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Foreword

Dear readers,

eight years ago, we were sitting around discussing the concept of the Exercitatio Corporis - Motus – Salus journal with our fellow founding members. We wanted to provide our readership with as much knowledge from the field of sport science as possible. The journal was born from the foundations laid by 'Pohyb, šport, zdravie' – a series of collections of scientific papers that had been published for many years. During its lifetime, that journal developed and underwent minor and major changes in reaction to the needs of society as well as to the domestic and global situation in the field of sport science.

Today, it is an honour for me to present the new peer-reviewed ***Slovak Journal of Sport Science (SJSS)*** *and add a few introductory words at the occasion of its first publication.*

The mission of the Slovak Journal of Sport Science is to present information from the field of sport science and other related scholarly fields with the primary focus on a) sports educology, b) sports humanistics, and c) sports kinanthropology. Its aim is to provide researchers, experts, and also the public with the results and conclusions of contemporary applied research conducted both in Slovakia and abroad.

The scientific quality of the ***Slovak Journal of Sport Science*** *at an international level will be guaranteed by a scientific board which consists of world-recognized foreign experts in the field of sport science who peer review internationally credited journals not only in Europe, but across the world.*

The goal of the editor-in-chief and the journal management is to create opportunities for scientists and their teams to present, discuss, and reflect on the current situation in the field, from both theoretical and practical perspectives, by publishing scientific studies, essays, reviews, annotations, information and reports which analyse the topic of practical physical education at a high scientific and professional level. Moreover, through this process we would like to encourage further research and development in the field of sport science not only among our contributors, but among as many experts from different research institutions as possible, both in Slovakia and abroad. Therefore, our journal management is working on inclusion of the journal in internationally recognized databases such as Scopus and Web of Science. However, if we want to improve the level of the journal from the perspective of scientific evaluation, it is necessary to cite published articles in recognized and indexed domestic and foreign journals.
The Slovak Journal of Sport Science is a progressive and up-to-date journal published in English and accompanied with Slovak abstracts in order to effectively disseminate knowledge internationally. The journal has been given a new management, an international scientific board and a new logo; it is published both in print and on-line at http://www.sjss.sk/. The

periodicity will remain as before – an issue will be published twice a year (June and December) – as will the original structure including the anonymous peer-reviewing process.
The Slovak Journal of Sport Science (SJSS) will be published by the Department of Physical Education and Sport at The Faculty of Arts of Matej Bel University in Banská Bystrica in cooperation with Slovak Conditioning Trainers Association (SAKT).

We look forward to receiving all feedback, e-mailed or in person especially your comments and ideas, because they enable us to keep improving.

I wish this project all the best and conclude with my hopes for its future: May the ***Slovak Journal of Sport Science*** *enhance open communication, live a long life, and meet the expectations of both laymen and experts. May the readers learn as much as possible, and engage in interesting discussions, and may the contributors find satisfaction in seeing their works published in a prestigious journal.*

In Banská Bystrica, 01. June 2016

prof. PaedDr. Ľudmila Jančoková, CSc.
Editor-in.chief

GENDER DIFFERENCES AMONG UNIVERSITY STUDENTS IN FLEXIBILITY AND MUSCLE STRENGTH: A PILOT STUDY

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The major objective of this study was identifying the differences in morphological characteristics and motor abilities pertaining to strength and flexibility between male and female students. The study sample participants were male and female subjects aged between 18 and 32 years. The sample included 100 university students (50 males and 50 females). The variables used for anthropometric measure assessment included the following: height, weight and body mass index. The following variables were used to assess strength: Strength shoulder extension left, Strength shoulder extension right, Strength shoulder flexion left, Strength shoulder flexion right. The study participants' flexibility was tested by means of the following variables: Extension body, Flexion body, Flexion body, Shoulder flexion left, Shoulder extension left, Shoulder flexion right, Shoulder extension right, Neck flexion, Neck extension, Neck lateral flexion left, Neck lateral flexion right. Independent samples T-test was used for determining statistically significant difference between genders for parameters pertaining to strength and flexibility assessment for each individual variable. The results of the tests used for determining the levels of motor ability in male and female university students indicate statistically significant differences at the level of the motor domain strength but not for the motor domain flexibility, for which none of the parameters measured showed statistically significant difference.

INTRODUCTION

Contemporary ways of living and working are marked by mostly static exertion, characterized by very low levels of locomotor apparatus deployment, and consequent adverse effects on the human organism. The human organism is an individual organized entity, and includes various dimensions of psychosomatic status. A host of factors exert an influence on modifying these dimensions in a positive or negative way. Technological development across all social domains have affordedhumankind certain advantages, mostly embraced by humans witha view to a more comfortable existence, yet these have also resulted in insufficient motor stimuli more generally, to the extent that the very existence of humans is brought into question. A number of studies have demonstrated that people have in fact become addicted to the modern way of life, engaging in physical activity insufficiently, even less than it is dictated by natural needs, which inevitably leads to 'modern-age' diseases as a consequence of a low level of functional ability.

One possible solution to this problem, identified based on experience in working with the university student population, could be to counteract the contemporary way of life by means of well-structured and expertly programmed physical activity (Aquatias, 2000; Dawson, Grant, Stinson & Chou, 2004). Such activity ought to be daily, for reasons of organism adaptation to new living conditions, influence on health status, increasing one's ability to work, as well as with a view to providingyoung people with active rest and relaxation. Practice,together with the results achieved while working with the student population, have to date demonstrated that physical activities varying in range and content may be unable to

produce desired results in terms of overall development unless practiced to a sufficient extent and at adequate time intervals (Nikolić & Madić, 2007). The reasons listed heretofore, as well as the fact that sport and recreation are currently not systematically included into studies at universities in Greeceand the consequent break in systematic physical activity following high-school education, inevitably lead to a stagnation of anthropological dimensions in the student population.

Regarding the university student population, one must bear in mind the fact that this period is still characterized by the body's growth and development, as well as by a development of motor abilities, including strength and flexibility (Arazi, Nia, Hakimi, &Mohamadi, 2012). Certain motor abilities, such as explosive strength, reach their peak manifestation during this period(18-22 years), whereas further growth and development are possible for others, primarily flexibility and endurance, usually owing to controlled and systematic physical activity (Pavlović, 2005; Arazi, Nia, Hakimi, & Mohamadi, 2012).

In view of the results obtained in studies to date, and taking into consideration the fact that the current higher education model does not provide a solution to the problem of organizing compulsory physical activity, a study was needed into the differences in morphological characteristics and certain motor abilities of university students. Consequently, the major objective of this study was identifying the differences in morphological characteristics and motor abilities pertaining to strength and flexibility between male and female students at the Alexander Technological Educational Institute of *Thessaloniki, Greece*.

METHODOLOGY

The study sample participants were male and female subjects aged between 18 and 32 years. The sample included 100 students (50 males and 50 females) at the Alexander Technological Educational Institute of *Thessaloniki, Greece*. All study participants were at the time full-time university students following an undergraduate academic study program.

The variables used for anthropometric measure assessment included the following: height (BH), weight (BW), and body mass index (BMI)[1]. The instruments used to assess these variables were the anthropometer and the Omron BF 530 scales. The following variables were used to assess strength in students of both sexes: Strength shoulder extension left (kg), Strength shoulder extension right (kg), Strength shoulder flexion left (kg), Strength shoulder flexion right (kg). The Jamar dynamometer was used to measure strength. The study participants' flexibility was tested by means of the following variables: Extension body (^{0}), Flexion body (^{0}), Flexion body (cm), Shoulder flexion left (^{0}), Shoulder extension left (^{0}), Shoulder flexion right (^{0}), Shoulder extension right (^{0}), Neck flexion (^{0}), Neck extension (^{0}), Neck lateral flexion left (^{0}), Neck lateral flexion right (^{0}), all of which were measured using the goniometer.

Testing took place in the dedicated kinesitherapy space at the Alexander Technological Educational Institute of *Thessalonikiin the morning. Light, temperature and humidity conditions were optimal. All testing was conducted in accordance with the ethical principles of conducting research on humans according to the 2008 Helsinki Declaration* (World Medical Association, 2011).

All data obtained in this study were analyzed by means of the statistical software SPSS 20. Descriptive statistics parameters, both central tendency and dispersion, were calculated for all variables, including: arithmetic mean (Mean); standard deviation (SD); minimal result (Min); maximum result (Max); Skewness (Skew) and Kurtosis (Kurt).

Independent samples T-test was used for determining statistically significant difference at the univariate level between the male and female student participantsfor parameters pertaining to strength and flexibility assessment for each individual variable.

[1] BMI was calculated using the formula BMI = body mass (kg)/(body height (m), according to Daley & Spinks (2000).

RESULTS

Table 1 Descriptive statistics for subjects' age

Gender	N	Mean	SD
Male	50	20.88	2.48
Female	50	19.92	1.19
∑	100	20.40	2.00

Table 1 provides data on the number of participants, as a whole group, male only, and female only, as well as their mean age with deviation.There were 50 participants in each gender group, the mean age of male subjects was 20.88± 2.48,while the mean age for women was 19.92 ± 1.19. The mean age for the participant group as a whole was 20.40 ± 2.00.

Table 2 Descriptive statistics for the parameters BH, BW, and BMI

Gender	Variable	N	Min	Max	Mean	SD	Skew	Kurt
Male	**BH**	50	165.00	196.50	178.47	5.87	.35	1.12
Male	**BW**	50	60.40	130.20	79.65	12.90	1.73	4.46
Male	**BMI**	50	12.60	36.80	24.74	3.87	.54	3.51
Female	**BH**	50	150.50	179.00	164.05	6.51	-.01	-.59
Female	**BW**	50	45.60	86.70	59.96	9.01	.80	.67
Female	**BMI**	50	17.40	30.80	22.30	2.59	.75	1.30
Total	**BH**	100	150.50	196.50	171.26	9.51	-.06	-.50
Total	**BW**	100	45.60	130.20	69.80	14.85	1.02	2.23
Total	**BMI**	100	12.60	36.80	23.52	3.50	.85	3.19

Table 2 presents descriptive statistics parameters for the following variables: BH, BW and BMI. Mean BH for men was 178.47± 5.87cm,and 164.05± 6.51cm for women. Mean BW for the male subjects was 79.65 ± 12.90kg,and 59.96kg ± 9.01kg for the female participants. Mean BMI for the men was 24.74 ± 3.87 kg/m² and 22.30 ± 2.59 kg/m² for the women.

