest effect in inter-group comparison was recorded for the output BMI (d = 0,24*). Both groups experienced average growth of body height and weight between the test and retest, which can be attributed to their natural development.

Experimental factor and evaluation of its efficiency

The experimental group, in contrast to the control group, had strength workout program included into the last 10 minutes of regular physical education lessons for a period of 12 weeks (24 lessons). The physical education lessons of all girls took place, except for the intervention program, according to the current plan of the relevant school and it was led by the relevant teacher during the whole period.

Table 2

Structure of strength exercises program

Week	Teaching aids	Description (number of repetition)
1.	Climbing pole, jump rope	Climbing (1x), „wheelbarrow“ (1x25 m), rope jumps with legs together (2x25), squat down - lying – squat down – jump (10x).
2.	Climbing pole	Climbing (1x), „wheelbarrow“ (1x25 m, „frog jumps (1x25m), „crayfish run“ (1x25 m).
3.	None	Squat down-„clap hands under the legs(2x10), front-support-arms back with half turn (2x10), „pendulum“ (2x5), press-up-kneeling position (2x10), sitting hands in the back-right/left elbow touches by turns right/left knee (2x15), prone position hands in the back-trunk bends back (2x15), squat down-front support-squat down-stand (2x5), backwards push-ups (2x10).
4.	Medicine ball, pad 30 – 40 cm, stop-watch	Push up with hands clap (2x5), front support – roll the medicine ball (2x10), front support change arm position (2x10), front support-turnabout 360^0 lengthwise right and left (2x10), front support-360^0 turnabout the legs (2x right/left), „crayfish“ move forward (1x 25 m), sit raise the arms-legs forwards right/left both (2x5).
5.	Ball, pad 70 – 80 cm, jump-rope, wall bars, climbing pole	Climbing (1x), rope jumps with legs together (2x25), wall bars front support – hands to the wall bars (2x5), squat down-take off to standing (2x15),handstand – walking on the hands from and to the wall bars (3x), bend forward over the pad, hands on the floor-leg backward to standing right/left. (2x5), wall bars hanging position-cycling imitation (2x8), bend left/right by turns. (2x10), medicine ball passing in couples (2*x*8).
6.	Balls, wall bars, stop-watch	Wall bars hanging position – legs forwards (2x10), prone position, hands on the front-trunk bends backwards (2x15), sit-up (2x12), From squat down to balanced element on arms(2x10), sit legs forward-ball on the belly-holding position (2x20), stand-squat down-laying-squat down-stand-squat down-push up-squat down-stand (2x8), front support-hands up left/right. (2x8), handstand on the wall bars at hips level-move hips away from wall bars and back (2x10)
7.	Climbing pole**,** jump-rope, stop watch	Climbing (1x), jump-rope with legs together (2x25), „Wheelbarrows“ (1x25 m), „frog jumps“ (1x25m), „crayfish run“ (1x25 m), stand-squat down-laying-squat down – stand (10x), ladies push-ups (2x10), sit-up (2x15).
8.	None	Squat down-front support-squat down-stand (2x10), front support-arms back with half turn (2x15), Squat down-„clap hands under the legs (2x15), prone position hands on the front-trunk bends backward (2x15), „pendulum“ (2x7), sit hands in the back-right/left elbow touches by turn right/left knee (2x15), push-up to kneeling (2x10), backwards push up (2x10).
9.	Stop watch, pads, medicine balls	„bump position“ (2x20s), front support-passing the medicine ball (2x15), „crayfish run“ forward (1x25 m), „crayfish run“ backwards- medicine ball on the bally (1x25 m), „wheelbarrow“ on the forearm on the pad-forward/backwards (1x25 m), „wheelbarrows“ in the pres sup on the pad-forwards/backwards (1x25 m),
10.	Climbing pole**,** jump rope	Climbing (2x), prone position hands in the back-trunk bends (2x15), lying – arms up - sit (25x), front support-turn 180^0 lengthwise left/right -back (2x10), squat down-lying-squat down-stand (2x10), ladies push-ups (2x10), handstand facing/back to the support (2x5s)
11.	pads 70 – 80 cm, stop-watch, jump rope	Front support-right/left arm up (2x8), „pendulum“ (2x10), „bump position (2x20s), lying arms up-arms and legs lift up above the pad by 10 cm (2x20s),handstand walk from and to the wall bars (5x), bend forward over the pad, hands on the floor – leg backward to standing right/left (2x10), jump rope with legs together (2x25), push up to kneeling (2x10).
12.	Wall bars	Squat down-„clap hands under the legs (2x15), lying-„candle position-feet Bering the head - lying (2x8), prone position hands on the front-trunk bends backwards (2x15), ladies push ups (2x10), front support-hand over hand forward (1x25m), handstand-walk from and to the wall bars-handstand 5 s (2x3), hanging position on the wall bars-legs up (2x10), climbing (2x).

Table 3

Motor tests

Test	Description	Source
T1: **Endurance in chin (pull-up)**	***Characteristic:*** Tests static and endurance-strength capabilities of the upper extremities and shoulder girdle	Eurofyt Unifittest (6-60)
	Execution: Proband steps up at elevated pad, grips the horizontal bar under-hand at shoulder width, takes the chin-up position so that the chin is above the bar. Moves up feet from the pad and remains in the position as long as possible..	
	Evaluation: Endurance time is measured in seconds. Test ends when the proband chin touches the pole or gets below it.	
T2: **Backward bend lying on belly**	***Characteristic:*** We test the strength and mobility of the trunk extensors and flexibility of the spine	Fitnessgram
	Execution: Proband takes basic position at flat pad in the gym, lying on the belly, holds arms close to the body with palms up. Performs bent backward from this position by slowly moving as high above the surface to a maximum height of 30 cm. Higher values are not desirable due to the high pressure on the intervertebral discs. Reached position must kept by the proband during measuring the height of the chin pad.	
	Evaluation: 2 attempts are performed, the better ones is taken into account. Results are measured by a ruler in cm and are determinated by the distance between the floor and the chin	
T3: **Sit-up**	***Characteristic:*** Test dynamic and endurance strength capabilities of abdo-minal flexor and lumbar-hip-thigh flexors.	Unifittest (6-60)
	Execution: Proband takes the initial position- laying with bent legs, hands under heads, elbows touch the pad. The second of the pair holds his feet firmly on the grand. On command performs a smooth transition from a lying to a sitting position, with no reflection from the ground, with a touch of elbows on his knees and return to starting position	
	Evaluation: Test is performed as quickly as possible for 1 minute and the number of complete and correct test is taken into account.	
T4: **Jump (vertical jump)**	***Characteristic:*** Test the strength explosive ability of legs.	By Neumanna (2003)
	Execution: Fix on the wall a centimeter scale of where the smallest girl can reach. Subsequently ends of 2nd till 5th fingers are lubricated by magnesia. She comes to the wall, stands on full feet, raises arm and pull lit upwards and marks the place on the wall where she reaches. Then she withdraws from the wall by 10-15 cm. Bends knee slightly, takes off with closed legs and swings arms and marks the place with highest point of reach.	
	Evaluation: It measures the difference (in centimeters) between the height of touch while standing on the grand and the jump. Counted are the best 3 attempts.	
T5: **Long jump from place**	***Characteristic:*** Tests dynamic explosive strengths ability of lower limbs.	Eurofyt Unifittest (6-60)
	Execution: Proband stood with toes close to the reflection line in slightly wide stand. Bends knee, swings arms and jumps forward with closed legs as far as possible. After landing on the feet remains standing. Measure the distance from the reflective line to the heel touch, which is closest to the line of reflection.	
	Evaluation: Recorded is the best of 3 attempts. Performance is measured in cm.	
T6: **Climbing**	***Characteristic:*** Tests muscle strength and endurance of arm flexors and muscles of shoulder girdle and lower limbs adductors	From www.sportival.cz (2012)
	Execution: Proband grabs the bar standing approximately 1,5 m above the grand and climbs with the leg-grab up to 4,5 m.	
	Evaluation: Measured is the time necessary to reach 4,5 m	

The exercise program (Table 2) was composed, with regard to the gymnastic focus of the whole experiment, in order to develop the strength abilities of the muscles and the inter-muscular coordination of the whole locomotive system. A methodical card was created for the teachers for every week. It included a schematic drawing, a description with terminology, the duration of the load, the number of repetitions and the material technical provision. Further, it included didactic styles, the methodical-organizational form and the didactic method. Preparatory exercises were created for individuals and for pairs of girls.

To evaluate the efficiency of the intervention program, motor tests (Table 3) were chosen to diagnose all girls at the beginning and at the end of the experiment. The tests were chosen from the Eurofit, Unifittest and Fitnessgram test batteries as well as from other sources. It is possible to find also the relevant standards of performance evaluation by the relevant sources.

Methods of statistical evaluation

In statistic processing, the exploratory data analysis was performed and the data normality was verified Shapiro-Wilk W-test. To assess the differences between the groups, we used either parametric tests (pair t-test, t-test for two independent sets) or non-parametric tests (Wilcox pair test, Mann-Whitney U-test). For interpretation of differences between the sets, we chose the level of statistic significance of $p < 0,05$. The results of statistical test are shown in tabs as achieved significance level, so called p-value (p). The following scale was chosen for evaluation of the effect level: $p > 0,05$ no effect; $0,05 \geq p > 0,01$ little effect*; $0,01 \geq p > 0,001$ medium effect**t; $p \leq 0,001$ big effect***.

Further, the factual significance level of the difference between the observed sets was assessed. Within 1 group the change between test and retest with a size of at least 1x multiple of determinative deviation of the control set was considered factually significant. To assess the factual significance level between the control and experimental level, so called Cohen's d was used for parametrical data.

The following scale was chosen for evaluation of the effect level: $d \leq 0,2$ no effect; $0,2 < d \leq 0,5$ little effect*, $0,5 < d \leq 0,8$ medium effect** and $d > 0,8$ big effect*** (Cohen, 1992). For non-parametric data, we performed the GCLESS (generalization of common language effect size) effect testing, which is marked with letter A in the charts. Effect A acquires values of 0 – 1; the higher the effect, the higher the significance of the phenomenon observed (Ruscio, 2008). The measured data were processed in the STATISTICA Cz, version 9.0 and MS Excel 2007 programs.

Results and discussion

The following charts include summaries of the results of the experimental investigation. Table 4 applies to verification of hypothesis H1; Table 5 applies to hypothesis H2. In both cases, it was necessary, in order to preserve the methodological cleanness of the experiment, to verify the initial mutual homogeneity of the experimental and control groups ($MT(V_E)\big|_{t_0} \cong MT(V_C)\big|_{t_0}$). The result shows that, except for test T4, the groups did not show mutual difference higher than low simultaneously in statistical and factual significance level in time t_0. Test T4 shows low difference according to p-value and medium difference according to d-effect. It is therefore questionable whether this test can be considered statistically convincing.