Table 3 Descriptive statistics for variables assessing participants' strength

Gender	Variable		Min	Max	Mean	SD	Skew	Kurt
Male	**Strength shoulder extension left (kg)**	50	4.60	24.10	11.86	3.98	.97	1.21
Male	**Strength shoulder extension right (kg)**	50	4.20	23.80	11.23	4.70	.73	.21
Male	**Strength shoulder flexion left (kg)**	50	7.30	30.30	15.00	5.12	1.14	1.71
Male	**Strength shoulder flexion right (kg)**	50	6.10	32.40	16.98	6.84	.40	-.82
Female	**Strength shoulder extension left (kg)**	50	2.20	12.90	7.82	2.50	.33	-.47
Female	**Strength shoulder extension right (kg)**	50	1.70	18.30	7.45	3.42	1.31	2.01
Female	**Strength shoulder flexion left (kg)**	50	2.90	84.00	11.02	11.18	5.89	38.61
Female	**Strength shoulder flexion right (kg)**	50	3.50	26.20	9.70	4.39	1.10	2.45

Table 3 presents descriptive statistics parameters pertaining to the participants' strength: strength shoulder extension left (kg),strength shoulder extension right (kg), strength shoulder flexion left (kg) and strength shoulder flexion right (kg). The mean values obtained across the parameters for assessing strength for the men were: strength shoulder extension left (kg) (11.86±3.98), where the minimal result obtained was 4.60 and the maximum value was 24.10, setting the value range at 19.50; strength shoulder extension right (kg) mean was (11.23± 4.70),with the minimal result at 4.20 and the maximum one at23.80, and a result range of19.60; strength shoulder flexion left (kg) mean was (15.00± 5.12),with the minimum result 7.30 and maximum 30.30,providing a result range of 23; strength shoulder flexion right (kg) mean was (16.98±6.84),with the minimum value of6.10 and maximum one of32.40,giving a result range of 26.30.

The results obtained across strength assessment parameters for the women were as follows: strength shoulder extension left (kg) mean was (7.82±2.50), with a minimal obtained value of 2.20 and maximum one of 12.90,and a result range of 10.70; strength shoulder extension right (kg) mean was (7.45± 3.42), with a minimum result of 1.70 and maximum one of 18.30,giving a result range of 16,60; strength shoulder flexion left (kg) mean was (11.02± 11.18), with a minimum value of 2.90 and a maximum value of 84.00, and a result range of 81.10; strength shoulder flexion right (kg) mean was (9.70±4.39),with a minimum result of 3.50 and a maximum one of 26.20 and a result range of 22.70.

The men achieved higher mean values across all parameters assessing strength. The differences, however, were considerable, as corroborated by the T-test.

Table 4 Determining the differences between men and women in variables assessing strength

Variable	F	Sig.	t	Sig. (2-tailed)	F
Strength shoulder extension left (kg)	5.33	.023	6.08	98	.000
Strength shoulder extension right (kg)	5.59	.020	4.59	98	.000
Strength shoulder flexion left (kg)	.33	.560	2.28	98	.024
Strength shoulder flexion right (kg)	11.13	.001	6.32	98	.000

Table 4. presents the results for differences in the variables for assessing strength, obtained via an independent samples T-test. Based on the table, a difference can be discerned between the men and the women participants in terms of strength, with statistically significant differences in the following variables:strength shoulder extension left (kg),with a difference significance of (sig = .000); strength shoulder extension right (kg), with a difference significance of (sig = .000);strength shoulder flexion right (kg), with a difference significance of (sig = .000). For the variable strength shoulder flexion left (kg), a difference, albeit not statistically significant one, was found.

Table 5 Descriptive statistics for variables assessing the participants' flexibility

Gender	Variable	N	Min	Max	Mean	SD	Skew	Kurt
Male	**Extension body (^{0})**	50	12	60	32.12	10.35	.50	.26
Male	**Flexion body (^{0})**	50	70	155	109.02	19.07	.14	-.26
Male	**Flexion body (cm)**	50	-20.00	36.00	7.32	15.71	.19	-1.30
Male	**Shoulder flexion left (^{0})**	49	14	178	149.82	27.91	-3.06	12.40
Male	**Shoulder extension left (^{0})**	49	14	160	44.18	26.70	2.93	10.76
Male	**Shoulder flexion right (^{0})**	49	40	176	153.12	20.47	-3.64	19.21
Male	**Shoulder extension right (^{0})**	49	8	80	38.43	17.26	.30	-.02
Male	**Neck flexion (^{0})**	50	30	90	61.72	12.54	-.08	.21
Male	**Neck extension (^{0})**	50	30	90	65.36	12.49	-.28	.38
Male	**Neck lateral flexion left (^{0})**	50	20	64	40.52	9.51	.39	-.00
Male	**Neck lateral flexion right (^{0})**	50	26	76	42.24	9.78	.95	1.68
Female	**Extension body (^{0})**	50	12	88	31.18	13.05	1.67	6.02
Female	**Flexion body (^{0})**	50	38	190	108.60	21.97	.39	4.23
Female	**Flexion body (cm)**	49	-10.00	40.00	8.3367	14.24	.75	-.46
Female	**Shoulder flexion left (^{0})**	50	30	180	150.68	24.63	-3.09	12.40
Female	**Shoulder extension left (^{0})**	50	10	80	41.58	16.78	.05	-.61
Female	**Shoulder flexion right (^{0})**	50	126	192	155.62	13.11	.17	.51
Female	**Shoulder extension right (^{0})**	50	10	146	39.56	21.38	2.41	11.54
Female	**Neck flexion (^{0})**	50	40	110	63.70	14.74	1.34	2.34
Female	**Neck extension (^{0})**	50	20	106	66.90	16.16	-.10	.64
Female	**Neck lateral flexion left (^{0})**	50	20	94	42.10	11.10	2.37	9.81
Female	**Neck lateral flexion right (^{0})**	50	22	66	41.22	8.41	.76	1.51

Table 5 presents the descriptive statistics parameters used to assess the participants' flexibility, namely: extension body (^{0}), flexion body (^{0}), flexion body (cm), shoulder flexion left (^{0}), shoulder extension left (^{0}), shoulder flexion right (0), shoulder extension right (^{0}), neck flexion (^{0}), neck extension (^{0}), neck lateral flexion left (^{0}), and neck lateral flexion right (^{0}). The obtained parameter values pertaining to flexibility assessment for the men were: extension body (^{0}) mean was (32.12 ± 10.35),with a minimal value of 12 and maximum one of 60, giving a result range of 48; flexion body (^{0})mean was (109.02 ± 19.07), with a minimal result of 70and a maximum one of 155, and a result range of 85; flexion body (cm)mean was (7.32± 15.71), with a minimal value of -20and a maximum one of 36, and a result range of 56; shoulder flexion left (^{0}) mean was (149.82 ± 27.91), with a minimal value at 14 and maximum value at 178, and a value range of 164;shoulder extension left (^{0}) mean was (44.18 ± 26.70), with a minimal value of 14 and maximum value of 160, and a result range of 146; shoulder flexion right (0) mean was (153.12 ± 20.47), with a minimum value of 40 and maximum result of 176, and a value range of 136; shoulder extension right (^{0})mean was (61.72 ± 17.26),with a minimal value of8 and maximum one of80, and a value range of 72; neck flexion (^{0}) mean was (61.72 ± 12.54), with a minimum value of 30 and a maximum value of 90, providing a value range of 60; neck extension (^{0}) mean was (65.36 ± 12.49), with a minimum value of 30and a maximum value of 90, and a value range of 60; neck lateral flexion left (^{0}) mean was (40.52 ± 9.51), with a minimal result obtained 20 and maximum one 64, and a value range of44; neck lateral flexion right (^{0}) mean was (42.24 ± 9.78),with a minimum result of 26 and a maximum value of 76, and the value range of 50.

Parameter values obtained at testing the female participants for flexibility were as follows: extension body (^{0}) mean was (31.18 ± 13.05),with a minimum value of 12 and maximum value of 88, and a value range of 76; flexion body (^{0}) mean was (108.60 ± 21.97),with a minimal result of 38 and maximum one of 190, and a value range of 152; flexion body (cm) mean was (8.33± 14.24), with a minimal value at -10,and a maximum result of 40, and the result range of 50; shoulder flexion left (^{0}) mean was (150.68± 24.63),with a minimal result of 30and maximum result of 180, and a value range of 150; shoulder extension left (^{0}) mean was (41.58± 16.78), with a minimum value of 10 and maximum value of 80, and a value range of 70; shoulder flexion right (^{0}) mean was (155.62 ± 13.11), with a minimal value at 126 and maximum one of 192, setting the result range at 66; shoulder extension right (^{0}) mean was (39.56 ± 21.38), with a minimum value of 10 and maximum obtained value of 146, and a result range of 136; neck flexion (^{0}) mean was (63.70 ± 14.74), with a minimum value of 40 and maximum value of 110, and a result range of 70; neck extension (^{0}) mean was (66.90 ± 16.16), with a minimum result of 20 and maximum value of 106, and the result range of 86; neck lateral flexion left (^{0}) mean was (42.10 ± 11.10),with the minimum result at 20and maximum value at 94, and the range of70; neck lateral flexion right (^{0}) mean was (41.22 ± 8.41), with a minimum value of 22, maximum value of 66, and result range of 44.

Table 6 Difference assessment between the sexes across variablestesting flexibility

Variable	F	Sig.	t	Sig. (2-tailed)
Extension Body (^{0})	.59	.442	.39	.691
Flexion Body (^{0})	.05	.816	.10	.919
Flexion Body (cm)	2.36	.128	-.33	.737
Shoulder flexion left (^{0})	.41	.523	-.16	.871
Shoulder extension left (0)	.61	.435	.58	.562
Shoulder flexion right (^{0})	.88	.351	-.72	.471
Shoulder extension right (^{0})	.13	.710	-.28	.773
Neck flexion (^{0})	.37	.542	-.72	.471
Neck extension (0)	2.23	.138	-.53	.595
Neck lateral flexion Left (^{0})	.14	.704	-.76	.447
Neck lateral flexion right (^{0})	1.50	.223	.55	.578

Table 6 presents the results obtained by means of the independent samples T-test, pertaining to difference across the variables assessing flexibility parameters. Based on this table, no statistically significant difference can be discerned between the men and women participants regarding the variables pertaining to flexibility. There is difference favoring the male group for the following variables:

Extension body (^{0}), Flexion body (^{0}), Shoulder extension left (^{0}), Neck lateral flexion right (^{0}). Difference favoring the women participants was discerned in the following variables: Flexion body (cm), Shoulder flexion left (^{0}), Shoulder flexion right (^{0}), Shoulder extension right (^{0}), Neck flexion (^{0}), neck extension (^{0}), neck lateral flexion left (^{0}). None of the differences in the means were statistically significant.

DISCUSSION

The initial dilemma that initiated this study was the following: Are there statistically significant differences in the domain of morphological characteristics and motor abilities such as strength and flexibility between male and female students at the Alexander Technological Educational Institute of *Thessaloniki, Greece? The results obtained in the study support the hypothesis concerning the difference between the sexes in terms of physical ability levels, strength and flexibility, as well as overweight status.*

Using a participant sample comprising 100 subjects of both sexes (50 male and 50 female) aged 20.4 ± 2 years, we examined differences in the motor abilities strength and flexibility. The following variables for the domain of strength were used for the assessment of selected motor abilities: Strength shoulder extension left (kg), Strength shoulder extension right (kg), Strength shoulder flexion left (kg), Strength shoulder flexion right (kg); for the domain of flexibility: Extension body (^{0}), Flexion body (^{0}), Flexion body (cm), Shoulder flexion left (^{0}), Shoulder extension left (^{0}), Shoulder flexion right (^{0}), Shoulder extension right (^{0}), Neck flexion (^{0}), Neck extension (^{0}), Neck lateral flexion left (^{0}) and Neck lateral flexion right (^{0}). Descriptive statistics methods were used to determine the differences between the subject groups in terms of how the variables were manifested and connected as per the initial hypothesis. T-test was used to determine the significance of differences across the arithmetic means.

The results obtained indicate the existence of statistically significant differences (sig = .000) between the male and female students aged 20.4 ± 2 years in terms of the following strength parameters: strength shoulder extension left (kg), strength shoulder extension right (kg), strength shoulder flexion right (kg). For the parameters where no statistically significant difference was found, data indicated a minimal difference in favor of the male group. The study conducted by Arteaga, Dorado, Chavarren and Calbet (2000) arrived at results indicating higher strength levels in male students than in the female students. No statistically significant difference was foundamong the results pertaining to establishing differences in the variables assessing flexibility, namely: Extension body (^{0}), flexion body (^{0}), Shoulder extension left (^{0}), Neck lateral flexion right (^{0}), Flexion body (cm), Shoulder flexion left (^{0}), Shoulder flexion right (^{0}), Shoulder extension right (^{0}), Neck flexion (^{0}), Neck extension ((^{0}) and Neck lateral flexion left (^{0}). However, differences did exist, namely in the following variables: flexion body (cm), shoulder flexion left (^{0}), Shoulder flexion right (^{0}), Shoulder extension right (^{0}), neck flexion (^{0}), Neck extension (^{0}) and Neck lateral flexion left (^{0}),where it was in the women's favor, while for the variables: Extension body (^{0}), Flexion body (^{0}), Shoulder extension left (^{0}) and Neck lateral flexion right (^{0}), the difference was in the men's favor.

Results of comprehensive studies into the effects of the sedentary way of life in countries of the European Union emphasize the prevalence of physical inactivity in the student population, and identify this as the primary direction toward which future research should orient itself in order to raise awareness in this population regarding the importance of physical activity and to enhance their motivation for engaging in physical activity (Stojanović, Višnjić, Mitrović, &Stojanović, 2009).

Numerous studies identify an active lifestyle and daily physical activity as being of paramount importance in obesity prevention (DiPietro, 1999), as well as in improving motor ability, primarily enhanced strength and flexibility parameters. Cross-sectional studies, however, seem to identify diminished need for engaging in physical activity, a lack of physical activity, as well as a lack of strategies that would promote exercise as a means for preventing health problems later in life. Test results have identified significant differences between men and women of the same age in terms of BMI level, favoring the women, yet the values were still high in both sexes and indicative of being overweight (mean values for female subjects were (22.30 ± 2.59 kg/m²),whereas for the men it was (24.744 ± 3.87 kg/m²) (WHO, 2000; for similar results, cf. Rogulj, Kovačević, Utrobičić, Krstulović & Jukić, 2011).

Numerous studies have been conducted so far comparing the levels of strength and flexibility in men and women (Miletić, Ćavar, & Ćorluka, 2007), since the impairment or deficiency in these domains at a young agecan be indicative of

possible public health problems later in life, in terms of acute or chronic diseases such as heart disease, hypertension, diabetes, lower back pain syndrome, and others. Recommendations for students include engaging in moderate physical activity for at least 30-60 minutes 3-5 times per week, although more recent advice calls for daily physical exercise (Macanović, Marković, Ferati, Arsić, Jocić & Arsić, 2013). The forms of physical activity this population most frequently opt for include: running, recreational activity, swimming, cycling, aerobics, and pilates (Andrijašević, Paušić, Bavčević & Ciliga, 2005; Salihamidžić & Varešlija, 2013). Despite the fact that aerobic activity dominates in this age range, it is exercises for improving strength that are recommended as optimal due to the biologically latent period for increasing muscle mass and flexibility (Stanković, Hadžikanudić, Hadžikanudić & Avdibašić, 2010).

All recommendations for lowering body weight, modifying BMI and enhancing motor abilities of strength and flexibility in university students refer to an adequate energetic balance, where one's caloric intake would not be greater than the energy expended, as was the case in our study. An important factor in this process is lifestyle modification, which would include decreasing daily caloric intake and increasing physical activity, as well as ongoing work with this population in terms of education and motivation,and promotion of physical activity, since this is the foundation for building a positive relationship toward physical activity, one's own health and body image.

CONCLUSION

The results of the tests used for determining the levels of motor ability in male and female university students indicate statistically significant differences at the level of the motor domain strength but not for the motor domain flexibility, for which none of the parameters measured showed statistically significant difference. This result is somewhat surprising given women's greater biological predisposition for flexibility. However, this result can be explained as being precipitated by the female students' diminished levels of physical activity, leaving this natural potential unable to fully develop. The level of the study participants'physical activity was not in accord with their calorie intake, and they were classified as borderline overweight. The results of this study open up new themes and avenues of research for future studies in other motor ability domains for students belonging to different sexes and age groups, and engaging in different levels of physical activity. Such studies would help raise awareness of the significance and advantages of physical activity.

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ABSTRAKT

ROZDIELY MEDZI POHLAVIAMI U VYSOKOŠKOLSKEJ POPULÁCII V OHYBNOSTI A SVALOVEJ SILY: PILOTNÁ ŠTÚDIA

Kľúčové slová: pružnosť, svalová sila, študenti, pohlavie

Cieľom predkladanej štúdie bolo identifikovať rozdiely v morfologických charakteristikách a motorických schopnostiach, ovplyvňujúcich silu a flexibilitu, medzi študentkami a študentmi. Výskumný súbor (n=100) tvorili muži (n=50) a ženy (n=50) vo veku 18 a 32 rokov. Antropometrické merania zahŕňali hodnotenie telesnej výšky, telesnej hmotnosti a Body Mass Index. Na hodnotenie sily boli použité nasledovné testy: sila ramena vo flexii vpravo, sila ramena vo flexii vľavo, sila ramena v extenzii vpravo, sila ramena v extenzii vľavo. Kĺbová pohyblivosť bola hodnotená goniometrom s využitím testov: záklon trupu (^{0}), predklon trupu (^{0}), predklon trupu (cm), predpaženie v ľavom ramennom kĺbe (^{0}), zapaženie v ľavom ramennom kĺbe (^{0}), predpaženie v pravom ramennom kĺbe (^{0}), zapaženie v pravom ramennom kĺbe (^{0}), predklon hlavy (^{0}), záklon hlavy (^{0}), úklon hlavy vľavo (^{0}), úklon hlavy vpravo ((^{0}). Štatistickú významnosť sme posudzovali medzi pohlaviami v jednotlivých testoch sily a flexibility s využitím T-testu. Signifikantné intersexuálne rozdiely sme zaznamenali pri hodnotení výsledkov motorických testov študentov vysokých škôl. Vo výsledkoch testov flexibility sme štatisticky významné rozdiely medzi študentkami a študentmi nezaznamenali.

THE LEVEL OF DEVELOPMENT OF BONE AND MUSCLE TISSUES OF STUDENTS APPLYING LORENTZ CONSTITUTIONAL AND MUSCLE INDEX

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Nowadays it is generally lived in conditions of rapid pace, poor quality and unhealthy nutrition, reduced or insufficient movement, in a word hipokinetic lifestyle. Consequences of hypokinesia are many, and refer mainly to diseases of the cardiovascular system, the respiratory system, and the occurrence of diabetes. In addition, it can also be stated and the uneven growth and development of the individual leading to the negative trend of the development of some anthropometric characteristics and also to the physical status of the individual. This research is dealing with the level of development of bone and muscle tissues of students of Physical Education and Sports of East Sarajevo. For the estimation of the level of development of bone and muscle tissue was applied Lorentz constitutional index (LKI) and muscle index (MI%). The results showed that it is about a tendency of the stronger development of bone and muscle tissues of students, where the mean value of LKI is (Mean= 2,2), and muscle index MI (Mean=10%), that is they are in the upper limit of the middle development musculature.

INTRODUCTION

One of the most important health issues of modern society is obesity.As the best method to prevent and stop this rapid growth in obesity is a combination of regular physical exercise and a balanced nutrition (Al Nakeeb et al., 2007). Proper and systematic physical exercise and sports activities have a positive impact on the health, physical development and functional abilities (Morris & Froelicher, 1991; Pate, Pratt, Blair, et al., 1995; First, Khomyakova, Purundzhan, et al., 2007; Vadasova & Balogha, 2012), both in younger and in older age (Trudeau, Laurencelle, Tremblay, et al., 1999). However, it was also pointed to the possibility of damage to health, as well as some diseases in which these activities would have the opposite effect, ie the deterioration of health conditions (Koplan, Siscovick & Goldbaum, 1985; Ghilarducci, Holly, & Amsterdam, 1989; Malina & Bouchard, 1991). It is therefore necessary to ensure that in these activities are involved only healthy, or those to whom these activities will be useful, and so that can be continuously monitored their physical development during systemic exercise and sporting activities (Wilmore, 1983; Telam, Leskinen & Yang, 1996 , Stewart, Dennison, Kohl & Doyle, 2004). This is achieved through regular and systematic mandatory health examinations by competent medical professionals. In addition to a medical examination in order to preserve of the health of individuals, athletes is needed to monitor and supervise the physical development (Sallis, McKenzie, Conway, Elder et al., 2003).

To estimate the physical development of one or more persons usually are used two anthropological methods: anthroposkopy (method of observation) and anthropometry (measurement method). Measurement of morphological characteristics of the human body, treatment and study of the data obtained are an integral part of a series of basic applied research, primarily in the field of sports medicine, military and industrial medicine and also in the field of physical education and sport (Malina, 1994; Jakonić, 2003). Anthropometric measurements and data processing in larger groups of respondents are performed as part of

research and hey enable obtaining the average values of some anthropometric parameters in the surveyed populations (Shepard, 1991). In so doing, by the so-called. longitudinal method of research, ie. monitoring and measuring the same group of people over the years, gains an insight into the dynamics of development of children and young people in a given area and under certain conditions of life (Hedley, Ogden, Johnson, et al., 2004), by so-called. transversal method of research, ie. one-time measurement of a large number of respondents of a particular population, obtains an insight into average condition of physical development. Health care professionals and experts in the field of physical education, have the opportunity to use anthropometric measurements for practical purposes, in order to assess the individual anthropometric status of tested individuals. Analysis of the results of anthropometric measurements enable the development of standards, using standard methods (comparison of results obtained by anthropometric measurements of a particular population of subjects with previously established standards for a particular population, for example determining the optimum and the relative body mass per De Mole, Brocov index, an optimal body mass per Brugsch, non-fat body mass per Willmoreu, the relative content of fat, Quetelet body mass index, Rorher index, index Pignet, Lorentz constitutional index, muscle index,...) and the index method (looking at the relationship between certain anthropometric parameters, ie. perceive the bodily proportions). Evaluation of morphological characteristics of the body by the index has limited, relative value and gives to the interviewer only a quick orientation on the physical development of the participants and are used above all in adults.