Table 4

Comparison of observed motor skills level in experimental and control group

Test	Group	Time	$\bar{X} \pm \sigma$ /unit/ X_{med} (X_{min} - X_{max})	$MT(V_E)\|_{t_0} \cong MT(V_C)\|_{t_0}$			$MT(V_E)\|_{t_1} > MT(V_C)\|_{t_1}$			H1
				p	*d*	*A*	*p*	*d*	*A*	
T1	V_E	t_0	9,3 ± 9,2 s 6,7 (0,0 – 35,4)	0,230	0,36*	0,59	0,117	0,43*	0,62	**N**
		t_1	12,9 ± 9,7 s 11,3 (0,0 – 36,5)							
	V_C	t_0	6,3 ± 6,9 s 5,1 (0,0 – 26,4)							
		t_1	9,0 ± 8,0 s 7,1 (0,0 – 36,2)							
T2	V_E	t_0	24,3 ± 3,8 cm 24,5 (15,0 -30,0)	0,131	0,40*	–	0,948	0,02	–	**N**
		t_1	26,0 ± 3,8 cm 26,0 (20,0 – 33,0)							
	V_C	t_0	25,9 ± 4,3 cm 25,0 (19,0 – 34,0)							
		t_1	26,1 ± 4,2 cm 25,5 (19,0 – 34,0)							
T3	V_E	t_0	34,3 ± 3,2 34,0 (28,0 – 40,0)	0,954	0,15	0,50	0,286	0,29*	–	**N**
		t_1	37,0 ± 5,6 36,5 (27,0 - 51,0)							
	V_C	t_0	33,1 ± 9,9 35,0 (6,0 - 50,0)							
		t_1	34,9 ± 8,9 35,0 (15,0 – 49,0)							
T4	V_E	t_0	36,4 ± 4,9 cm 37,0 (27,0 – 46,0)	0,014*	0,65**	–	0,164	0,36*	–	**N**
		t_1	38,5 ± 4,7 cm 40,0 (28,0 - 46,0)							
	V_C	t_0	40,3 ± 6,8 cm 40,0 (26,0 – 52,0)							
		t_1	40,6 ± 6,7 cm 40,0 (25,0 - 54,0)							
T5	V_E	t_0	156,4 ± 21,0 cm 158,0 (111,0 – 189,0)	0,432	0,21*	–	0,877	0,04	–	**N**
		t_1	164,4 ± 21,9 cm 167,0 (122,0 – 203,0)							
	V_C	t_0	160,3 ± 16,7 cm 157,0 (130,0 – 193,0)							
		t_1	163,6 ± 16,6 cm 162,5 (135,0 –							

			194,0)							
T6	V_E	t_0	14,8 ± 6,7 s 13,2 (8,0 – 33,2)	0,222	0,56**	0,61	0,473	0,33*	0,57	**N**
		t_1	12,2 ± 4,8 s 11,1 (5,8 – 25,5)							
	V_C	t_0	11,7 ± 4,0 s 11,6 (4,5 – 18,2)							
		t_1	10,8 ± 3,5 s 10,9 (5,3 – 17,8)							

Legend: $\bar{X}$ – arithmetic average, σ– standard deviation, X_{med} – median, X_{min}– minimum, X_{max}– maximum, p – p-value, d – effect d, A – effect A, Y/N – validity/invalidity

Table 4 and 5 further show that hypothesis H1 cannot be proved at the defined levels of statistic and factual significance and hypothesis H2 is confirmed at the same time. That means that the efficiency of the proposed program must be questioned. On the other hand, it is obvious that the girls of the experimental group showed higher increase of the level of strength abilities than those of the control group during the twelve-week strength workout program. It is confirmed also by the relative frequency of the number of girls who performed better in the retest at least by 1x-multiple of determinative deviation. That deviation oscillates between 19,4 – 41,9 % in the experimental group, while dropping below 10 % in the control group and being even at zero level in tests T1 and T3 (Table 5).

What causes can the contradiction between the validity of hypotheses H1 and H2 have? First of all it must be remembered that the research was implemented on a relatively small sample for practical and financial reasons. Such fact can cause the following problem. Both sets show great variance in the level of strength abilities of individual girls in all tests (see chart 4, standard deviation). At the same time, the increase of performance within time Δt is relatively low for both groups. Therefore the difference between the groups can be inconclusive from statistic perspective. Further, it is necessary to consider the intensity and the time of action of the experimental agent. It is possible that the threshold level of the impulse must be higher. Thus the total duration of the exercise program should be longer. Last but not least, external influences acting upon the individual groups of girls must be admitted. Particularly, the influence of the teacher, who's subjective approach disrupts the objectiveness of the whole experiment, cannot be fully eliminated. Such facts should be verified in a wider study in the future.

Conclusion

This pilot study could not prove unequivocally that the level of the observed strength abilities of girls aged 11 – 12 years would be significantly increased by integrating strength workout program into 24 lessons of compulsory physical education. But the same exercise program caused significant increase of improvement of the level of the observed strength abilities of the observed group of girls. The results show that the integration of regular ten-minute strength workout exercise into the lessons of school physical education has positive influence on the level of strength abilities of six-grade girls, which is in concordance with general conclusions of other authors.

Table 5

Comparison of motor skills improvement (girl) in the experimental and control group

Test	Group	$\bar{X} \pm \sigma$ /unit/ X_{med} (X_{min} - X_{max})	η (%)	$MT(V_E)\big\|_{t_0} \cong MT(V_C)\big\|_{t_0}$			$\Delta MT(V_E) > \Delta MT(V_C)$			H2
				p	*d*	*A*	*p*	*d*	*A*	
T1	V_E	3,6 ± 3,4 s 2,4 (0,0 – 14,7)	35,5	0,230	0,36*	0,59	< 0,001***	1,91***	0,95	**Y**
	V_C	–2,8 ± 4,1 s –1,8 (–13,6 – 4,1)	0,0							
T2	V_E	1,6 ± 2,4 cm 2,0 (–4,0 -7,0)	25,8	0,131	0,40*	-	< 0,001***	0,76**	0,78	**Y**
	V_C	–0,2 ± 4,1 cm –1,0 (–6,0 – 10,0)	10,0							
T3	V_E	2,8 ± 4,1 s 2,0 (–3,0 – 16,0)	19,4	0,954	0,15	0,50	< 0,001***	1,10***	0,84	**Y**
	V_C	–2,8 ± 4,1 s –1,8 (–13,6 - 4,1)	0,0							
T4	V_E	2,1 ± 2,4 cm 2,0 (–2,0 - 8,0)	41,9	0,014*	0,65**	-	< 0,001***	1,09***	0,78	**Y**
	V_C	–0,3 ± 2,7 cm 0,0 (–11,0 – 6,0)	3,3							
T5	V_E	8,1 ± 10,0 cm 6,0 (–14,0 – 32,0)	32,3	0,432	0,21*	-	< 0,001***	1,03***	0,87	**Y**
	V_C	–2,3 ± 8,0 cm –2,0 (–18,0 – 28,0)	6,7							
T6	V_E	–2,0 ± 2,7 s –0,7 (–8,6 – 1,9)	32,3	0,222	0,56**	0,61	0,002**	1,02***	0,74	**Y**
	V_C	0,7 ± 2,9 s 0,0 (–4,5 – 7,5)	3,3							

Legend: $\bar{X}$ – arithmetic average, σ – standard deviation, X_{med} – median, X_{min} – minimum, X_{max} – maximum
p – *p*-value, *d* – effect *d*, *A* – effect *A*, η – relative frequency of improved (at least 1x σ) Y/N – validity/invalidity

Based on the research results, we are submitting the following suggestions and proposals for educational practice.

1. We suggest strength workout programs to be regularly integrated into the lessons of school physical education in sufficiently long periods, which will lead to increasing level of strength abilities, constituting one of the conditioning abilities limiting the performance of gymnastic exercise skills. Our research shows that to increase the level of strength abilities of 6-grade girls, it is sufficient to apply strength workout program during 10 minutes in each lesson of physical education during three months.

2. We suggest integrating the strength workout programs into the lessons of school physical education from the lowest grades of elementary school already, observing the

principles for their setup and respecting the age particularities of children and their biological development. To variegate the strength workout programs, we suggest making use of alternative teaching methods, e.g. use of gymnastics means, different teaching forms, integration of gymnastic exercises also into other lessons than those with gymnastic orientation, etc. Individual exercises must be modified to preserve their variety and attractiveness, and positive feedback of the PE teacher to correctly performed exercises is equally important.

3. We suggest integrating, additionally to strength workout programs with specific duration, also different strength workout exercises in the course of the whole school year, to help to universal harmonic development of the children.

The authors of this study are aware of the fact that the research does not solve the problems of gymnastic lessons in school physical education of six-grade pupils. But they believe that their results will contribute to extend the knowledge and to improve the approach to the contents of gymnastic curriculum in elementary schools.

References

1. ARKAEV, L. J., SUČILIN, N. G. 2004. Kak gativiť čempionov. Moskva : *Fizkuľtura i sport.* ISBN 5-278-00739-7
2. BROOMFIELD, L. 2011. *Complete Guide to Primary Gymnastics*. Human Kinetics, 2011. 124 s. ISBN-13: 978-0-736-08658-5.
3. BUBEN, J. 2009. *Výkon ve sportovní gymnastice z pohledu funkční antropologie u výkonnostního stupně nejmladších, mladších a starších žáků*. Dizertační práce. Olomouc : FTK UP.
4. BUKAČ, L. 2008. Dlouhodobý sportovní výkon mládeže. *Tělesná výchova a sport Mládeže*. Roč. 74, č. 4, s. 6-16. ISSN 1210-7689.
5. COHEN, J. 1992. Statistical Power Analysis. *Current Directions in Psychological Science.* Vol. 1, No. 3, pp. 98-101. Retrieved July 2010.
6. GOTTVALDOVÁ, I. 2003. Hodnocení dynamické síly dolních končetin u dívek ve věku 8 – 12 let. In „*Nové perspektivy výzkumu a praxe v kinantropologii*“. Sborník příspěvků mezinárodní studentské konference konané na UK FTVS 20. – 21. Března 2003 v rámci oslav 50. Výročí ITVS – FTVS. Praha : Univerzita Karlova, Fakulta tělesné výchovy a sportu. ISBN 80-903285-1-2.
7. GUZ, S. M. 2009. Vlijanie zaňjatij atletičeskoj gymnastikoj na skorostno-cilovie, silovie posobnosti i funkcionalnie pokazatěli školnikov 12-17 let. In: *Učenye zapisky univerziteta imeni P. F. Lesgafta*. Roč. 10, č. 56, s. 32-37. [on-line] [cit. 2011-11-16]. Dostupné z WWW: <http://bmsi.ru/doc/af14e7c3-ea76-4173-b81a-13509593c2a1>.
8. GUŽELOVSKIJ, A. 1985. Význam „kritických“ období v ontogenezi pro teorii a praxi tělesné výchovy. Nástin teorie tělesné kultury. Praha : Olympia, 1985. In HAVEL, H., HNÍZDIL, J., a j. *Rozvoj a diagnostika silových schopností*. 1.vyd. Ústí nad Labem : Univerzita J. E. Purkyně. ISBN 978-80-7414-189-8.
9. HATIAR, B. 1997. Súčasný trend vývoja gymnastiky. In: *Gymnastika – prostriedok v ontogenéze človeka*. Zborník KGTÚ. Bratislava: UK, s.11-15.
10. HORKEL, V., HORKELOVÁ, H. 2009. Silové schopnosti v gymnastice. In HAVEL, H., HNÍZDIL, J., aj. *Rozvoj a diagnostika silových schopností*. 1. vyd. Ústí nad Labem : Univerzita J. E. Purkyně. ISBN 978-80-7414-189-8.
11. KREMNICKÝ, J. 2010. *Zmeny úrovne gymnastických zručností vplyvom specializovaného programu v etape gymnastickej predprípravy*. 1. vyd. Ústí nad Labem : Pedagogická fakulta, Univerzita J. E. Purkyně v Ústí nad Labem, 156 s. ISBN 978-80-7414-275-8.