Body composition (BC) is an important indicator of physical fitness and general health of athletes (Warner, Fornetti, Jallo, & Pivarnik, 2004; Van der Ploeg, Gunn, Withers, et al. 2003) and nowadays it also is a frequently discussed topic in scientific literature. According to, Claessens, Hlatky, Lefevre, & Holdhaus, 1994) the shape of the body and its morphology is, in addition to physical abilities, psychological characteristics and energetic system capacity, one of the major factors determining sporting performance. Diagnostics of body weight is often the subject of research by which to gain a real insight into current status of a defined population and the possible negative trends of growth and development over a certain period of time (Sorensen et al. 2000a; Dopsaj, et al. 2005).

The problem of analysis of anthropological characteristics of students of the Faculty of Sport and Physical Education in Novi Sad researched Srdić et al. in 2009. The sample included 122 students of both sexes, and based on the measurements of anthropometric parameters (body height, body weight, skinfold thickness, body circumferences and diameters) the degree of nutritional status, body composition and somatotype were assessed. The average body height of young men was 181.46±5.53cm, while the girls were on average 166.86±5.93cm tall. The average value of the body mass index was within normal limits. Most of the respondents of both sexes was well nourished, 6.06% of girls were underweight, while 9.09% of girls and 28.09% boys had excessive body weight. At 4.49% of boys excess body weight was due to increased fat-free mass. Overweight body mass with increased fat mass had 19.10% of boys and 6.06% girls, while the multiple increased fat mass was determined in four boys and one girl. Average fat mass was 18.01±3.57% in males and 26.68±6.03% in girls. Muscle mass accounted for an average of 42.77±7.57% of total body weight in boys and 36.76±2.99% of body weight in girls. Compared to somatotype, the majority of respondents of both sexes had a mesomorphic-endomorph type of material.

In the study Dopsaj et al. 2006 were identified classification criteria for the assessment of body mass index of students. The sample consisted of 311 female students of the Police Academy, aged 19 to 24 years with the aim of diagnosing BMI as key measure to assess the physical status and nutritional status. The results showed that the average BMI of the sample female students is 21.59±2.29kg/m², and the range of scores from 16.20 to 29.24kg/m². What is with the statistically significance established, is that already during the study 4.50% of the population of the female respondents belong to the category with a BMI value ranging from 26.38 to 29.24kg/m², and according to the current medical standards (or consensus) belong to the category of overweight (obesity medium) females, or category of individuals with inadequate that is professionally unacceptable physical status. What is surprising is that in the category of underweight there are 11.58% (BMI below 19.1kg/m²) and in the category of anorexic are even 1.61% of female respondents from the tested female student population (BMI below 17.5 kg/m²). Applying transversal research methods, Jankovic et al. 2007 on a sample of 267 male and 88 female students of the Police

Academy (KPA) from Belgrade made a diagnosis of basic anthropometric characteristics in function of the study year. Basic anthropometric characteristics of respondents were presented by body mass, body height, body-mass index (BMI). The results showed that in the KPA students during their studies came to statistically significant trend change in increase of BM as key measure to assess the volume of the body (1.20kg per year of study) and with BMI, ie. nutritional status (0,42kg/m² per year of study). Compared to female students, the results showed that during the study KPA came to a statistically significant trend change in reductions in BMI, ie. nutritional status (-0.56kg/m² per year of study).

Students of physical education and sports, it can be said, belong to a separate population of physically active people, given the nature of the faculty and physical activities practiced during the study. It is because of the nature of faculty that evaluation of morphological characteristics is of great importance in this population of students (Pavlović, Raković, Mihajlović, et al. 2015). Also, this way of defining the development of bone and muscle tissue provides a good perception of the morphological space of the tested population. Taking into account previous studies that treated similar issues on the same or other populations, the main objective of this study was to determine the level of development of bone and muscle tissues of students applying Lorentz constitutional index and index of muscle.

METHOD

The study comprised of a group of third year students of the Faculty of Physical Education and Sports in East Sarajevo, male, age 21 ± 0.5 years. A total of 48 students was covered, with an average height of 184 ± 8,94cm, body mass 81 ± 9,08kg. All subjects gave consent and voluntarily participated in the study. For the assessment of the development of bone and muscle tissues of students using the index method was applied Lorentz constitutional index (LKI) and muscle index (MI%), (Jakonić, 2003).

The formula for calculating the LKI = OG-OT-14

LKI - Lorentz constitutional index;
OG – Mean volume of chest (cm)
OT - abdomen volume (cm)
< 0 the excess of body mass (obesity)
> 0 stronger development of bone and muscle tissue

If the body mass of adults is greater than its optimum mass, by calculating the index can be roughly estimated that the increase in body mass is conditioned by a stronger level of development of bone and muscle (active) or adipose tissue (ballast) tissue. The positive values (greater than 0) indicate the stronger development of bone and muscle tissue. Negative values indicate the excess of body weight conditioned by the excess of adipose tissue (obesity, adipose-constitution).

The formula for calculating the muscle index MI = ONs - ONo x 100 = %

ONo

MI – muscle index (%); ONs - the volume of the upper arm bent; ONo- the volume of upper arm extended

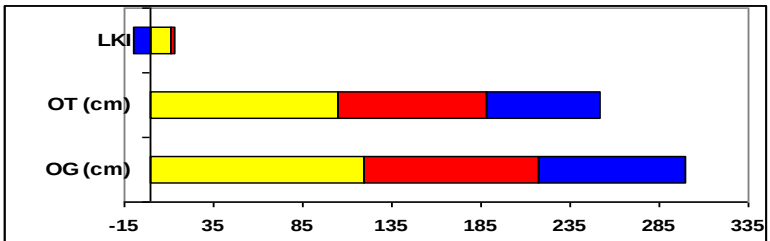
Results were scored as follows:
< 5% - poorly developed musculature;
5-12% - average developed musculature;
> 12% - stronger developed musculature

RESULTS AND DISCUSSIONS

Table 1 Descriptive statistic Lorentz constitution index

	Mean	*Min*	*Max*	*Range*	*SD*	*Skew*	*Kurt*
OG	97,98	83	119	36	6,87	,50	1,11
OT	83,07	64	105	41	7,47	,23	1,49
LKI	2,2	-10	11	21	4,74	-,26	-,05

Legend: *Mean-arithmetic mean of the measurement results; MIN-minimum values of measurement results; MAX-maximum values of measured results, Range-range results min. and max; SD-standard deviation; Skew - (inclination distribution), Kurt (elongation distribution); LKI-Lorentz constitutional index; OG- Mean volume of chest (cm); OT-abdomen volume (cm)*



	OG (cm)	OT (cm)	LKI
Min	83	64	-10
Mean	97,98	83,07	2,2
Max	119	105	11

Chart 1 Lorentz index of parameters (descriptive statistics)

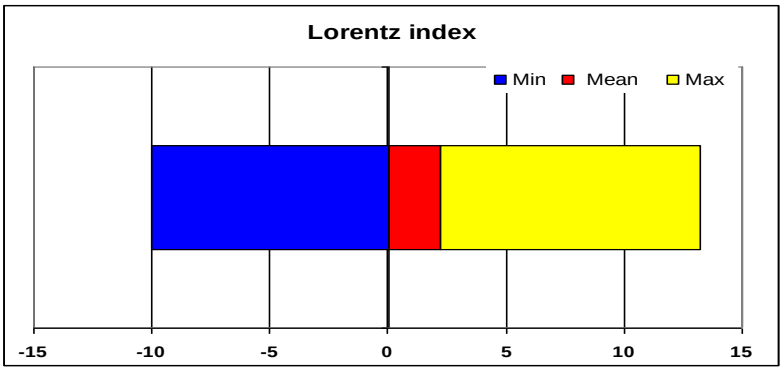


Chart 2 Numerical indicators of Lorentz index

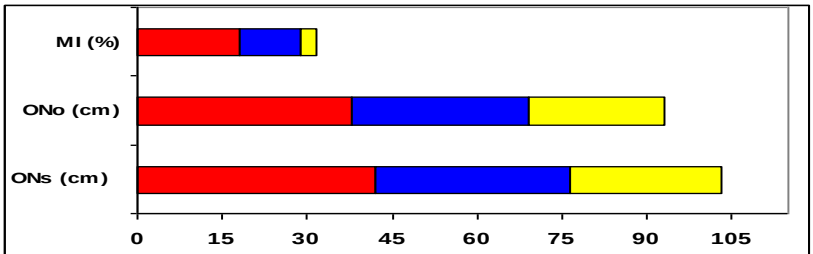
Table 1 gives the basic statistical parameters of circular skeleton dimensionality, ie. medium volume of chest (OG), the volume of the abdomen (OT) and Lorentz constitutional index (LKI) students. The average value of the volume of the chest of the respondents is about 98cm (Mean = 97,98cm) with a minimum score of 83cm and a maximum of 119cm. The mean volume of the stomach (OT) is (Mean = 83,07cm) with a minimum score of 64cm and a maximum of 105cm. On the basis of these and body weight. On the other hand, the maximum value of (+11) is an indicator of the good condition results the mean value of Lorentz constitutional index was obtained, which showed a positive value, different from zero (LKI = 2.2). This result suggests that it is about the tendency the stronger development of bone and muscle tissues of students. Minimum value (LKI = -10) is an indication that among the respondents were those who have excess body weight which is the assumption of more adipose constitution, or un proportional relationship of body height and a stronger development of skeletal muscle system of one respondent (Chart 2).

Table 2 Descriptive statistics muscle index

	Mean	*Min*	*Max*	*Range*	*SD*	*Skew*	*Kurt*
ONs	34,27	27,00	42,00	15,00	3,15	-,22	,23
ONo	31,05	24,00	38,00	14,00	2,97	-,17	,02
MI %	10,58	2,85	18,18	15,33	4,22	-,04	-,75

***Legend**: Mean-arithmetic mean of the measurement results; MIN-minimum values of measurement results; MAX-maximum values of measured results, Range-range results min. and max; SD-standard deviation; Skew - (inclination*

distribution), Kurt (elongation distribution); MI – muscle index (%); ONs - the volume of the upper arm bent; ONo- the volume of upper arm extended



	ONs (cm)	ONo (cm)	MI (%)
Min	27	24	2,85
Mean	34,27	31,05	10,58
Max	42	38	18,18

Chart 3 Descriptive statistics muscle index

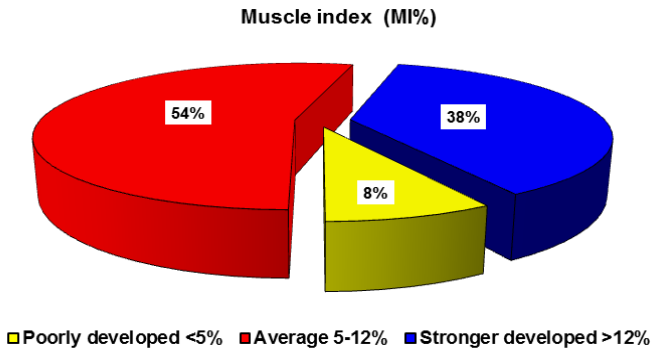


Chart 4 Development of the musculature of students (MI%)

Table 2 also presents the basic statistical parameters of circular dimensionality of the cranial extremities, ie. upper arm. Volumes were measured in two variants, the upper arm bent-flexion (ONs) and the upper arm outstretched-extension (ONo). Based on these indicators was calculated muscle index of students (MI%).

The average value of the volume of the upper arm bent (ONs) of students was slightly more than 34cm (Mean = 34,27cm) with a minimum score of 27cm and a maximum of 42cm. The average value of the measured volume of the upper arms outstretched (ONo) is about 31 cm (Mean = 31,05cm) with a minimum volume of the upper arm of 24cm and a maximum of 38cm. Based on these results, was calculated and obtained the mean value of muscle index of students (Mean = 10.58%). Based on these results of MI% over 10% it can be concluded that students are in the upper limit of the mean development of musculature. This result suggests that it is about tendency for the stronger development of muscle tissues of students, as demonstrated Lorentz constitutional index (LKI) only in the domain of both bone and muscle tissue. Recorded minimum value of muscle index (MI = 2.85%) is an indication that among the students were those who have less developed musculature. On the other hand, the maximum value of (MI = 18%) is an indicator of good condition and a stronger development of the muscular system of one respondent. A range of results (over 15%) between the min. and max. value is an indication of considerable heterogeneity of students in terms of development of the musculature, or the value of the muscle index (MI%). After examining the individual results of subjects (Chart 4) there were obtained numerical values that only 8% of students had poorly developed musculature (<5%), and 54% were with medium-developed musculature. With more developed musculature were 38% of the students. This result of 38% enabled that in the overall

result of muscle index students are in the "upper limit" (MI = 10.58%) of medium development of musculature (range 5-12%).

Growth in height and weight is an indicator of nutritional status, resulting in a variety of endogenous and exogenous factors. The prevalence of obesity, particularly infantile obesity has risen rapidly in the last two decades, both in industrialized and in developing countries. This phenomenon is determined by the World Health Organization (WHO, 2006), starting from 1998, considering that obesity is a major health problem of the world. In order to observe this aspect, WHO recommends for assessing the somatic and phenotype, the use of anthropometric data. It is believed that anthropometry is valid for a universal technique that allows the evaluation of physical development, the state of nutrition and health. Evaluation of somatic phenotypes to physical development in vulnerable populations is imposed by the World Health Organization. Based on experience, (Iacob, Dragoi & Melinte, 2011) have been developed the study of algorithms that can be used during developing public health strategy.

Body composition provides us with a detailed physiological profile of an athlete (Heyward & Wagner, 2004). The amount of active mass determines the value of individual parameters of physical fitness. Optimal BC for a specific sport discipline is, however, difficult to determine. A determiner of physical activity is active muscle mass while fat mass is to be rather eliminated by athletes. Excessive adipose tissue acts as a dead weight in activities where the body mass must be repeatedly lifted against gravity during locomotion and jumping (Reilly, 1996). Lean body mass contributes to the production of power during high-intensity activities and provides greater absolute strength for resistance to high dynamic and static loads.

Regular physical activity and aerobic fitness are associated with lower risk of coronary heart disease, and reduced influence of psychological stress (Lorenz, Van Cdoornen, & Eco De Geus, 1993). Also research of some authors (Gutin, Barbeau, Owens, et al., 2002; Ara, Vicente-Rodriguez, Jimenez-Ramirez, Dorado, et al., 2004) has been proven many times and confirmed in practice that regularly participation in sports activities is closely related to the increase of physical condition and reducing body fat in boys, both pre adolescence and in older age (Schwartz, Shuman, Larson, et al., 1991). It is very important not to forget that training with high load can lead to negative influence on the arterial disease (Ghilarducci, Holly, & Amsterdam, 1989). Well-planned and implemented training can have positive effects on the body constitution, regardless of where the age (Khomyakova, Purundzhan, et al., 2007). In our case, the student population is representative of a wider population, which is characterized by numerous psychosomatic changes, the population involved in sports activities as professionals or amateurs. It can be rightly said that the mere teaching at the university is one aspect of the training process, so-called olympic cycle. This is a significant period of time when it can be positively act on the transformation of subjects. As a result of that teaching process occur transformations of their morphological status, or the condition of the muscular and skeletal systems. This is the period in which it can be performed various analyzes in terms of monitoring and diagnostics of all anthropological characteristics, as well as bone and muscle index. In our sample of students obtained are the results that are in most cases characterized by precisely this population of students of physical education and sport, to whom physical activity is a primary, and as such, differentiates them from other populations of the same age. To confirm this done numerous studies have been conducted.

Ganciu, 2013 was on a sample of 40 students from the University of Bucharest, explored the development of respiratory parameters: respiratory frequency, vital capacity and Lorentz index. The sample was divided into experimental and control group. The control group worked with classical, traditional means, while the experimental group used the cardio program. The final results were better than the initial, recorded at the beginning of the experiment, but in the experimental group there was a significant increase in all investigated parameters between the initial and final testing, as compared to the control group, where the growth rate was lower.

Certain studies have investigated the problem of athletes and their parameters of anthropological status. In a study conducted in Turkey, on 153 men who have different levels of physical activity, BMI values were as follows: American footballers 27.76±5.18kg/m², volleyball players 24.49±2.90kg/m², basketball players 24.70±2.65kg/m², footballers 23.37±2.78kg/m², and for students who do not exercise regularly 23.42±3.62kg/m (Pelin, Kürkçüoglu, Özener, et al. 2009) and percentages of body fat values were different with respect to gender and sport they do. Sınırkavak et al. in 2004 Values obtained values of subcutaneous fat tissue in men students of

physical education and sport from 11.80±0.55%. In a survey conducted by Akın et al. in 2004 in five different sports, including 100 male athletes, subcutaneous body fat values were as follows: 13.06% wrestling, football 15.1%, 18.2% weightlifting, handball 20.8% and 16.8% of taekwondo. This is significant, although there are a number of studies to estimate physical fitness of anthropometric characteristics, there are not many studies on the physical proportions for a good physical condition. Part of the research with the handball players have confirmed that they have wide shoulders, narrow hips and middle chest latitude, and football players have a long body and narrow hips (Cakiroglu et al. 2002; Çıkmaz et al, 2005). In conclusion, the participants in this study were found to have a normal body mass index, RPI, WHR and fat percentage value. According to the physical structure they have medium body structure, with broad shoulders, narrow upper body and hips. Also, in addition of active athletes the subject of research of some authors is the student population that is also at the stage of growth and development. Kurt, et al. in 2011 conducted a survey in order to determine the physical proportions of Turkish students of physical education and sport. This study involved 258 men of physical education and sport who practice on a recreational level, age 22.40±2.75 years, body height: 178.67±9.43cm, weight: 73.44±13.64kg. They were evaluated in terms of BMI, RPI, WHR, percentage of body fat, index Cormique, Monourier index, Acromio-iliac index, Martin index, Biacromial index and hip index. The results were as follows: BMI: 22.86±2.66kg/m², RPI: 42.89±1.77cm/kg, WHR: 0.79±0.05%, percentage of body fat 14.43±4.41%, Cormique index of 51.51±1.58%, Monourier index 94.31±6.10%, Acromio-iliac index of 63.88±6.61%, Martine index of 6.11±0.48%, Biacromial index 22.32±1.86% and hip index 13.89±0.97%. Although the respondents showed normal-healthy in terms of BMI, WHR, and percentage of body fat, they also showed a thicker middle section of the body, a narrow upper body and narrow hips.

Budakov, et al. (2012) are, using an anonymous questionnaire survey conducted research among 800 students from the University of Novi Sad, aged 20 to 24 years, of equal representation of gender structure in order to determine the nutritional status and physical activity of students. Older students had higher average BMI (Mean=24.49) than younger (Mean=23.36), as opposed to female students where younger have a slightly higher BMI (Mean=20.49) than older (Mean=20.37). There were 116 (29%) obese students, while 62 (15.5%) female students were underweight. Physically active were 451 (56.4%) students. Older students were physically more active, 481 (60.1%), compared to the younger, 399 (49.9%) ($p<.01$). On a sample of 180 students, from the Faculty of Physical Education and Sports in Eastern Sarajevo (Pavlovic, Raković, & Pupiš, 2014) using longitudinal research method, performed diagnostics of basic anthropometric characteristics in function of monitoring of differences of somatic changes in order to determine the differences in basic anthropometric characteristics. The results showed that in students of FFVS during the four-year period, there was a statistically significant trend of differences that defined the considerable heterogeneity of the population. All the above studies that were conducted on the student population speak mainly about heterogeneity, the increased values of the measured parameters (BMI, respiratory frequency, vital capacity, Lorentz index) and other parameters of morphological space, as in the case of our sample. Mainly it is about numerical indicators from the extremely negative to the extremely positive results (Pavlović, et al. 2015).

Namely, today lifestyle is in terms of the fast pace, poor and unhealthy diet, decreased or lack of movement, in one word hypokinetic lifestyle. The effects of hypokinesia are numerous, and mostly refers to diseases of the cardiovascular system, the respiratory system and the occurrence of diabetes. In addition, it can be stated also uneven growth and development of the individual leading to the negative trend of the development of individual and anthropometric characteristics and the physical status of the individual (body height, weight and BMI). The close relationship between health status and body mass has been known for a long time. Somatic type of man can be determined by genetic factors, diet, socio-economic conditions, age, gender, etc.., what may have the ability and give valuable information for researchers of modern societies (Muñoz- Cachón, et al. 2007).

Although this is about, we can say, physically active population, the negative consequences are obvious and they are reflected in the morphological status of the respondents, which may further lead to many medical disorders. In our case, although it was not about some invasive methods, however, there have been determined certain changes in the status of the student population, which may be a good initial indication of the physical status and as

the initial recommendation about future physically active lifestyle.

CONCLUSION

The study comprised of a group of students of third year, from the Faculty of Physical Education and Sports in East Sarajevo, male, age 21 ± 0.5 years. A total of 48 students were included, with an average height of 184 ± 8,94cm, body mass 81 ± 9,08kg. The study was aimed to determine the level of development of bone and muscle tissues of students applying Lorentz constitutional index and muscle index (Jakonić, 2003). The results showed that it is about the tendency for the stronger development of bone and muscle tissue of students, where the mean value is LKI = 2,2 in the range of from Min. = -10. to Max. = +11. This is an indicator that among the respondents were those who have excess body weight which is the assumption of adipose constitution, that is the disproportionate ratio of body height and body weight. On the other hand, the maximum value of (+11) is an indicator of the good condition and a stronger development of the muscle skeletal system of one respondent.

Based on the results of MI% of over 10% it can be concluded that the students are in the upper limit of the medium development of musculature. Recorded minimum value of muscle index (MI=2,85%) is an indication that among the students were those who have less developed musculature. On the other hand, the maximum value of (MI = 18%) is an indicator of good condition and a stronger development of the muscular system of one respondent. A range of results (over 15%) between the min. and max. value is an indication of considerable heterogeneity of students in terms of development of the musculature, that is the value of the muscle index (MI%). The results showed that only 8% of students had poorly developed musculature (<5%), and 54% were with medium-developed musculature. With more developed musculature were 38% of the students. This result of 38% enabled that in the overall result of muscle index students are in the "upper limit" (MI = 10,58%) of medium development of musculature.

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ABSTRAKT

VYUŽITIE LORENTZOVHO A SVALOVÉHO INDEXU PRI POSUDZOVANÍ ÚROVNE KOSTNÉHO A SVALOVÉHO TKANIVA U ŠTUDENTOV

Kľúčové slová: kosti a svalové tkanivo, index, študenti, hodnotenie.