12. KREMNICKÝ, J. 2004. Spevňovacie cvičenia v etape športovej predprípravy v športovej gymnastike. In *Telesná výchova, šport a zdravie*. Banská Bystrica : KTVŠ, FHV UMB, s. 53-63. ISBN 80-8075-03-3.
13. KRIŠTOFIČ, J. 2006. *Pohybová příprava dětí – kondiční a koordinační gymnastická cvičení*. Praha : Grada. ISBN 80-2471-636-4.
14. KRIŠTOFIČ, J. 2004. *Gymnastická průprava sportovce.* Praha : Grada. 188 s. ISBN 80-247-1006-4.
15. MÁČEK, M., RADVANSKÝ, J. et al. 2011. *Fyziologie a klinické aspekty pohybové aktivity*. První vydání. Praha : Galén. 245 s. ISBN 978-80-7262-695-3.
16. NEUMAN, J. 2003. *Cvičení a testy obratnosti, vytrvalosti a síly*. 1. vyd. Praha : Portál, 160 s. ISBN 80-7178-730-2.
17. PEREČINSKÁ, K. 1997. Pohybové programy na spevnenie tela. In *Tělesná výchova a sport mládeže*. Roč 63, č. 2, s. 40-43. ISSN 1210-7689.
18. PROSKUROV, E. M. 2011. Osobennosti ispolzovanija silovych upražněnij, kak sredstva uluč-šenija fizíčeskogo razvítija maľčikov 5-6x Klatov, v processe fakultativních zaňatij po sportivnoj gimnastike. In: *Pedagogika, psichologija i mediko-biologičeskie problémy fizíčeskogo vospitanija i sporta* [online]. 2011, č. 4, s. 130-133 [cit. 2011-11-16]. ISSN 1818-9210. Dostupné z: <http://www.nbuv.gov.ua/Portal/Soc_Gum/PPMB/texts/2011_4/11pemosg.pdf>.
19. RUSCIO, J. 2008. A probability-based measure of effect size: robustness to base rates and other factors. *Psychol Methods*. Vol. 13, n. 1, p. 19–30.
20. STREŠKOVÁ, E. 2008. *Gymnastika vo fylogeneze a ontogeneze člověka*. Bratislava : ICM AGENCY. ISBN 978-80-89257-09-6.
21. STREŠKOVÁ, E. 1991. Technická príprava mladých gymnastiek. Bratislava : *TVŠ,* roč. I, č. 3/1991, s. 33-36.
22. STREŠKOVÁ, E. 1980. Sledovanie objemu, intenzity a obsažnosti tréninkového zaťaženia 8 – 10-ročných gymnastiek. *Teor. praxe tel. vých.* Vol. 28, no II /1980, s. 698-700.
23. TLAPÁK, P. 2010. *Tvarování těla pro muže a ženy.* 8. vyd. Praha : ARSCI. 266 s. ISBN 978-80-7420-001-4.
24. TŮMA, Z., ZÍTKO, M., LIBRA, M. 2004. *Kapitoly o gymnastice (I.).* Praha : ČOS. 68 s. ISBN 80-86402-13-4.
25. VLASÁKOVÁ, N., MAZUROVOVÁ, Z. 1994. I děti mohou posilovat. In *TVSM*. Ročník 60, č. 3, s. 20-28.
26. ZÍTKO, M. et al. 2005. *Všeobecná gymnastika. Speciální učební text.* 4. Vydání. Praha : ČASP, 2005. 94 s. ISBN 80-86586-08-1.
27. Šplh **s** přírazem. [on-line] [cit. 2012-1-10]. Dostupné z WWW: < http://www.sportvital.cz/sport/testy/fitness-testy/sila/splh-s-prirazem/>.

RESUMÉ

VPLYV POSILŇOVACIEHO CVIČEBNÉHO PROGRAMU NA ROZVOJ SILOVÝCH SCHOPNOSTI V ŠKOLSKEJ TELESNEJ VÝCHOVE

Pavlína Vrchovecká, Václav Bittner, Elena Strešková

Cieľom štúdie bolo preukázať pozitívny vplyv posilňovacieho cvičebného programu na rozvoj silových schopností dievčat stredného školského veku (11 – 12 rokov). V priebehu dvanástich týždňov bol na vybranú skupinu dievčat aplikovaný cvičebný program, ktorého súčasťou bola aj diagnostika silových schopností. Z výsledkov tejto pilotnej štúdie vyplýva, že uplatnenie pravidelného desaťminútového posilňovacieho cvičenia na hodinách školskej telesnej výchovy má pozitívny vplyv na úroveň silových schopností dievčat šiestych tried. Program nájde uplatnenie predovšetkým v rámci tematického celku gymnastika.

PHYSICAL ACTIVITY FOR THE PREVENTION OF CHILDHOOD OBESITY: AN OVERVIEW OF KEY RESEARCH CHALLENGES FOR PHYSICAL EDUCATION

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Summary: The aim of the present work is to examine the contribution of school physical education to public health, with a special focus to the prevention of overweight, and to consider some fundamental questions and assumptions framing research on physical activity during childhood and adolescence. In particular, this paper comprises four major subtopics related to the key research challenges for physical education. First, it summarize the epidemiological aspects of child obesity and the public health guidelines related to young people's participation in physical activity, highlighting evidence linking sedentary behaviour and overweight in young people. The other three subtopics contain some questions and assumptions which the Authors consider fundamental to solving challenging problems related to the research on physical education. Can physical education have a lifelong effect? Can physical education affect young people's physical activity beyond the curriculum and outside of school? How teaching and learning environment affects students' physical activity? The Authors address these issues by over viewing the research literature pertaining to school-based intervention studies, with specific emphasis on the developmental, psycho-social and environmental factors which can promote physical activity in and outside of school. Future research in physical education need to consider the global epidemic of physical inactivity and the factors contributing to this epidemic, by adopting mixed-methods and multidisciplinary designs, as advocated in ecological models.

Key words: *health, motor performance, obese children, physical activity levels, physical education, epidemiological aspect, lifelong effect*

Introduction

Physical education (PE) has long been considered a vital part of a school's curriculum, as it is one of the most important vehicles for promoting physical activity in young people (National Association for Sport and Physical Education, 2001). Efforts to change PE from a product (i.e., physical fitness scores) to a process orientation (i.e., physical activity behaviour), have seen health professionals emphasizing what has been termed *Health-Related Physical Education* (HRPE), which promotes participation in regular physical activity (McKenzie, 2003). An example of this paradigm shift can be seen in the Healthy People 2010 guidelines (United States Department of Health and Human Services, 2000), which include many PE-related objectives targeting activity behaviour, and recommend offering daily PE to all

students who should be physically active for at least 50 % of the time available. These objectives are based on the premise that PE is a key factor of the person's social, motor, emotional and cognitive growth and should play a vital role in public health promotion (Bailey, 2006). However, the importance of physical activity is often neglected by many individuals in public health and clinical medicine (Blair, 2009).

Physical activity during childhood and adolescence is related to many benefits, including reduced adiposity, improved cardiovascular efficiency, decreased symptoms of depression and anxiety, higher self-esteem, and improved academic performance (Strong et al., 2005; Hills, King, & Armstrong, 2007). Conversely, physical inactivity is one of the most worrying problems of the 21st century (Blair, 2009). Research highlighted that a sedentary lifestyle increases the risk of developing overweight and obesity, and many other chronic conditions in both childhood and adolescence (Strong et al., 2005), with detrimental effects on motor development and skill acquisition (Malina, 2004). Given that childhood physical activity patterns influence adult physical activity (Bates, 2006; Hills et al., 2007), school could be an important social context for the health promotion program implementation and the most suitable environment for each student to develop the knowledge, behaviours, and motor skills necessary to acquire and maintain a physically active lifestyle.

Physical activity and obesity during childhood and adolescence

Epidemiological aspects

Physical activity of children and adolescents is an essential component of any strategy to prevent or treat overweight and obesity (Stensel, Gorely, & Biddle, 2008), which are now considered a public health problem with serious social and economic consequences (Wyatt, Winters, & Dubbert, 2006). Obesity is one of the most important risk factors for a number of chronic diseases (including diabetes, cardiovascular diseases and cancer), which are associated with a greater probability of premature death and disability (World Health Organization, 2010). In the last decade, the number of obese children has increased from fivefold to tenfold in industrialised countries, and about fourfold in developing countries (Flynn et al., 2006). Although overweight and obesity previously were considered a problem only in high-income countries, today are growing rapidly in low-to-medium income countries, and particularly in urban areas (World Health Organization, 2010). Over 42 million children in the world below five years of age are overweight (World Health Organization, 2010). Considering that overweight children and adolescents are more likely to become obese adults, the increased incidence of childhood obesity is a social concern (Wyatt et al., 2006).

In Europe the highest rates of overweight children are found in Portugal (32 %, range age: 7 – 9 years), Spain (31 %, range age: 2 – 9 years), and Italy (27 %, range age: 6 – 11 years), while lower rates are shown in Germany (13 %, range age: 5 – 6 years), Cyprus (14 %, range age: 2 – 6 years), and Serbia and Montenegro (15 %, range age: 6 – 10 years), (Branca, Nikogosian, & Lobstein, 2007). The "OKkio alla salute" study carried out on 45.590 third grade Italian students, found that 23.6 % and 12.3 % of children were overweight and obese, respectively (Epicentro, Centro Nazionale di Epidemiologia, Sorveglianza e Promozione della Salute, 2010). Northern European countries tend to have lower rates of child obesity than southern European countries, while in the Western Europe it was shown a marked increase in the prevalence levels in recent decades (Lobstein, 2010). In the Eastern Europe, the prevalence of obesity among children and adolescents tends to be lower, but is

increasing with rates of 17 % in the Czech Republic and Serbia, 18 % in Poland and Bulgaria, and 26 % in Croatia (Lobstein, 2010).

Research has amply demonstrated that one of the most important causes of overweight and obesity is a prolonged positive energy balance, which is often linked to unhealthy eating habits and lack of physical activity (Hills et al., 2007). Although several studies carried out on adult population, indicate a negative relationship between overweight and the amount of physical activity, findings on samples of children and adolescents are more controversial (Stensel et al., 2008). In fact, during childhood and adolescence, it is difficult to evaluate the causal relationships between physical activity or sedentary behaviours and body weight regulation (American Dietetic Association, 2006). From this point of view, guidelines should ensure a maximum degree of suitability of the preventive and awareness-raising measures, by orienting action planning in educational and public health policy.

The recommended quantity of physical activity is a key factor in the health promotion and disease prevention (see Bates, 2006, for a review). The amount of daily physical activity is a fundamental parameter that requires systematic integration with the variety of motor tasks, in order to promote skill acquisition. However, recommendations and guidelines for physical activity of children and adolescents have been developed only recently, and they can be summarized as follow (Bates, 2006):

- children and youth should practice at least 60 minutes of daily physical activity;
- children should participate in short bouts of intense physical activity lasting 15 minutes or more each day;
- children and youth should participate in a variety of enjoyable and age-appropriate activities, designed to achieve optimal health, wellness, fitness, and performance benefits;
- children and youth should be encouraged to reduce the time spend on sedentary activities;
- prolonged sedentary time is associated with an increased risk of becoming overweight and obese.

Despite the benefits of physical activity to health and wellbeing in children and adolescents, youth physical activity seems to be decreasing over time (Knuth & Hallal, 2009). Biological (e.g., age, gender, body mass index), social (e.g., parents' physical activity habits and attitudes, peer influence, subjective norms), and environmental (e.g., program and facility access, time spent outdoors) factors are likely to contribute to such a marked trend (Hills et al., 2007). In the HBSC (Health Behaviour in School-Aged children) study, it was found that the rates of Italian adolescents performing physical activity for more than one hour a day at least 5 days a week, ranged from 40.58 % (11-year-olds) to 29.75 % (15-year-olds), and this trend was inversely related with age (Lazzeri, Rossi, & Giacchi, 2006). More recently, the "Okkio alla salute" study showed that only 1 child in 10 in primary Italian school meets daily physical activity recommendations, with a higher prevalence of inactivity in girls (Epicentro, Centro Nazionale di Epidemiologia, Sorveglianza e Promozione della Salute, 2010). Similarly, a study carried out on Serbian schoolchildren aged 10 – 18 years, found that less than 20 % of the children were engaged in active sports more than 7 hours weekly, and boys were more active (25 %) than girls (10 %), (Pavlovic M, Grujic V, & Oshaug A, 2005).