V súčasnosti všeobecne žijeme v podmienkach rýchleho tempa, nekvalitnej a nezdravej výživy, máme minimalizovaný alebo nedostatočný pohyb, žijeme tzv. hipokinetickým životným štýlom. Dôsledkov hypokinezie je veľa a vzťahujú sa predovšetkým na choroby srdcovo-cievneho systému, dýchacieho systému a vzniku cukrovky. Okrem toho môže byť tiež dôsledkom nerovnomerný rast a vývoj jedinca, ktorý vedie k negatívnym trendom vývoja niektorých antropometrických charakteristík a aj fyzického stavu jednotlivca. Tento výskum sa zaoberá zisťovaním úrovne rozvoja kostných a svalových tkanív študentov Telesnej výchovy a športu na východe Sarajeva. Pre odhad úrovne rozvoja kostných a svalových tkanív bol aplikovaný LCI a MI. Výsledky ukázali, že ide o tendenciu vyššieho vývoja kostných a svalových tkanív

študentov, kde stredná hodnota Lorentzovho indexu LCI je (priemer= 2,2), a svalového indexu MI (priemer=10%), ktoré sa nachádzajú v hornej hranici stredného rozvoja svalovej hmoty.

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HDL LEVEL IN AMATEUR BODYBUILDRES WHO MISUSE THE COMBINATION OF TESTESTERONE PRODUCTS AND ANABOLIC STEROIDS IN BOSNIA AND HERZEGOVINA

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Key words:

androgenic-anabolic steroids, amateur bodybuilders, arterial hypertension, hyperlipidaemia, vascular disease.

Who suffer from the Adonis effect are unaware of anabolic steroid's side effects, whose misuse can be prescribed to their need to achieve perfect muscles proportion and quality physical performance, without the motivation to compete. Risk factors such as increased LDL (Low-density lipoprotein), increased levels of serum lipid, reduced HDL (High-density lipoprotein), and arterial hypertension are some of the major factors which have an important role in the pathogenicity of atherosclerosis. These risk factors are responsible for causing permanent cardiovascular damage in young amateur bodybuilders aged 18 to 25. **Objective**: The aim of the study is to estimate the side effects of misusing androgenic anabolic-steroids in combination with testosterone in case of young amateur bodybuilders who have no motivation to compete. In addition, this study will offer an estimate and an analysis of a 5 years research conducted on Bosnian and Herzegovinian young amateur bodybuilders aged 18 to 25 in regards to the testosterone influence in the combination with anabolic steroids and what side effects it might have on vascular status, specifically in regards to HDL/LDL (High-density lipoprotein/Low-density lipoprotein serum lipid). **Methods**: The study was conducted on 60 individuals in period from 2010 to 2015 and based on amateur exercising program. 30 subjects are recognised as those using the Androgenic-anabolic steroids in combination with testosterone during a 5 year period, and were compared with 30 subjects who did not use Androgenic-anabolic steroids. Non-invasive methods were used in case of all subjects (clinical examination and vascular ultrasound examination of vein system). The routine of anaerobic training units in the Gym for bouth groups was 1,5 - 2 hours performed 4-6 times per week. **Results:** Final analysis has revealed that among the population of young anabolic steroid users, the statistically dominant are males (100%) or 30 subjects. Analysis has revealed that in Androgenic anabolic-steroid group in case of 14 subjects or (44,8%), arterial prehypertension condition with hyperlipidaemia is more represented then in comparison with the group of 6 subjects or (18,5%) who do not use anabolic-steroids and was statistically considered significant by using p value less than 0,05. ($p<0,05$). HDL (High-density lipoprotein) levels under 1.03 mmol/L were more present in a group of anabolic-steroid users in 28 subjects or (93,3%), which is statistically significant ($p<0,05$). **Conclusion:** Amateur male bodybuilders aged 18 to 25 are dominant androgenic anabolic steroids users, trying to achieve better muscle proportion and physical performance while neglecting the anabolic steroids side effects which have devastating consequence on vascular system and increase the serum lipids levels. Side- effects of using steroids in recreational exercising program in young amateur bodybuilders are mostly connected with the development of arterial hypertension and hyperlipidaemia, which progresses the pathogenicity of cardiovascular disease with devastating health disorders.

INTRODUCTION

In order to gain better quality physical performances and improve the musculoskeletal system in as shortest time interval as possible, the misuse of anabolic androgenic steroids has been globally increasing. This alternative and quite often

desperation lead method pays the price of the success when it starts developing from harmless Adonis complex into a life threatening symptoms of cardiovascular diseases. [1,2] Testosterone-based synthetic derivatives (Sustanon, Boldenon, Cipionat, Propionat) along with classical anabolic androgenic steroids (Winstrol, Dianabol, Deca-Durabolin) have quickly found their way in the application among young athletes in elite sport, as well as among amateur body builders, exhibiting dramatic series of progression in damaging the cardiovascular system. Apart from diabetes mellitus as one of the extreme risk factors which lead to cardiovascular diseases, the arterial hypertension with hyperlipidaemia likewise represents a key risk factor during the cardiovascular pathogenesis[3,4.] There are numerous studies which have proven the existence of arterial hypertension (I stage- mild hypertension 140-159/90-99 mmHg and II stage- medium hypertension 160-79/100-109 mmHg) among young amateur bodybuilders who do not exhibit any clinical symptoms.

Kuipers and authors have discovered the increase of blood pressure in athletes ranging from 74 to 86 mm Hg, after ten weeks of steroid use in combination with the use of testosterone. There are likewise significant studies confirming the increase of systolic blood pressure from 10-12 (mm Hg) during one year[5.] The scientific literature acknowledges the increase of systolic and diastolic blood pressure amongst some young amateurs, even though recently performed study of Hartgens and co-authors has not confirmed systolic and diastolic elevation of the blood pressure, and that further studies are necessary in order to confirm the fact [6.7] The increase of the cholesterol level with the decrease in HDL (High-density lipoprotein) and an increase of LDL (Low-density lipoprotein) is one way of predicting the pathogenesis of accelerated atherosclerosis, and the very start of clinical cardiovascular disease [8,9,10]. However, how would these irrational and constant steroid cycles affect the young and healthy group of amateurs in bodybuilding, who do not possess scientific knowledge, are not motivated to compete between the age of 18 and 25 and do not have any prior diseases (asymptomatic clinical diagnosis indicating no illnesses, while the lipidogram parameters are within referential values). What would be the benefit of anaerobic physical activity in regards to health and body, and what would be the benefit of choosing the traditional diet without appropriate nutritional values, as well as looking at what would be the devastating effects on the vascular system and health after five years of constant cycle use including the cleansing period of 2-5 months each year.

Singh and co-authors have conducted a study of the anabolic steroids supplementation effects primarily with testosterone cypionate, indicating that constant intramuscular 600mg/per week applications of testosterone significantly lower the HDL level within the serum, while on the short run (up to 2 months) the applications do not affect the decrease of HDL which would induce the risks of cardiovascular disease.

Once the testosterone cypionate use has ended along with other anabolic products, it takes up to four to twelve weeks with diet modification to bring within the referential value of low-density lipoprotein HDL, or at least bring it close to the referential values [11] . The main aim of this research is to determine the level of HDL in the group of amateur bodybuilders which (mis)use the combination of testosterone and anabolic steroids.

The method used was that of retrospective – prospective study performed between the January 2010 and January 2015. It included 60 subjects (Bosnia and Herzegovina) in the age between 18 and 25, who have participated anaerobic amateur fitness programme (weight lifting and/or use of exercise equipment for individual and systemic muscle groups) 4 to 6 times per week up t 1,5 and 2 hours without any motivation to compete. The overall sample was divided into two groups:

1. group A (30 subjects) have used anabolic steroids in combination with testosterone during the period of 5 years including the cleansing period of 2-5 months per year
2. group B (30 subjects), have not used anabolic steroids in combination with testosterone

None of the subjects had any prior coagulation diseases, haemophilia or malignancy, or any other cardiovascular diseases. All the subjects practice free diets, which likewise includes traditional Bosnian food with the liberty to use nutrition supplements. The lipid and vascular system will be used for comparison in defined groups.

The results were processed by the use of standard statistical programme (Excel 2013), and presented by the help of tables and graphs where p value lower then 0,05 ($p<0,05$) will be taken as a measure of statistical significance.

RESULTS

Table 1 Overview of gender representation among subjects who use anabolic steroids and those who do not

OVERVIEW OF GENDER REPRESENTATION AMONG SUBJECTS WHO USE ANABOLIC STEROIDS AND THOSE WHO DO NOT					
			Amateurs who use anabolic steroids		Total
			No	Yes	
Gender	Male	N	30	30	60
		%	100	100	100
	Female	N	0	0	0
		%	0	0	0
Total		N	30	30	60
		%	50,0	50,0	100,0

Table 2 The overview of the combination in which the subjects have most frequently used anabolic steroids during the 5 year period

THE COMBINATIONS OF ANABOLIC STEROIDS USED MOST FREQUENTLY DURING THE PERIOD OF 5 YEARS WITH THE PERIODS INDICATING THE BREAK OF THEIR USE (CLEANSING PERIOD) 2 TO 3 MONTHS PER YEAR	N	%
-Dianabol (Methandrostenolone) **25-50mg** oral use -**Sustanon** (4 types of testosterone **250, 250mg/ml** **30 mg** Testosterone propionate **60 mg** Testosterone phenylpropionate **60 mg** Testosterone isocaproate **100 mg** Testosterone decanoate) **-Deca-Durabolin (Nandrolone Decanoate)** from **300** to **600** milligrams of intramuscular use	3	11,4
-Sustanon (4 types of testosterone) intramuscular use **-Dianabol** 25-50mg oral use	9	28,6
-Boldenon Undeclinate(based on slow release testosterone)200-600mgs intramuscular use **-Dianabol**25-50mg oral use	8	25,7
-Testesteron- propionate 350-700 mg intramuscular use **-Dianabol**25-50mg oral use	8	25,7
-Winstrol (Stanozolol) intramuscular use 35 and 75 milligrams / oral use 25 and 50 miligrams **-Sustanon** (4 types of testosterone) intramuscular use	2	8,6
Total	30	100,0

Table 3 HDL level in amateurs who use anabolic steroids and those who do not after five years of research

HDL LEVEL IN AMATEURS WHO USE ANABOLIC STEROIDS AND THOSE WHO DO NOT AFTER FIVE YEARS OF RESEARCH WITH PERIODS INDICATING THE BREAK OF THEIR USE (CLEANSING PERIOD) 2 TO 5 MONTHS PER YEAR					
			GROUP		Total
			Amateurs who use anabolic steroids	Amateurs who do not use anabolic steroids	
Low HDL, HDL <1.03 mmol/L	HDL <1.03 mmol/L	N	28	13	41
		%	93,3	43,3	68,3
	HDL >1.03 mmol/L	N	2	17	19
		%	6,7	56,7	31,7
Total		N	30	30	60
		%	50,0	50,0	100,0

Table 4 An estimate of lipid and vascular status in amateurs and bodybuilding contestants who have used different combinations of illegal anabolic steroids during the five year long research

AN ESTIMATE OF LIPID AND VASCULAR STATUS IN AMATEURS AND BODYBUILDING CONTESTANTS WHO HAVE USED DIFFERENT COMBINATIONS OF ILLEGAL ANABOLIC STEROIDS DURING THE FIVE YEAR LONG RESEARCH INCLUDING PERIODS INDICATING THE BREAK OF THEIR USE (CLEANSING PERIOD) 2 TO 5 MONTHS PER YEAR				
		GROUP		Total
		Amateurs who do not use anabolic steroids	Amateurs who use anabolic steroids	
HIPERTENSIO ARTERIALIS I stage – mild hypertension 140-159/90-99 mmHg	N	1	4	5
	%	3,7	13,8	8,9
PREHIPERTENSIO ARTERIALIS I stage - mild hypertension 120-129/80-89 mmHg **HIPERLIPIDEMIA** HDL-a <1.03 mmol/L , LDL-a > 4,53 mmol/L, total cholesterol> 5,5 mmol/L)	N	6	14	20
	%	18,5	44,8	32,1
OBESITAS (Obesity)	N	7	9	16
	%	22,2	31,0	26,8
(LDL-a) < 4,53 mmol/L	N	12	3	15
	%	40,7	10,3	25,0
VENE RETICULARIS TELEANGIEKTASIS (I stage) (asymptomatic aetiology)	N	3	0	3
	%	11,1	,0	5,4
VARICES CRURIS **(** II stage) (asymptomatic aetiology)	N	1	0	1
	%	3,7	,0	1,8
Total	N	30	30	60
	%	50,0	50,0	100,0

The statistical data analysis of the subjects who have used anabolic steroids in combination with testosterone significantly confirms the presence of mild hypertension (arterial prehypertension) (140-159/90-99 mmHg) followed by hyperlipidaemia (an increased level of LDL <1.03 mmol/L, decreased level of HDL >4,53 mmol/L, as well as an increase of the total cholesterol score >5,5 mmol/L) in (44,8%) or 14 subjects as opposed to (18,5%) or six subjects (p<0,05).

The first stage of asymptomatic insufficiency (Vene reticularis) of the superficial venous system was noted in (11,1%) of cases or in case of 3 subjects within the group of those who have not used anabolic steroids in combination with testosterone, and no statistically significant differences between the groups was established (p>0,05).

The second stage of asymptomatic venous insufficiency (Varices cruris) was noted in only one subject or (3,7%) within the group of those who did not use anabolic steroids in combination with testosterone, and no statistically significant difference between the groups was established (p>0,05). Analytical difference in the obesity values (obesity) was noted in a small number in case of 7 subjects or (22,2%) within the group of those who have not used anabolic steroids, and in case of 9 subjects (31%) within the group of those who have used anabolic steroids, but without noting any statistically significant differences between the groups (p>0,05).

DISCUSSION

The study results likewise indicate the impact of traditional diet which in combination with anabolic steroids leads to drastic decrease in the HDL value and an increase in LDL values. This is shocking information for the young active amateurs aged 18 to 25. The conducted research indicated that the subjects who attend regular fitness exercising programmes, without any motivation to compete have used anabolic steroids during the period of 5

years, and have statistically significant increased values of systolic and diastolic blood pressure (first and second stage of hypertension) combined with increased values of blood lipids as opposed to the subjects who have not used anabolic steroids, which is likewise confirmed by Yeater, Reed, Ullrich and co-authors[5]. The analysis gained by the conducted study in gender representation in the group of amateur bodybuilders aged 18 to 25, recorded statistically significant data in male subjects who used anabolic steroids in (100%) of cases or in case of 30 subjects, which explains the increase in the number of male population. In further analysis we have evaluated the most common and the most favourite use of illegal anabolic steroids, and have reached to a conclusion of 5 most favourable products used by amateurs in combination with testosterone products, but without any statistically significant difference in its application.

The combination of Winstrol and Sustanon is the least favourable in amateurs and its use has been noted in just 2 subjects or (8,6%). Is the cause assigned to its price or quality of its effects, it requires further studies to be conducted in order to clarify that question and to gain scientific facts. Its anabolic effects can be compared with Dianabol, but Winstrol has no equal tendency towards retaining water. Stazonolol does not convert to estragon, therefore anti-estragon is not required in combination with this steroid, and has the least side effects. Winstrol results in better quality and defined look, which makes it a perfect steroid to be applied during the period of loosing fat or the "reduction" period, especially when one is very careful in retaining water and fat. However it does not contribute to the massiveness of the muscle mass and that probably testifies to its low use. In 9 subjects or (28,6%) the most used combinations are Dianabol and Sustanon. After 5 years of monitoring we have analysed lipid and vascular status in amateur bodybuilders aged 18 to 25, both within the group of those which used anabolic steroids and in group of those that did not. Statistical analysis of the group of subjects who used anabolic steroids has significantly confirmed the presence of combination of arterial prehypertension and hyperlipidaemia in case of (44,8,%) or 14 subjects as opposed to (5,7%) or 2 subjects, which favours the high progression frequency of risk factors leading to cardiovascular systemic diseases.

Likewise a low level HDL has been noted in 93,3% or 28 subjects who have used anabolic steroids in combinations with testosterone which favours the study performed by Taggart and co-authors [11]. The free choice in amount and calories value of traditional food (high fat, high calorie, low nutrition food), is likewise one of the determining factors leading to a great decrease in HDL values below 1.03 mmol/L. Damages on the superficial venous system of the lower extremities in first and second stage were not statistically proven, unlike frequent obesity. Body building amateurs (aged 18 to 25) who have used anabolic steroids in combination with testosterone during their anaerobic exercising programme are classified as high risk population in developing cardiovascular diseases, as seen through the analysis of lipid status and an increase of arterial pressure.

CONCLUSION

Conducted study analysis favours the intensity increase of developing Atherosclerosis Pathogenesis, where behind an image of allegedly healthy young amateur, there is potential heart disease patient, a potential coronary or vascular patient in need of revascularization. The benefits of this irrational training on the health in subject using doping cannot be elaborated from the context of this research, neither can it be statistically proven, favouring the progression of systematic arteriosclerosis and stenosis and occlusive diseases.

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ABSTRAKT

ÚROVEŇ HDL U AMATÉRSKYCH BODYBUILDEROV, KTORÍ ZNEUŽÍVAJÚ KOMBINÁCIE TESTESTERONOVÉ VÝROBKY A ANABOLICKÉ STEROIDY V BOSNE A HERCEGOVINE

Kľúčové slová: androgénno-anabolické steroidy, amatérsky kulturisti, arteriálna hypertenzia, hyperlipidémia, cievne ochorenia

Tí, ktorí trpia Adonisovým syndrómom si neuvedomujú vedľajšie účinky anabolických steroidov, ktoré môžu byť zneužité a predpísané pre ich potreby, aby dosiahli perfektné svalové proporcie a kvalitu fyzického cvičenia bez motivácie na súťaženie. Rizikové faktory, ako je zvýšenie hladiny LDL (lipoproteín s nízkou hustotou), zvýšenie hladiny lipidov v sére, zníženie HDL (lipoproteín vysokej hustoty) a arteriálna hypertenzia sú jednými z hlavných faktorov v patogenéze aterosklerózy. Uvedené rizikové faktory priamo ovplyvňujú vznik trvalého kardiovaskulárneho poškodenia u mladých amatérskych kulturistov vo veku od 18 do 25. Cieľ: Cieľom štúdie je stanovenie vedľajších účinkov zneužívania androgénnych anabolických steroidov v kombinácii s testosterónom v skupine mladých amatérskych kulturistov, bez súťažnej motivácie. Táto štúdia ďalej poskytuje odhad a analýzu 5 rokov trvajúceho výskumu mladých amatérskych kulturistov z Bosny a Hercegoviny vo veku 18 až 25, zameraného na určenie nežiaducich účinkov užívania testosterónu v kombinácii s anabolickými steroidmi, na stav vaskulatúry, konkrétne v súvislosti s HDL / LDL. Metódy: Štúdia bola vykonaná na vzorke 60 probandov amatérskych športovcov, v období od roku 2010 do roku 2015. Sledovanú vzorku tvorilo 30 probandov, ktorí užívali androgénne-anabolické steroidy v kombinácii s testosterónom po dobu 5 rokov, a 30 probandov, ktorí androgénne-anabolické steroidy neužívali. V prípade všetkých subjektov boli použité neinvazívne metódy (klinické vyšetrenie a ultrazvukové vyšetrenie žilového systému). Dĺžka trvania anaeróbnych tréningových jednotiek v posilňovni pre obe skupiny bola 1,5 - 2 hodiny vykonávaná 4-6 krát týždenne. Výsledky: Konečná analýza preukázala, že v skupine mladých užívateľov anabolických steroidov štatisticky dominujú muži (100%) resp. 30 probandov.

Analýza ďalej preukázala, že v skupine užívajúcej androgénne anabolické steroidy bol v prípade 14 probandov (44,8%) prítomný arteriálny prehypertenzný stav s hyperlipidémiou, čo v porovnaní so 6 probandmi (18,5%), ktorí anabolické steroidy neužívali predstavuje štatisticky významný rozdiel (p <0,05). Hladina HDL pod 1,03 mmol / l bola prítomná v skupine užívateľov anabolických steroidov u 28 probandov (93,3%), čo bolo rovnako štatisticky významné na hladine štatistickej významnosti p <0,05. Záver: Amatérski kulturisti vo veku 18 až 25 sú užívateľmi androgénne anabolických steroidov, s cieľom dosiahnuť lepšie svalové proporcie a fyzickú silu so zanedbaním významu nežiaducich účinkov užívania anabolických steroidov, devastujúcich ich cievny systém a zvyšujúcich hladinu lipidov v sére. Vedľajšie účinky užívania steroidov v tréningovom programe rekreačných mladých amatérskych kulturistov sú väčšinou spojené s rozvojom arteriálnej hypertenzie a hyperlipidémie, ktoré progredujú v kardiovaskulárne ochorenia a devastujúce zdravotné poruchy.

THE LEVEL OF EXPLOSIVE STRENGTH OF THE LOWER LIMBS IN THE GROUP OF THE STUDENT'S

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Original scientific paper

Key Words:

students, level, motor skills, testing

Present study detects current state of the level of explosive strength of lower limbs of university students attending studies at Department of Physical Education and Sports, Faculty of Arts, Matej Bel University in Banská Bystrica. Students attended subject focused on diagnosis and research in sport. The sample consisted of 13 men (age ± 20.14 years; height ± 176.9 cm; weight ± 71.4 kg) and 4 women (age ± 19.87 years; height ± 168.4 cm; weight ± 58.2 kg). Measurement was realized on 11th of March in 2016 (in the beginning of the summer semester 2015/2016). We diagnosed three vertical jumps - 10 plyometric vertical jumps – PJ (Height, Time of Contact, Reactivity and Stiffnes); Squat Jumps – SJ (Height, Power, Force and Velocity; 3 repetitions) and Counter Movement Jumps-CMJ (Height, Power, Force and Velocity; 3 repetitions). Results present following mean values: mean value of CMJ test was 34.84 cm, mean value of SJ test was 30.74 cm and mean value in PJ test realized by 17 students (10 repetitions) was 9.65 cm with mean time of contact with the ground at the level of 110. 54 ms. Results were put to correlation analysis where we detected mutual dependence between all variables. We found out high unit of mutual dependence where values of correlation coefficient were 0.913465 – 0.930023.