A review on trends of physical activity has suggested that youth activity behaviour seems to be decreasing over time, also in PE classes (Knuth & Hallal, 2009). As a cones-

quence, fitness levels are also declining, exposing children and youth to the risk of various diseases (Knuth & Hallal, 2009). A systematic review has suggested that a) high levels of cardio-respiratory fitness in childhood and adolescence are related to a healthier cardiovascular profile later in life, b) improvements in muscle strength from childhood to adolescence are negatively associated with adiposity changes, and c) a healthier body composition in childhood and adolescence is related to a healthier cardiovascular profile later in life (Ruiz et al., 2009). In a study conducted on girls aged 7 – 15 years old, it was found that for the past 36 years there is an asymmetry in the somatic development and motor performance, showing a positive secular trend in the body height and weight, but stagnation up to decline in the physical performance (Kopecký & Přidalová, 2008). In addition, over a 45-year period (1958 – 2003) there has been a global decline in aerobic performance of –0.36 % per annum (Tomkinson & Olds, 2007). This secular decline may be due to a number of social, behavioural, physical, psychosocial and physiological factors (Tomkinson & Olds, 2007).

The increase of obesity and decline of fitness among boys and girls unveil some questions to be dealt with. Having considered the evidence, we will discuss questions regarding the key research challenges for PE.

Can PE have a lifelong effect?

There is little evidence that traditional PE classes either increase physical fitness or establish lifelong habits of physical activity (Trost, 2006). The Recommendation Rec (2003) 6 of the Committee of Ministers (Council of Europe, 2003) explicitly tackles the issue of including a regular and adequate PE in the school curriculum for all age groups, with a minimum number of hours of 180 minutes weekly in three periods. However, a limited number of students in all grades are exposed to daily PE for the entire school year, and the time spent on moderate-to vigorous physical activity in most PE classes is fairly limited (Trost, 2006; Stratton, Fairclough, & Ridgers, 2008).

The declining amounts of school class time for PE are cited as a possible cause for increasing childhood obesity (Stratton et al., 2008), which in turn has adverse effects on both motor performance and physical self-perception (Morano, Colella, & Capranica, 2011; Morano, Colella, Robazza, Bortoli, & Capranica, 2011). In addition, PE appeared to be under threat in many countries because it is commonly perceived as a low-status subject (Hardman, 2000). The reduction in the number of hours of PE, greater autonomy for schools in terms of decision-making, the decentralisation of responsibilities, funding limits and insufficient training of PE teachers have all contributed to shifts in the cultural and educational conception of the discipline (Hardman, 2008). This view of PE may be damaging from an active-promoting perspective. Thus, significantly more research is needed to investigate the extent of impact that PE may have on physical fitness and activity in children and young people.

There are several examples of quality school-based intervention programs that have been demonstrated to increase physical fitness among children and adolescents (Sollerhed & Ejlertsson, 2008; Morano, Colella, & Fiore, 2009). Dobbins et al. (2009) showed that school-based physical activity interventions have a positive impact on lifestyle behaviours and physical health status measures (i.e., higher duration of physical activity, increased maximal oxygen consumption, reduced TV watching time), but they not influence body mass index and leisure time physical activity rates. Many local organisations have taken steps to promote physical activity in schools as a way to counter childhood obesity. It has

been demonstrated that the introduction of physical activity in schools does not directly lead to a reduction in body weight; its main effects are to increase physical activity levels and motor performances. Specifically, it was found that school-based programs with expanded PE lessons could improve physical fitness of overweight boys and girls (Sollerhed & Ejlertsson, 2008; Morano, Colella, & Fiore, 2009).

Recent evidence shows that reduction of sedentary behaviour and increased physical activity can be effective measures for the prevention and treatment of child obesity (Stensel et al., 2008). However, as Harris et al. (2009) have stressed in their meta-analysis, increased physical activity does not improve the body mass index of primary school children. Furthermore, review papers have reported that most intervention programs with a strong emphasis on increased physical activity for the prevention and treatment of childhood obesity have produced no, weak or minimal effects on reducing obesity or improving physical activity participation (Summerbell et al., 2003; Kamath et al., 2008). Kropski, Keckley, and Jensen (2008) have suggested that it is difficult to draw any conclusions about the efficacy of school-based obesity prevention programs, mainly due to the small number of studies and different used methodology. Therefore, the evidence supporting a role for increased physical activity and reduce sedentary behaviours in the management of childhood obesity is not strong. More specifically, there has been limited research into PE from a public health perspective (Stratton, et al., 2008), and further examination of active and inactive behaviours is required.

Can PE affect young people's physical activity beyond the curriculum and outside of school?

A physically active lifestyle requires the individual participation in both structured and unstructured activities. The structured activities are scheduled or planned physical activities which require the adult presence, involve a number of participants, and systematically take place in specific contexts (i.e., school and extra-school). Unstructured activities are more spontaneous (i.e., cycling or walking to school, play after school); they do not require the adult presence and take place outside the main institutional contexts (Struzzolino & Pesce, 2009). According to Stone et al. (2009), short and frequent periods of intense activity offer the same health benefits to children as longer sessions. This suggests that children and youth should be encouraged to take part in frequent and short periods of physical activity, corresponding to their natural behaviour. Furthermore, exercise programs should be promoted through school, even if they include activities that take place before or after school hours (e.g., recreational activities and/or sport), by involving local organisations and structures, voluntary associations and sports clubs. In other words, physical activity may take a variety of forms, including structured (i.e., exercise, PE, sport) and unstructured (i.e., unsupervised play, active transportation) leisure activities (Struzzolino & Pesce, 2009).

Many PE-based interventions have been successful in increasing students' class-time physical activity, as well as some psychological variables (Stratton et al., 2008). Research revealed positive effects on body image and physical self-efficacy of overweight and obese children aged 8 – 9 years after additional PE lessons program (2 times week^{-1}), and these improvements were not due to changes in BMI (Morano, Colella, Capranica, 2009a, 2009b). The influence of PE on physical activity "seems to be greatest when programs allow students' experiences of self-determination and feelings of competence in their own abilities, and when they emphasised enjoyment and positive experiences" (Bailey, 2006, p. 398). In one

example, a study involving 859 English primary school children showed that students with the highest levels of PE enjoyment and perceived competence (i.e. the individual's perception of physical condition, sport and strength competence) have also highest out-of-school physical activity levels (Carrol & Loumidis, 2001).

However, few studies have reported changes in psychosocial variables or improvements in students' habitual physical activity (Stratton et al., 2008), suggesting that interventions in PE can increase physical activity in the short to medium term. Conversely, the long term effects of these interventions and their impact on individual health and well-being are not clear (Stratton et al., 2008). In order to improve the quality and quantity of this database, significant research is needed. This could be achieved by developing PE-based interventions that build on current successfull experiences and have a greater focus on promoting physical activity in and outside of school. From this viewpoint, the contributions of research to understanding the effects of PE on youth physical activity must be considered in respect to the accuracy of the measurement of physical activity and psychosocial constructs. Furthermore, longitudinal tracking of students over a number of PE lessons would provide higher information about changes in physical activity, fitness and psychosocial determinants of activity behaviours, also relating to gender and age differences.

How teaching and learning environment affects students' physical activity?

PE studies should also investigate how teaching and learning environment affects students' physical activity, in order to provide more information about the determinants of activity behaviour like self-efficacy, perceived competence, and enjoyment. The current literature emphasizes the importance of assessing the perceived motivational climate in PE to help teachers recognize their own behaviours and attitudes that could influence students' physical activity (Bortoli et al., 2008). Research investigating children's motivation in physical activity has shown that the beliefs people hold about their ability (i.e., self-efficacy) could be one of the major influencing factors (Wang, Biddle, 2001). In addition, perceived competence and task orientation are positively related to self-determination, which in turn positively predicts enjoyment (Standage, Duda, & Ntoumanis, 2003). Cognitive, affective and behavioural responses (such as feelings of satisfaction, higher perceived ability, intrinsic motivation, positive attitude toward PE, and increased physical activity behaviours) have been linked to perceptions of a mastery climate (Parish & Treasure, 2003). A mastery climate (i.e., task-involving climate) places emphasis on skill mastery, effort, and social relations, whereas a performance climate (i.e., ego-involving climate), draws attention to social comparison, normative-based evaluation, and competition (Bortoli et al., 2008). Research showed that male adolescents who participated in one-year additional PE lessons (4 hours week-1), at the end of the program reported better physical performances, higher self-efficacy and enjoyment, and perceived the motivational climate in PE more mastery-involving compared to peers who participated in traditional PE lessons program (2 hours week-1), (Morano, Colella, & Fiore, 2010).

Given that in PE research psychosocial and environmental variables are important determinants of behaviour, multiple factors should be measured over time and the interactions among them be considered by using mixed-methods and multidisciplinary designs. From this point of view, future research should investigate the relationship between several measures

of performance (i.e., physical capabilities and motor skills) and some psychological factors (i.e., self-efficacy, self-concept, self-esteem, bodily perception, and motivation), particularly in overweight children who demonstrated lower actual and perceived physical competences than their normal-weight peers (Morano, Colella, Robazza, Bortoli, & Capranica, 2011). In fact, the mediation effect of perceived competence on physical activity is an important but yet underestimated, mechanism partially responsible for physical inactivity and, subsequently, for obesity (Stodden et al., 2008).

Cross-sectional and longitudinal studies showed that specific physical self subdomains are moderate correlates of physical activity, but the causal link between physical-self perception and activity behaviour is not clear (Crocker, Kowalski, & Hadd, 2008). For example, there is evidence suggesting that the psychosocial benefits of increased physical activity in obese children are not always related to weight reductions (Goldfield et al., 2007), but it is still unclear what is the role of psychological and social factors in the management of pediatric obesity (Oude Luttikhuis et al., 2009) and, in particular, whether improvements in psychosocial functioning may lead to increased PA in obese young people (Goldfield et al., 2007). Thus, a research challenge for PE should be to determine the direction of causality between physical self-perception and physical activity. Researchers should utilize longitudinal and experimental designs to examine changes – especially reciprocal effects – in physical activity and the self over time. They should also design and develop interventions that can facilitate changes in teacher's competencies to create a quality learning context that supports student motivation towards physical activity in and outside of school.

Conclusion

School PE programs are uniquely situated to address the epidemic of obesity and sedentary behaviour during childhood and adolescence, by increasing physical activity levels and promoting healthy lifestyles. Such programs can best contribute to health promotion by providing a variety of enjoyable and sustainable activities in which all participants can feel good about their performance, and get excited about monitoring their progress. These activities should be oriented to the development of the intrinsic motivation and to the acquisition of meanings and values of movement in function of healthy lifestyles. In other words, PE programs should confirm the public health role that school plays and also foresee the promotion of physical activity during out-of-school hours (i.e., active transportation use, sport and exercise participation, screen time reduction) through the involvement of community and private organizations. Family, school and community involvement are all needed to assure adherence to the official guidelines on how much physical activity children need to boost their health and stave off obesity.

The effectiveness of physical activity promotion strategies in children requires a concerted and multisectoral approach, based on ecological models which target individual, physical and social environments, plus policies (Hills, 2009). From this view point, in order to develop and evaluate interventions aimed at increasing physical activity participation among obese children, longitudinal and experimental studies are needed to measure over time some factors that co-exist with obesity (e.g. low perceived ability, body image concerns, poor physical fitness), and to consider the interactions among them within a multidimensional approach.

References

1. AMERICAN DIETETIC ASSOCIATION (ADA) 2006. Position of the American Dietetic Association: individual-, family-, school-, and community-based interventions for paediatric overweight. *Journal of the American Dietetic Association*, *106*, 925-945.
2. BAILEY, R. 2006. Physical education and sport in schools: a review of benefits and outcomes. *Journal of School Health*, *76*, 397-401.
3. BATES, H. 2006. *Daily physical activity for children and youth: a review and synthesis of the literature*. Alberta, Canada : Alberta Education.
4. BLAIR, S. N. 2009. Physical inactivity: the biggest public health problem of the 21st century. *British Journal of Sports Medicine*, *43*, 1-2.
5. BORTOLI, L., COLELLA, D., MORANO, M., BERCHICCI, M., BERTOLLO, M., ROBAZZA, C. 2008. Teacher-Initiated Motivational Climate in Physical Education Questionnaire in an Italian sample. *Perceptual and Motor Skills, 106*, 207-214.
6. BRANCA, F., NIKOGOSIAN, H., LOBSTEIN, T. 2007. *The challenge of obesity in the WHO European Region and the strategies for response*. Geneva : World Health Organization.
7. CARROLL, B., LOUMIDIS, J. 2001. Children's perceived competence and enjoyment in physical education and physical activity outside school. *European Physical Education Review*, *7*, 24-43.
8. COUNCIL OF EUROPE, Committee of Ministers (2003). Recommendation Rec (2003) 6 of the Committee of Ministers to member states on improving physical education and sport for children and young people in all European countries. Retrieved June 7, 2012 from:

   https://wcd.coe.int/ViewDoc.jsp?id=21055&Site=CM
9. CROCKER, P. R. E., KOWALSKI, K. C., HADD, V. 2008. The role of the self. In A. L. SMITH & S. J. H. BIDDLE (Eds.), *Youth physical activity and sedentary behavior*. *Challenges and solutions* (pp. 215-237). Champaign, IL: Human Kinetics.
10. DOBBINS, M., DE CORBY, K., ROBESON, P., HUSSON, H., TIRILIS, D. 2009. School-based physical activity programs for promoting physical activity and fitness in children and adolescents aged 6-18. *Cochrane Database of Systematic Reviews*, *1*, CD007651.
11. EPICENTRO, CENTRO NAZIONALE DI EPIDEMIOLOGIA, Sorveglianza e Promozione della Salute. *OKkio alla salute. Promozione della salute e della crescita sana nei bambini della scuola primaria*. Retrieved March 7, 2010 from:

    http://www.epicentro.iss.it/okkioallasalute/default.asp
12. FLYNN, M. A., MCNEIL, D. A., MALOFF, B., MUTASINGWA, D., WU, M., FORD, C., ET AL. 2006. Reducing obesity and related chronic disease risk in children and youth: a synthesis of evidence with 'best practice' recommendations. *Obesity Reviews*, *7*Suppl. 1, 7-66.
13. GOLDFIELD, G. S., MALLORY, R., PARKER, T., CUNNINGHAM, T., LEGG, C., LUMB, A., et al. 2007. Effects of modifying physical activity and sedentary behavior on psychosocial adjustment in overweight/obese children. *Journal of Pediatric Psychology, 32*, 783-793.
14. HARDMAN, K. 2008. The situation of physical education in schools: a European perspective. *Human Movement*, *9*, 5-18.
15. HARDMAN, K. 2000. The state and status of physical education in schools in international context. *European Physical Education Review*, *6*, 203-229.
16. ARRIS, K. C., KURAMOTO, L. K., SCHULZER, M., RETALLACK, J. E. 2009. Effect of school-based physical activity interventions on body mass index in children: a meta-analysis. *Canadian Medical Association Journal*, *180*, 719-726.
17. HILLS, A. P. 2009. It's time to be more serious about activating youngsters: lessons for childhood obesity. *Journal of Exercise Science and Fitness*, *7*, S28–S33.

18. HILLS, A. P., KING, N. A., ARMSTRONG, T. P. 2007. The contribution of physical activity and sedentary behaviours to the growth and development of children and adolescents: implications for overweight and obesity. *Sports Medicine*, *37*, 533-545.
19. KAMATH, C. C., VICKERS, K. S., EHRLICH, A., MCGOVERN, L., JOHNSON, J., SINGHAL, V., et al. 2008. Behavioral interventions to prevent childhood obesity: a systematic review and meta-analyses of randomized trials. *Journal of Clinical Endocrinology and Metabolism*, *93*, 4606-4615.
20. KNUTH, A. G., HALLAL, P. C. 2009. Temporal trends in physical activity: a systematic review. *Journal of Physical Activity and Health*, *6*, 548-559.
21. KOPECKÝ, M., PŘIDALOVÁ, M. 2008. The secular trend in the somatic development and motor performance of 7-15-year-old girls. *Medicina Sportiva*, *12*, 78-85.
22. KROPSKI, J. A., KECKLEY, P. H., JENSEN, G. L. 2008. School-based obesity prevention programs: an evidence-based review. *Obesity*, *16*, 1009-1018.
23. LAZZERI, G., ROSSI, S., GIACCHI, M. 2006. Attività fisica e tempo libero. In Gruppo di ricerca HBSC. *Stili di vita e salute dei giovani italiani tra 11-15 anni.* pp. 59-66. Retrieved June 7, 2012 from: www.hbsc.unito.it/hbsc/files/stilidivita1_file%20stampa.pdf
24. LOBSTEIN T. 2010. Prevalence and trends in childhood obesity. In D. CRAWFORD, R. W. JEFFERY, K. BALL, J. BRUG Eds., *Obesity epidemiology. From aetiology to public health* pp. 3-16. 2nd ed. New York: Oxford University Press.
25. MALINA, R. M. 2004. Motor development during infancy and early childhood: overview and suggested directions for research. *International Journal of Sport and Health Science*, *2*, 50-66.
26. McKENZIE, T. L. 2003. Health-related physical education: Physical activity, fitness, and wellness. In S.J. SILVERMAN, C.D. ENNIS *Student learning in physical education: Applying research to enhance instruction* pp. 207-226. 2nd ed. Champaign, IL : Human Kinetics.
27. MORANO, M., COLELLA, D., CAPRANICA, L. 2011. Body image, perceived and actual physical abilities in normal-weight and overweight boys involved in individual and team sports. *Journal of Sports Sciences*, *29*, 355-362.
28. MORANO, M., COLELLA, D., CAPRANICA, L. 2009a. Effects of additional physical education lessons program on body image and self-efficacy in overweight children. *Book of Abstracts 6th Conference of the European Association for Sociology of Sport* EASS, Rome, Italy, 27-30 May, p. 193.
29. MORANO, M., COLELLA, D., CAPRANICA, L. 2009b. Effects of a two-year additional physical education program on physical performance and self-perception in overweight girls. *Book of Abstracts 14th Annual Congress of the European College of Sport Science* ECSS, Oslo, Norway, 24-27 June, p. 388-389.
30. MORANO, M., COLELLA, D., FIORE, P. 2009. Effetti di un programma di attività fisica sulla prestazione motoria e la percezione di sé in bambine in sovrappeso e obese. *European Journal of Physical and Rehabilitation Medicine, 45* Suppl. 1 to No. 3.
31. MORANO, M., COLELLA, D., FIORE, P. 2010. Motor performance, physical self-efficacy and motivational climate in male adolescents. *The Journal of Sports Medicine and Physical Fitness*, 50, 11-12.
32. MORANO, M., COLELLA, D., ROBAZZA, C., BORTOLI, L., CAPRANICA L. 2011. Physical self-perception and motor performance in normal-weight, overweight and obese children. *Scandinavian Journal of Medicine and Science in Sports*, *21*, 465-473.
33. National Association for Sport and Physical Education – NASPE 2001. *Physical Education is critical to a complete education. Position Statement*. Reston, VA: Author.

34. OUDE LUTTIKHUIS, H., BAUR, L., JANSEN, H., SHREWSBURY, V. A., O'MALLEY, C., STOLK, R. P., SUMMERBELL, C. D. 2009. Interventions for treating obesity in children. *Cochrane Database of Systematic Reviews, 1*, CD001872.
35. PARISH, L. E., TREASURE, D. 2003. Physical activity and situational motivation in physical education: Influence of the motivational climate and perceived ability. *Research Quarterly for Exercise and Sport*, *74*, 173–182.
36. PAVLOVIC, M., GRUJIC, V., OSHAUG, A. 2005. Nutrition and physical activity of the population in Serbia. *World Review of Nutrition and Dietetics, 94*, 51-59.
37. RUIZ, J. R., CASTRO-PIÑERO, J., ARTERO, E. G., ORTEGA, F. B., SJÖSTRÖM, M., SUNI, J., et al. 2009. Predictive validity of health-related fitness in youth: a systematic review. *British Journal of Sports Medicine*, *43*, 909-923.
38. SOLLERHED A. C., EJLERTSSON, G. 2008. Physical benefits of expanded physical education in primary school: findings from a 3-year intervention study in Sweden. *Scandinavian Journal of Medicine and Science in Sports*, *18*, 102–107.
39. STENSEL, D. J., GORELY, T., BIDDLE, S. J. H. 2008. Youth health outcomes. In A. L. SMITH, S. J. H. BIDDLE Eds., *Youth physical activity and sedentary behavior. Challenges and solutions* pp. 31–57. Champaign, IL: Human Kinetics.
40. STONE, M. R., ROWLANDS, A. V., MIDDLEBROOKE, A. R., JAWIS, M. N., & ESTON, R. G. 2009.The pattern of physical activity in relation to health outcomes in boys. *International Journal of Pediatric Obesity*, 4, 306-315.
41. STANDAGE, M., DUDA, J. L., NTOUMANIS, N. 2003. Predicting motivational regulations in physical education: the interplay between dispositional goal orientations, motivational climate and perceived competence. *Journal of Sports Sciences*, *21*, 631–647.
42. STODDEN, D. F., GOODWAY, J. D., LANGENDORFER, S. J., ROBERTON, M. A., RUDISILL, M. E., GARCIA, C., GARCIA, L. E. 2008. A developmental perspective on the role of motor skill competence in physical activity: an emergent relationship. *Quest, 60*, 290-306.
43. STRATTON, G., FAIRCLOUGH, S. J., & RIDGERS, N. D. 2008. Physical activity levels during the school day. In: A. L. Smith & S. J. H. Biddle Eds., *Youth physical activity and sedentary behavior. Challenges and solutions* pp. 321-350. Champaign, IL : Human Kinetics.
44. STRONG, W. B., MALINA, R. M., BLIMKIE, C. J. R, DANIELS, S. R., DISHMAN R. K., GUTIN, B., et al. 2005. Evidence based physical activity for school-age youth. *The Journal of Pediatrics,* 146, 732–737.
45. STRUZZOLINO, I., PESCE, C. 2009. Giochi tradizionali di movimento nell'avviamento allo sport. *SdS - Scuola dello Sport, Rivista di cultura sportiva*, *83*, 23-32.
46. SUMMERBELL, C. D., ASHTON, V., CAMPBELL, K. J., EDMUNDS, L., KELLY, S., WATERS, E 2003. Interventions for treating obesity in children. *Cochrane Database of Systematic Reviews*, 3, CD001872.
47. TOMKINSON, G. R., OLDS, T. S. 2007. Secular changes in pediatric aerobic fitness test performance: the global picture. In G. R. TOMKINSON & T. S. OLDS. Eds. *Pediatric Fitness: Secular Trends and Geographic Variability* pp. 46-66. Basel, Switzerland: Karger.
48. TROST S. G. 2006. Public health and physical education. In D. KIRK, D. MACDONALD, M. O'SULLIVAN Eds., *The Handbook of Physical Education* pp. 163-187. London : Sage.
49. United States Department of Health and Human Services – USDHHS 2000. *Healthy people 2010.* Washington, DC: U.S. Gov. Printing Office.
50. WANG, C. K .J., BIDDLE, S. J. H. 2001. Young people's motivational profiles in physical activity: A cluster analysis. *Journal of Sport and Exercise Psychology*, *23*, 1–22.

51. World Health Organization - WHO. 2010 *10 Facts on obesity*. Retrieved March 7, 2010 from: http://www.who.int/features/factfiles/obesity/ facts/en/index.html
52. WYATT, S. B., WINTERS, K. P., & DUBBERT, P. M. 2006. Overweight and obesity: prevalence, consequences, and causes of a growing public health problem. *The American Journal of the Medical Science*, *331*, 166-174.

RESUMÉ

TELESNÁ AKTIVITA AKO PREVENCIA DETSKEJ OBEZITY: PREHĽAD KĽÚČOVÝCH VÝSKUMNÝCH MOŽNOSTÍ V TELESNEJ VÝCHOVE

Milena Morano, Dario Colella

Cieľom predkladanej práce je skúmanie prínosu školskej telesnej výchovy v oblasti zdravia, s osobitným zameraním na prevenciu nadváhy. Príspevok zahŕňa štyri hlavné podtémy súvisiace s kľúčovými výskumnými otázkami v telesnej výchove. Sumarizuje epidemiologické aspekty detskej obezity a zdravotné usmernenia súvisiace so zapojením sa mládeže do pohybovej aktivity, zdôrazňujúc súvislosť medzi sedavým spôsobom života mladých ľudí. Ostatné tri podtémy obsahujú niektoré otázky a predpoklady, ktoré autori považujú za zásadné pri riešení náročných problémov týkajúcich sa výskumu v telesnej výchove. Autori vykonali prehľad výskumnej literatúry, týkajúcej sa intervenčných štúdií, s osobitným dôrazom na vývojové, psycho-sociálne a environmentálne faktory, ktoré môžu podporiť telesnú aktivitu v škole a mimo nej. Z hľadiska budúceho výskumu v telesnej výchove je potrebné zvážiť globálnu epidémiu fyzickej nečinnosti ako aj faktory, ktoré prispievajú k tejto epidémii kombinovaním viacerých výskumných metód a multidisciplinárnych štúdií tak, ako to je v ekologických modeloch.

I/D POLYMORPHISM OF THE GENE FOR ANGIOTENSIN CONVERTING ENZYME IN ATHLETES IN RELATION TO SPEED AND ENDURANCE ABILITIES

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Summary: This research was focused on determination of genetic predispositions for speed and endurance. The first group was formed by pupils of ice-hockey classes in Bratislava. The average age of 162 members of this group was 13.0 years. The second group included adult athletes (marathon runners n = 215 and half-marathon runners n = 222) aged 18 to 77 years. We examined also the genotype of the control group of non-sporting population (n = 252) aged 14.6 years in average.

A positive relation between the ACE gene polymorphism and the maximum running speed was found in 13-year old pupils. In comparison to the control group, significantly higher representation of D/D genotype (35.5 %) was found in the group of boys of the speed type, while the percentage of D/D genotype was lower (only 10 %) in boys with below-average running speed. I allele was found in as many as 61.3 % of boys with below-average running speed, thus the difference against D allele was statistically significant ($p < 0.01$).

The genotype frequency in the whole sample of marathon and half-marathon runners did not differ from the control group of non-sporting population. High frequency of I (insertion) allele (55.8 %) as well as I/I genotype (34.9 %) was confirmed in marathon runners placed no worse than 150th. The frequency of I allele in half-marathon runners placed no worse than 100th was found in 53.3% and frequency of genotype I/I in 30 %.

The study showed significant representation of I/I genotype in top-performance endurance athletes as well as significant occurrence of D/D genotype in athletes showing high levels of the maximum running speed. However, after a thorough analysis of frequencies of all three genotypes in athletes we must consider also an option that sports performance is closely tied to not only speed and endurance in the simplified form, but also to strength, endurance in speed and other combined motor abilities.

Key words: I/D polymorfism ACE gene, speed and endurance abilities, genetic predisposition

The sentence "An excellent athlete must be both born and built" is often quoted in sports anthropology. This sentence, translated into the biological terminology, means that sports performance is conditioned by both the genotype (inborn dispositions) and factors of the surrounding environment (economical, social, ethnical, as well as geographical and climatic conditions). The extent of application of both inborn and environmental factors to individual cases depends on the particular characteristic or feature in question.

The degree of genetic conditionality of individual motor abilities determines also the possibilities of their development and their effects in general. If the hereditability is strong, possibilities of the development will be limited. Effects of physical exercises and training on those individuals are lower. Reaching the edge of the sports performance is conditioned by the relevant structure of predispositions and features together with optimum conditions of the surrounding environment. As mentioned by Brown (2001), a sport talent often depends on the observer. However, despite such subjective assessment, recognition of a sport talent is possible in many cases. Exceptional abilities of children can be detected by parents, teachers or even by an inexperienced coach. However, a sports talent, apparent only based on physical and emotional factors, does not always guarantee a successful sports career.

In general, it applies that motor abilities and features, highly affected by hereditability, are relatively stabile and conservative in the course of ontogenesis. Their definitive levels depend on their initial levels to a significant extent, even when the environmental conditions are optimum and relatively progressive, as regards application of training means. From the aspect of individual development, it can be assumed that an individual has a tendency to remain within a certain band of development, which limits are determined by his/her genetic predisposition.

The sports preparation of children and youth is connected with the selection of talented individuals or with their inclusion into a specific sports specialisation. Empiric knowledge of genetic conditionality of physical and motor characteristics is applied namely to initial phases of the process of sports talents selection. Based on the genealogic method it has been stressed that a considerable part of somatic, physiological but also motor characteristics is similar between the parents and their children or between the siblings, thus there exist strong genetic bonds between the close relatives. If a certain characteristic, important for the given kind of sports activity, is completely or nearly completely conditioned by a genotype, it is necessary to find individuals who inherited it from their parents as they have predisposetions for its utilisation in the training process.

In addition to classical methods of determination of motor predispositions (according to fitness test results, or results of special tests relating to particular kinds of sport), there currently exist also advanced procedures of biomolecular genetics. Identification of motor predispositions in this manner is possible under certain accurately specified conditions. Based on specific means of the applied molecular genetics it appears that the assessment of individuals and their inclusion into individual sports specialisations can be aided by determination of certain heritable markers by means of genetic analysis (Montgomery et al., 1998, 1999; Rankinen et al., 2000; MacArthur and North, 2005; Eynon et al., Sessa et al., 2011, Sawczuk et al. 2011, and others). Its methods, however, are demanding from both financial and organisational aspects and they are currently applied only on the level of theoretical research.

Determination of the genetic component of sports performance of an individual is a new element of the clinical research in the field of sports medicine sciences as well as a demonstration of a new direction of the applied molecular genetics in sport. The attention of sport researchers is more and more orientated to the issue of genetic determination of performance, thus also to the issue of selection of individuals gifted for sport. Angiotensin converting enzyme (ACE) gene I/D polymorphism can be one of the genetic factors determinating the performance of athletes.

According to several authors, ACE gene I/D polymorphism has become a concrete element with evident effects on the physical performance of a man. Rennin-angiotensin system (RAS) exists as an endocrinal regulator regulating also certain specific functions of the human body. Puthucheary et al., (2011) confirmed significant relation of I (insertion) allele in athletes practicing endurance kinds of sport. Their research demonstrated that I allele is closely tied to body resistance against a long-time load. On the other hand, D (deletion) allele associates with power sports performance. They also confirmed that there are exceptions, which cannot be included into any of these specific categories. For example, where the sample included both athletes (triathlonists) and well-prepared and fit soldiers, no relation between the ACE gene and the level of performance was found (Puthucheary et al., 2011).

An important and yet unanswered question is the role of genotype in improvement of physical performance in the course of intensive training and in determination of training duration and intensity necessary for individuals of various genotypes to reach a comparable change, where relations between specific genes and the initial level of motor performance (such as in selection of talented children) exist.

It is also necessary to stress that there are also studies, which did not unanimously prove the association between the sports performance and ACE gene (Nazarov et al., 2001, Mayerson et al., 1999; Yang et al. 2005; Scott et al, 2005). When the research is focused on examination of athletes with combined motor abilities (swimmers, water sports, skiers, triathlonnists etc.), the relations are not always confirmed and that is the problem. The endurance component of triathlonists' performance is definitely different from that of swimmers, rowers or skiers. Discrepancies found within those researches can relate in particular to improper selection of samples. This should be taken into account, therefore the conditions of selection must be united and the research must include only uniform groups practicing the same kind of sport.

Thus, a successful genetic analysis depends in particular on correctly defined requirements of determination of relations between genetic predispositions and motor abilities. Mayerson et al. (1999) recorded proportional linear representation of I allele in 91 Olympic runners in dependence on the track length. In other words, the longer the track, the higher the occurrence of I (insertion) allele in athletes. When assessing a group of other 404 Olympic athletes practicing a mixture of 19 kinds of sport (where endurance was not the key criterion of performance), occurrence of I allele was about the same as in the control group. Therefore, it appears that from the methodological aspect, the primary condition of determination of relations between genetic predispositions and motor performance, in addition to homogenous samples, is namely the criterion of performance (Hruškovičová, Šelingerová & Šelinger; 2005, Hruškovičová et al., 2006; Jaklič & Šelingerová, 2010).

This was also the focus of our research, which purpose was to ascertain the interaction between the genetic predisposition and performance of athletes practicing endurance and

speed/power kinds of sport. We assume that there are differences in the distribution of genotypes in selected athletes chosen according to the criterion of performance and the control group of non-sporting population.

Methods

The groups of athletes were selected based on both the published information and our own experience in research focused on the talented youth selection for sport. The purpose of our study was to find relations between the ACE gene I/D polymorphism and the level of a specific motor activity – maximum running speed and running endurance. Based on those attributes, our research included three samples – athletes of the junior age group, adult athletes of various levels of performance and the control group of non-sporting population.

The research samples included:

- Ice-hockey players from Bratislava (n = 162) of the average age of 13.0 years (sd = 1.79). The genetic analysis of boys was evaluated according to the criterion of running performance at maximum speed on 15 m track with 20 m start-up section. Within this section, we selected six consecutive running steps performed at maximum speed. The speed of steps was measured by a special device for measurement of running step kinematic parameters (Šelinger, 1993).
- Participants of the International Marathon of Peace in Košice, aged 18 to 77 years (215 marathon runners and 222 half-marathon runners). The genotype frequency in both groups was assessed according to placing.
- The control group of healthy non-sporting individuals (n = 252 subjects) of the average age of 14.6 years (sd = 4.38).

Methodology of the genotype examination

In both groups of athletes as well as in the control group, we examined the genotype for angiotensin converting enzyme (ACE), located on q23 of chromosome 17, which takes part in regulation of enzyme level in the body. There are two allele forms of the gene, differring from each other by presence or absence of 287 bp in intron 16. D (deletion) allele relates to a higher level of plasmatic ACE, while I (insertion) allele relates to its lower level. The highest level of ACE in plasma was found in homozygous D/D forms and the lowest one in homozygous I/I forms. Blood samples were analysed in the Laboratory of Clinical and Molecular Genetics of Detská fakultná nemocnica s poliklinikou in Bratislava. The results of DNA analysis were assessed based on the χ^2 statistic. Data were compared with those of the control non-sporting group by means of standard methods of statistics.

Results

Ice hockey

The genotype and frequency of individual alleles in ice-hockey players was assessed according to their level of performance reached in running speed (Fig. 1). We ascertained that the D/D genotype determinates the level of the maximum running speed. In group IH1 (fast players), differences were found between ACE genotype and control group at 1 %

level of statistical significance. In group IH2 (slow players), significantly higher number of homozygous forms of I/I genotype was confirmed in comparison to D/D forms ($p < 0.01$).

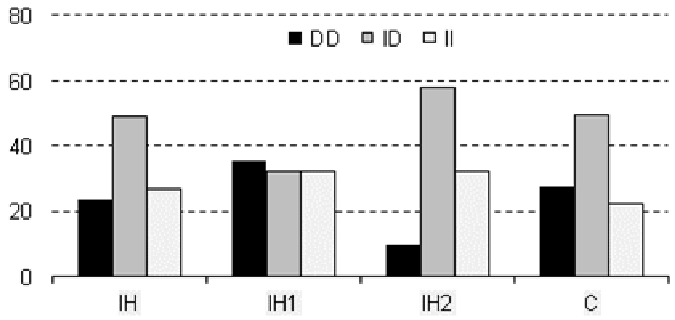

Figure 1

Relative frequencies of ACE gene in ice hockey players

IH – Ice-hockey players, n = 126
IH1 – Selection of 31 ice-hockey players with the highest level of running speed out of 126 tested persons
IH2 – Selection of 31 ice-hockey players with the lowest level of running speed out of 126 tested persons
C – Control group, n = 252

The occurrence of D/D genotype in ice-hockey players with below-average to low running speed was minimised to 9.7 %, but the occurrence of I/I genotype was similar to that of the speed-type boys. On the other hand, the heterozygous I/D form was found in as many as 58 % of slow-type boys. Therefore, we believe that a significantly higher number of heterozygous I/D genotypes could relate to speed-endurance predispositions of ice-hockey players (Fig. 1). This was confirmed also by the analysis of individual alleles occurrence: D (deletion) and I (insertion). The difference between D and I allele frequency in speed-type boys (group IH1) was statistically insignificant; however, we found significantly high occurrence of I allele in slower boys (group B). The statistical difference between individual alleles was on the level of 1% significance (Table 1).

Table 1

Relative frequencies of I and D alleles in ice hockey players

	I allele	**D allele**	**Diff.**	**X^2 –stat.**	**n**
IH – Ice hockey players	51.6	48.4	3.2	0.7922	126
IH – Selection of ice hockey players with the highest running speed	48.4	51.6	3.2	0.8015	31
IH2 – Selection of ice hockey players with the lowest level running speed	61.3	38.7	22.6	0.0050**	31
C – Control group	47.2	52.8	5.6	–	252

Marathon and half-marathon

Significant differences in frequency of individual ACE genotypes were found also in marathon runners divided according to their placing (Fig. 2, Table 2). In top-performance marathon runners (placed no worse than 50th, group A) and average-performance marathon runners (placed 51st to 200th, groups M2-M4), differences between individual genotypes were found on the level of 5 % significance by means chi-quadrate test. Important is that D/D genotype was not found in the group of top marathon runners (group M1). The lower the performance, the higher was the frequency of D/D genotype. The heterozygous form of I/D genotype was high in runners placed no worse than 100th (groups M1 and M2). Statistically significant differences ($p \leq 0.05$) against the control group were found only in the groups of the first three performance categories (placed no worse than 150th).

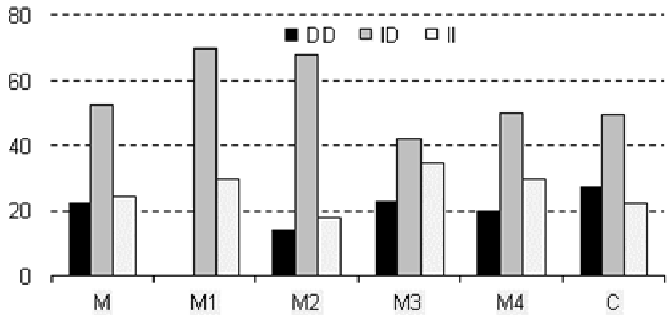

Figure 2

Relative frequencies of ACE gene in marathon runners

M – Marathon runners, n = 215
M1 – Placing 1...50, n = 20
M2 – Placing 51…100, n = 28
M3 – Placing 101…150, n = 26
M4 – Placing 151…200, n = 30
C – Control group, n = 252

Table 2

Relative frequencies of I and D alleles in marathon runners

	I allele	**D allele**	**Diff.**	**χ^2 –stat.**	**n**
M – Marathon runners	50.9	49.1	1.9	0.4574	215
M1 – Placing 1 … 50	65.0	35.0	30.0	0.0004**	20
M2 – Placing 51 … 100	51.8	48.2	3.6	0.3600	28
M3 – Placing 101 … 150	55.8	44.2	11.5	0.0868	26
M4 – Placing 151 – 200	55.0	45.0	10.0	0.1191	30
C – Control group	47.2	52.8	5.6	–	252

In the group of half-marathon runners, higher representation of I/I genotype was found only in participants placed no worse than 100th. Significance of differences between the athletes and the control group was not confirmed (Fig. 3, Table 3).

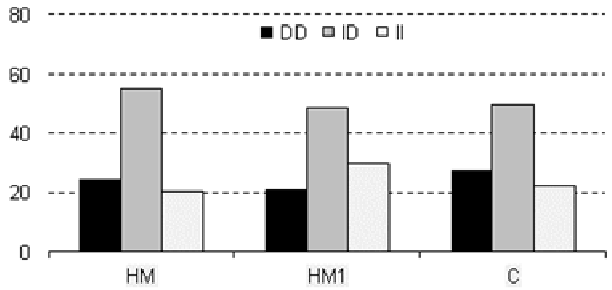

Figure 3

Relative frequencies of ACE gene in half-marathon runners

HM – Half-marathon runners, n = 222

HM1 – Placing 1...50, n = 47

C – Control group, n = 252

Table 3

Relative frequencies of I and D alleles in half-marathon runners

	I allele	**D allele**	**Diff.**	**χ^2 –stat**	**n**
HM – Half-marathon runners	47.8	52.3	4.5	0.9155	222
HM 1 – Placing 1 … 100	54.3	45.7	8.5	0.1585	47
C – Control group	47.2	52.8	5.6	–	252

he achieved results witness the relation between ACE gene I allele and endurance sports performance (Table 1 – 3). It appears that I (insertion) allele of the ACE gene can be one of the factors affecting the endurance load. At the same time, presence of D (deletion) allele can be a benefit for speed/power sports load or kinds of sport, where the speed and power elements are preferred to endurance. This fact was highlighted e.g. in studies of Mayerson et al. (1999) and Nazarov et al. (2001).

The genotype of the control group of non-sporting population was similar to the entire group of marathon runners and half-marathon runners (regardless the sports performance criterion). This information confirms the necessity of genetic presumptions assessment according to specification of research samples. Despite the high number of athletes in individual kinds of sport, it is impossible to obtain exact results if the above performance criterion was not taken into account and highly specific research conditions were not met.

Conclusion

With the help of the genetic analysis of blood samples of athletes and control group members, we reached the following conclusions:

1. We found a shift in the genotype frequency of homozygous (D/D) form occurrence in the selected group of speed-type boys. When compared to the control group, significantly higher representation of D/D genotype was found in boys of the speed type, while represenттation of D/D genotype in boys with below-average running speeds was only on the level of 10%. I allele was found in as many as 61.3% of boys with below average running speed, D allele was lower in boys with high speed predispositions (48.4 %). We did not record higher frequency of I/I homozygous genotype in ice-hockey players who had not reached the expected level of speed. The increased frequencies of the heterozygous I/D genotype form indicate predispositions for speed and endurance, which combination is the decisive factor of success in ice hockey (such as speed, strength, endurance in speed).

2. Significant differences in individual ACE genotypes frequency were found also in marathon runners divided according to their placing. Significant differences were found namely in top marathon runners (placed no worse than 50^{th}) and marathon runners of the middle category (placed 51^{st} to 200^{th}). Important information is that the occurrence of D/D genotype was not recorded in the group of top runners, while the frequency of D/D genotype occurrence was increasing with the decreasing performance of runners. The occurrence of the heterozygous I/D genotype form was high in marathon runners placed no worse than 100^{th}. Statistically important differences against the control group of non-sporting population ($p \leq 0.05$) were found only in groups of the first three performance categories (placed no worse than 150^{th}).

3. In the group of half-marathon runners, higher occurrence of I/I genotype was found only in participants placed no worse than 100^{th}. Significance of differences between the athletes and the control group was not confirmed.

The study demonstrated significant occurrence of I/I genotype in endurance athletes of the top performance category as well as significant occurrence of D/D genotype in athletes showing high levels of the maximum running speed. When making a thorough analysis of frequency of all three genotype forms in both groups of athletes, however, we must consider also the option that the sports performance is firmly tied not only to speed and to endurance in the simplified form, but also to strength, endurance in speed and other combined motor abilities.

References

1. BROWN, J. 2001. Sports talent. How to identify and develop outstanding athletes. *Human Kinetics Publ*., Champaign (III), 2001.
2. EYNON, N., ALVES, A. J., YAMIN, C., SAGIV, M., DUARTE, J. A., OLIVEIRA, J., AYALON, M., GOLDHAMMER, E., SAGIV, M., MECKEL, Y. 2009. Is there an ACE ID – ACTN3 R577X polymorfisms interaction that influences sprint performance? *Int. J. Sports Med.* 30, 2009, 12, p. 889-91.
3. HRUŠKOVIČOVÁ, H., ŠELINGEROVÁ, M., ŠELINGER, P. 2005. Genetická determinácia bežeckej rýchlosti. In ŠELINGEROVÁ, M., ŠELINGER, P. *Sledovanie rozvoja pohybových schopností a výkonnostného rastu športovo talentovaných detí a mládeže v závislosti od úrovne ich bio-*

logickej zrelosti. Zborník príspevkov projektu grantovej úlohy č. 1/7205/20. Bratislava : ICM Agency , 2005, p. 20-23.

4. HRUŠKOVIČOVÁ, H., DZURENKOVÁ, D., ŠELINGEROVÁ, M., BOHUŠ, B., TIMKANIČOVÁ, B., KOVÁCS., L. 2006. The angiotenzin converting enzyme I/D polymorfism in long distance runners. *J. Sports Med. Phys. Fitness*. 2006, 46, p. 209-213.
5. JAKLIČ, H., ŠELINGEROVÁ, M. 2010. The angiotensin converting enzyme I/D polymorfism and physical performance. *Eur. J. Human Genetics*. 2010, 18, 1, p. 201.
6. MacARTHUR, D. G., NORTH, K. N. 2005. Genes and human elite athletic performance. *Hum. Genet.* 2005, 116, p. 331-339.
7. MAYERSON, S., HEMINGWAY, H., BUDGET, R., MARTIN, J., HUMPHRIES, S., MONTGOMERY, H. E. 1999. Human angiotensin I-converting enzyme gene and endurance performance. *J. Appl. Physiol*. 1999, 87, p. 1313-1316.
8. MONGOMERY, H. E., MARSHALL, R., HEMINGWAY, H., MAYERSON, S., CLARKSON, P.,DOLLERY, C. et al. 1998. Human gene for physical performance. *Nature.* 1998, 393, p. 221-222.
9. MONTGOMERY, H. E. et al. 1999. Angiotensin-converting enzyme gene insertion/deletion polymorphism and gene response to physical training. *Lancet.* 1999; 353, p. 541-545.
10. NAZAROV, I. B., WOODS, D. R., MONTGOMERY, H. E., SHNEIDER, O. V., KAZAKOV, V. I., TOMILIN, N. V., ROGOZKIN, V. A. 2001. The angiotensin converting enzyme I/D polymerphism in Russian athletes. *Eur. J. Human Genetics.* 2001, 9, 10, p. 797-801.
11. PUTHUCHEARY, Z., SKIPWORTH, J. R., RAWAL, J., LOOSEMORE, M., VAN SOMEREN, K., MONGOMERY, H. E. 2011. The ACE gene and human performance: 12 years on. *Sports Med.* 2011, 41, 6, p. 433-48.
12. RANKINEN, T., PERUSSE, L., GAGNON, J., ChAGNON, Y. C., LEON, A. S., SKINNER, J. S. et al. 2000. Angiotensin-converting enzyme ID polymorfism and fitness phenotype in heritage family study. *J. Apll. Physiol.* 2000, 88, p. 1029-1035.
13. RANKINEN, T., WOLFARTH, B., SIMONEAU, J. A., MAIER-LENZ, D., RAURAMAA, R., RIVERA, M. A., BOULAY, M. R., CHAGNON, Y. C., PERUSSE, L., KEUL, J., BOUCHARD, C. 2000. No association between the angiotensin-converting enzyme ID polymorphism and elite endurance athlete status. *J. Appl. Physiol.* 2000, 88, p. 1571-1575.
14. SAWCZUK, M., MACIEJEWSKA, P., CIESZCZYK, P., EIDER, J. 2011. The role of genetic research in sport. *Science & Sports.* 2011, 26, p. 251-258.
15. SCOTT, R. A., MORAN, C., WILSON, R. H., ONYWERA, V., BOIT, M.K., GOODWIN, W. H., GOHLKE, P., PAYNE, J., MONTGOMERY, H., PITSILADIS, Y. P. 2005. No association between angiotensin converting enzyme (ACE) gene variation and endurance athlete status in Kenyans. *Comaparative Biochemistry and Physiology.* 2005, 141, p. 169-175.
16. ŠELINGER, P. 1993. Meassurement of running kinematical parameters. Proceedings of II. International Symposium „Sport of the Young". Ljubljana – Bled, 1993, p. 1-4.
17. SESSA, F., CHETTA, M., PETITO, A., FRANZETTI, M., BAFUNNO, V., PISANELLI, D., SARNO, M., IUSO, S., MARGAGLIONE, M. 2011. Gene polymorfisms and sport attitude in Italian athletes. *Genet. Test Mol. Biomarkers*. 2011, 15, 4, p. 285-90.
18. WOODS, D. R., WORLD, M., RYASON, M. P. et al. 2002. Endurance enhancement related to the human angiotensin I-corventing enzyme I-D polymorfism is not due tu differences in the cardiorespiratory response to training. *Eur. J. Appl. Physiol*. 2002, 86, p. 240-244.
19. YANG., N., MACARTHUR, D., WOLDE, B., ONYWERA, V. O., BOIT, M. K., WILSON, R. H., SCOT, R. A., PITSILADIS, Y. P., NORTH, K. 2005. ACTN3 genotype is not associated with elite endurence status in Ethiopians and Kenyans. *Med. & Science in Sports & Exercise.* 2005, 37, 5, p.472.

RESUMÉ

INZERČNO-DELEČNÝ POLYMORFIZMUS GÉNU PRE ANGIOTENZÍN KONVERTUJÚCI ENZÝM (ACE) VO VZŤAHU K BEHU MAXIMÁLNOU BEŽECKOU RÝCHLOSŤOU A K VYTRVALOSTNÉMU BEHU

Mariana Šelingerová, Helena Jaklič, Peter Šelinger, Dagmar Dzurenková

V rámci výskumu sme sa zamerali na zistenie genetických predispozícií pre bežeckú rýchlosť a vytrvalosť v behu. Prvú skupinu tvorili žiaci športových tried v Bratislave s hokejovým zameraním. Priemerný vek tejto 162-člennej skupiny bol 13,0 rokov. Druhú skupinu tvorili dospelí športovci (maratónci, n = 215 a polmaratónci, n = 222) vo veku 18 až 77 rokov. Vyšetrili sme aj genotyp kontrolnej skupiny nešportovcov (n = 252), priemerného veku 14,6 roka. U hokejistov sme zistili pozitívny vzťah medzi polymorfizmom génu ACE a maximálnou bežeckou rýchlosťou. Voči kontrolnej skupine mali chlapci rýchlostného typu signifikantne vyššie zastúpenie genotypu D/D (35,5 %) a naopak chlapci podpriemernej bežeckej rýchlosti mali relatívne zastúpenie genotypu D/D nižšie (len 10 %). Alela I sa vyskytla až u 61,3 % chlapcov podpriemernej rýchlosti, rozdiel voči alele D bol štatisticky významný ($p < 0,01$). U maratóncov, ktorí sa umiestnili do 150. miesta, sme potvrdili vysokú frekvenciu výskytu inzerčnej alely I (55,8 %) ako aj genotypu I/I (34,9 %). U bežcov polmaratónu umiestených do 100. miesta bola frekvencia alely I zastúpená v 53,3 % a frekvencia genotypu I/I v 30 %.

PHYSICAL PERFORMANCE OF YOUNG ATHLETES ACCORDING TO BIOLOGICAL MATURITY

POHYBOVÁ VÝKONNOSŤ ŠPORTUJÚCICH DETÍ A MLÁDEŽE V ZÁVISLOSTI OD BIOLOGICKEJ VYSPELOSTI

Marcela Geciová

The aim of our work was focused on physical performance of young athletes depending on somatic development and their biological maturity. We would like to identify changes in physical performance, somatic characteristics during two years. We focused on relations between physical performance, somatic development and biological maturity of adolescent athletes. The sample consisted of swimmers and hockey players aged from 10 to 13 years old. Only ice hockey players achieved extraordinary performance in strength according to somatic development. At the end of research we confirmed our assumption, that somatic characteristics and strength of the girls stopped developing. Changes in two years in standing long jump were dynamic in somatic accelerated children. Special physical performance in both sports is determined by strength and velocity. We did not confirm assumption about higher changes in the bone age instead of somatic age in two years period. We found out that general physical performance depends on biological maturity more in a group of boys. According to our research, we recommend, that adolescent athletes should be more generally orientated during the training. Physical performance of adolescent boys should be evaluated according to bone age or somatic age.

***Supervisor**: RNDr. Mariana Šelingerová, PhD.*

DEPENDENCE OF PERFORMANCE AND SOME KINEMATICAL FACTORS IN SHOT PUT

ZÁVISLOSŤ VÝKONU VO VRHU GUĽOU OD VYBRANÝCH KINEMATICKÝCH PARAMETROV TECHNIKY

Marek Hardoň, Martin Vaváček

The work deals with the structural biomechanical analysis of some kinematic parameters and performance on glide and rotational shot put technique. The aim of the thesis is to find out and compare selected biomechanical parameters in relations to the sports performance in the glide and rotational shot put technique with 3D biomechanical analysis. Then to contribute to the clarification of the relationships between selected indicators of activity of the shot put techniques and sport performance with the possibility of applying regression and subsequent prediction. It is based on an ex post facto research type. Monitored group consisted of selected Czech shot putters, who took part in official outdoor competition organized by the Czech Athletics Committee. Research has confirmed that regardless of the technique used by shot putters at the competition, their performance significantly dependents on the size of the angle of rotation axis arm performance to the axis of the basin in the moment of double – support phase (glide, r = 0,818, rotation technique, r = 0,861). On the basis of multiple correlation analysis, we can confirm that the vertical component of the common centre of gravity velocity of the body from the moment of basic support phase to double-support phase is one of the most important parameters of glide technique. It contributes to sport performance in glide technique with 44, 25 %. Parameter of maximum angular speed of the elbow in the rotation technique from the moment of taking basic support phase to double support phase leads shot put performance with 35, 93 %. On the basis of acquired knowledge can be stated that regardless of the technique used, we recommend to take a position as quickly as possible with the as longest double – support phase as possible. In this work we wanted to contribute to a comprehensive perspective in the area of influence of biomechanical factors on the shot put performance as well as to extend sphere of knowledge including the topic which we have never met in the literature which was available.

***Supervisor**: Assoc. prof. Marián Vanderka, PhD.*

LEVEL AND THE RELATIONSHIPS BETWEEN THE SPECIAL TESTS, FUNCTIONAL RESPONSE OF ORGANISM AND SPORTS PERFORMANCE OF THE COMPETITIVE SWIMMERS

ÚROVEŇ A VZŤAHY MEDZI ŠPECIÁLNYMI TESTAMI, FUNKČNOU ODOZVOU ORGANIZMU A ŠPORTOVÝM VÝKONOM VÝKONNOSTNÝCH PLAVCOV

Marián Hrabovský

The work focuses on performance level in special motoric tests, its changes, and relations between functional parameters, test performance, and the best performance of competitive swimmers. It also explores dependence of the sport performance described by selected parameters in the science of sport kinanthropology. Parameters, examined on groups of 14 – 17 years old male swimmers (n = 12) and 14 – 17 years old female swimmers (n = 12), were: performance in special tests – 800 m, 1 500 m, 3 000 m freestyle, and functional response of organism to load – heart rate, maximal lactate, lactate after 20 minutes, descent of lactate. Tests were performed in 50 m swimming pool during 5 periods of one year preparation. Changes in functional parameters confirm the performance raise. Dependence between lactate parameters has been found in all tests, low conditionality between sport performance and functional parameters and its high determination by special tests performance. The most versatile test to determinate the body's readiness for sport performance was 800 m freestyle. The most convenient aerobic endurance test was 3 000 m freestyle.

Supervisor: *Doc. PaedDr. Yvetta Macejková, PhD.*

THE IMPACT OF COOPERATIVE LEARNING IN PHYSICAL EDUCATION AND SPORTS FOR CHANGING THE CLIMATE OF THE CLASS

VPLYV KOOPERATÍVNEHO UČENIA V TELESNEJ A ŠPORTOVEJ VÝCHOVE NA ZMENU SOCIÁLNEJ KLÍMY

Martina Pánisová

This thesis aims to solve the research situation of the science branch Sports Educology. The aim of this research is to bring new research findings on the impact of cooperative learning in physical education and sports for changing the social climate of the class. The main tasks were to find out preference relations among pupils and change of variables of the social climate in the classroom. We found out that the effect of cooperative learning has positive effects on preference relations in the group with a more positive influence for girls. Experimental factors were cooperative activities that are applied to the learning process. We have found that the effect of cooperative learning positively affects the relationships in a group with more positive influence on girls. On the basis of the statistical data we may conclude that the implementation of cooperative learning in physical education and sport is statistically significantly contribute to the shaping of positive preference relations of pupils and highly statistically significant in the girls' groups. The results of the social climate of the classroom in its conclusion bring the facts that the cooperative learning significantly improves most of the variables of the social climate of the classroom for girls taking a student learning the 1 % level of statistical significance ($p \leq 0,01$), variable in the relationship between students at 1 % level of statistical significance ($p \leq 0,01$), variable orientation of students to tasks at the 5 % level of statistical significance ($p \leq 0,05$) and only one variable for boys taking a student learning the 10 % level of statistical significance ($p \leq 0,10$). Using cooperative learning in physical education and sport contributes to the improvement of sociometric indices (positive sociometric status and resulting status) in the output sociometric test for girls and boys.

Supervisor: *Assoc. prof. PaedDr. Janka Peráčková, PhD.*

THE EFFECTIVENESS OF COEDUCATIONAL PHYSICAL AND SPORT EDUCATION AT SECONDARY SCHOOLS

EFEKTÍVNOSŤ KOEDUKOVANÉHO VYUČOVANIA TELESNEJ A ŠPORTOVEJ VÝCHOVY NA GYMNÁZIÁCH

Veronika Dančíková

The research was focused on the issue of coeducational physical and sport education at secondary schools. It was a two-group, time-parallel pedagogical experiment in natural conditions of school physical and sport education. We surveyed the impact of an experimental factor on the attitudinal change of students' opinions to physical and sport education, to physical activity and class climate, using standardized questionnaires. We also surveyed motor skills in volleyball and basketball as well as attendance in each group. The experimental factor in our experiment was the coeducation of physical and sport education. It resulted in different opinions between groups but also between genders in the group. Results and opinions were analyzed and compared to results and opinions of our control group.

We assumed that the coeducational classes will influence the students´ attitudes to sports activities differently. We assumed positive impact on girls but negative on boys. Our hypothesis was confirmed. Attitudes of boys who attended coeducational physical and sport education focused on physical activity were statistically significantly worse after this experiment. Girl's attitudes who attended coeducational physical and sport education are changing to better ones, three of six dimensions even with statistical significance. To sum it up we can conclude, that coeducation of physical activities has positive impact on girl's attitudes to movement activities, but negative on boys.

Regarding the class climate we cannot state that coeducation has a significant impact on some components of the class climate. The difference between an input and output results of the class competition, difficulty of learning and class cohesion were without important changes. The only statistical significance was found in the cases of conflict and satisfaction in experimental group. No major differences were found also when we compared the results of boys and girls separately. To sum it up we can state, that coeducation has slightly positive impact to the class climate, but it differs from one class to another, due to this fact, that each class represents unique social environment.

Experimental group as well as control group in volleyball and basketball skill tests improved significantly. Despite the higher number of pupils at coeducational lessons, we observed a statistically significant improvement in skills, and therefore we believe that coeducational physical education is a good alternative in teaching sports games in schools with limited space possibilities.

We conclude that coeducational physical and sport education is a good alternative of physical and sport education for adolescents. In particular, girls changed their opinions positively. Coeducational physical and sport education can be one of the types of lessons, which encourages girls to be more actively involved and also could helps to decrease their absence from physical and sport education lessons.

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ACTA FACULTATIS EDUCATIONIS PHYSICAE
UNIVERSITATIS COMENIANAE

Publicatio LII/II

Vydala Univerzita Komenského v Bratislave
Vytlačilo Polygrafické stredisko UK v Bratislave

ISBN 978-80-223-3329-0