INTRODUCTION

Strength abilities are conditioned genetically approximately in 65% while the explosive strength is conditioned in 75%. Many authors (Dapena, 1989; Foster et al., 2001; Kawamori- Haff, 2004) stated that muscle strength is considered as the factor which influence the sports performance the most it is also inevitable and very important element (Kušnírová, 2016).

The strength is conditioned by hypertrophy of muscle fibres from the point of view of cell level while fast twitch muscle fibres are more dominant than slow twitch muscle fibres. From the point of view of metabolism, the strength is conditioned by sufficiency amount of emergency resources their ability of fast using and possibility of their fast regeneration (Vindušková, 2003). The explosive strength is one of the strength abilities which is characterized by Kasa (1995) as dynamic strength ability which gives to body and its parts the biggest acceleration thanks to production of fast muscle effort. Vavák (2005), Grmanová (2006) and Lednický (2008) and Vanderka (2013) charcteriz the explosive strength of lower limbs as the complex physical ability which belongs to decisive factor of sport performance in variou sport types as basketball, volleyball, sport gymnastics, martial sports, swimming and others. Mentioned sports are compulsury subjects which students of physical education and sport must attend during their studies. According these facts we expect that the level of explosive strength of lower limbs of our sample will be on satisfactory level..

The level of explosive strength can be increased by procedures and their combinations which teachers usually integrate in education process to provide students possibilities to increase the level of physical abilities. Sedláček & Lednický (2010) incorporate into mentioned procedures the increase of muscle matter – enlargement of muscle cross-section, improvement intramuscular coordination – not all motor units are connected when solving of physical task but there is estimation that almost 60% of motor units are connected and higher percentage of motor units

are connected in extreme situations (90% of motor units when drowning). The organism mobilize as motor units as are necessary for solving some physical task. It leads to the selection of means (Hamar - Lipková, 2001), for example: jump from an elevate place (up to 2 m) - braking when the thigh is parallel to the ground; stimulating are squats, sits, jumps from 90% of maximum weight. Furthermore, by improving of intramuscular coordination- there is a harmony of muscle groups which are involved in height of jump. A supplementary load may not be big or improvement (increasing) of energy supplies (reserves), because there is an emergency reserve in the muscle of ATP, CP, which is not big – for realizing of 5 repetitions; It uses the principle of super compensation when training leads to depletion of energy resources, and afterwards the rest follows (Pupiš - Korčok -Rakovica 2005; Pupiš, 2009). The energy reserve is much greater in trained athletes. The present study was realized in order to determine the current level of explosive strength of lower limbs and parallel we will realize further measurements and tests of monitored physical abilities and observe changes that occur in students after particular semester in which they have to pass mentioned sports activities as the compulsory subjects. All three tests were realized barefoot on firm floor and after the warm-up. Only best results are presented in our research. We used following mathematical methods as methods of data collection: average, standard deviation, minimum and maximum. We examined the interdependence between variables, and we used correlation analysis through which we found out values of correlation coefficients. Values of the correlation coefficient was evaluated in following way: a positive correlation in case r> 0; negative correlation in case y <0, and do not correlate together in case R is = 0.

METHODOLOGY

Explosive strength of lower limbs was diagnosed by diagnostic device Myotest (device was created for measurement and optimalization of muscle performance). We used following tests for realization: squat jump (SJ)- is a vertical jump test to measure statodynamic muscle expansion of lower limbs without allowing any counter movement. The hands are held on the hips during the jump, thus avoiding any arm swing. The aim is to achieve maximal height. The task of the sample was to realize three repetitions. We monitored: Height (H), Power (P), Force (F) and Velocity (V). The second test was countermovement jump. The hands are held on the hips during the jump to avoid any effect of arm-swing. The aim of the sample was to realize three repetitions focused on maximal height. We monitored: Height (H), Power (P), Force (F) and Velocity (V). The last test was test to measure plyometric jumps. The aim was to realize 10 repetitions but results present only average of following values: Height (H), Time of Contact (C), Reactivity (R) a Stiffness (S). We focused on measurement of contractile abilities of muscle of lower limbs (flexibility, stiffness) while the values point out on spring qualities which influence the performance during the impulse which is related to the ground (floor).

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RESULTS

Results of the research showed the current state of the level of explosive strength of lower limbs of university students attending physical education studies at Department of Physical Education and Sports, Faculty of Arts, Matej Bel University in Banská Bystrica. The sample consisted of 17 respondents (13 men, 4 women). The examined sample attended testing of explosive strength of lower limbs through 3 tests: plyometric jumps, countermovement jump and squat jump. Test were realized by diagnostic device Myotest. Results are presented in Table1-3 and in Figures 1-3. Results were put to correlation analysis to detect the level of interdependence between variables.

Figure 1 presents Counter movement jump test in which we found out that woman respondent no. 15 achieved the minimum height of jump with the value of 23.2 cm. The maximum height was monitored in male respondent no.3 who achieved the value 47.9 cm. The average of results points out on value of 34.48 cm. When we compared women and men results we came up to fact that the worst results were achieved by women. According mentioned result we can state that women of our sample were no table to compete men´ results.

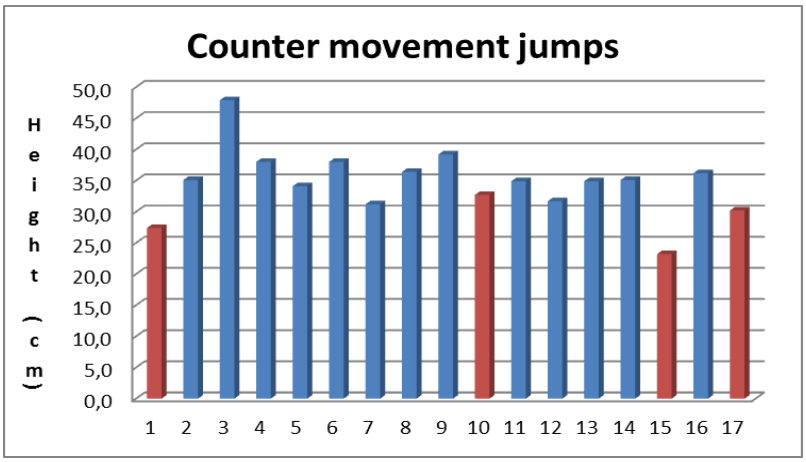

Figure 1 Results of CMJ test – max. height of the respondents´ jump

Table 1 presents complete results of CMJ test. We present values of maximum height of the jump, , Power (w/kg), Force (N/kg) and Velocity (cm/s). The average maximum height of the jump which was achieved by the sample had value of 34.48 cm while the value of SD= 5.16 and the value of median = 34.9 cm. We detected significant difference between minimum and maximum with the level of 24.7 cm. We have to be aware of the fact that the minimum value belongs to female respondent and maximum value to male respondent. Detection of maximum height of the vertical jump was one of the most important parameter in this test.

We found out that the average values of the sample in Power parameter were on the level of 46.55N/kg while the value of SD = 15.76and of median 22.6W/kg. The minimum value was 27.8W/kg and maximum value was 97.2W/kg what presents the difference on the level of 69.4W/kg (more than twice the amount). We diagnosed that the average values in Force parameter were on te level of 23.39N/kg in which SD SD = 2.43 and median = 22.6N/kg. The last monitored parameter was Velocity in which we found out that the average values of the sample were on the level of 284.46cm/s while the values of SD = 106.07 and values of median = 247.0cm/s.

Table 1 Results of CMJ test

Couter movement jumps	Height (cm)	Power (W/kg)	Force (N/kg)	Velocity (cm/s)
Min	23,2	27,8	20,6	186,0
Max	47,9	97,2	30,2	613,0
SD	5,16	15,76	2,43	106,07
Medián	34,9	43,7	22,6	247,0
Priemer	34,48	46,55	23,39	284,46

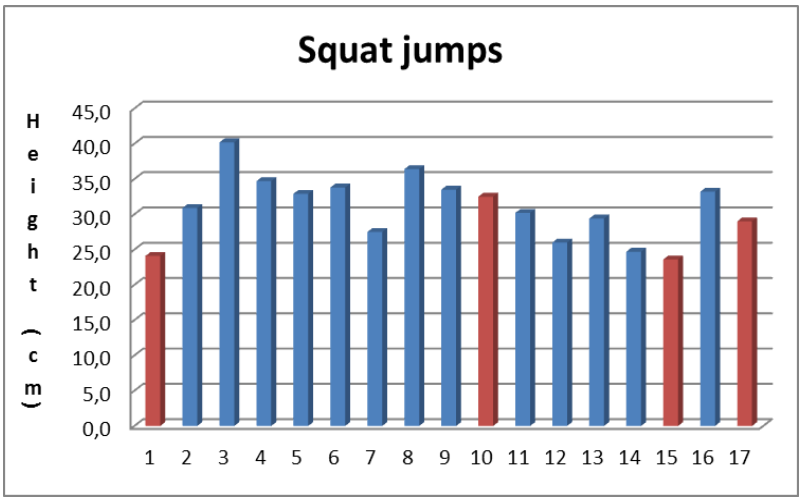

Figure 2 Results of SJ test– max. height of the respondents´ jump

Figure 2 presents results of the sample in SJ test. Results point out on the level of maximum height of the jump. Female respondents are coloured by red colour and male respondents by blue colour. The lowest height of the jump was monitored in female respondent no. 15 who achieved the value of 23.6 cm. The highest jump was monitored in male respondent no.3 who achieved the height with the value of 40.2 cm. The average values of the sample were on the level of 30.74 cm. Difference between women (the best and the worst performance) was diagnosed on the level of 8.9 cm and between men on the level of 15.5 cm.

Table 2 Result of SJ test

Squat jumps	Height (cm)	Power (W/kg)	Force (N/kg)	Velocity (cm/s)
Min	23,6	17,0	17,3	181,0
Max	40,2	56,5	42,7	347,0
SD	4,46	8,76	5,18	35,28
Medián	30,9	42,2	23,6	236,0
Priemer	30,74	40.82	24,89	240,18

Table 2 present complete overview of results which were examined in SJ test. All respondents attended and participated on the test. We found out the average values of vertical jump on the level of 30.74 cm while SD = 4.46 and median had the value of 30.9cm. We found out that the minimum value in Power parameter had the value of 17.0W/kg and maximum value of 56.5W/kg. The average of values was on the level of 40.82W/kg, SD = 8.76 and median = 42.2W/kg. We monitored that the minimum value in Force parameter had the value of 17.3N/kg, maximum value of 42.7N/kg, SD = 35.28, median = 23.6 N/kg and the average of values was detected on the level of 24.8N/kg. We detected that the average of the values in Velocity parameter was on the level of 240.18cm/s, minimum value of 181 cm/s, maximum value of 347cm/s in which SD = 35,28 and median was on the level of 236cm/s.

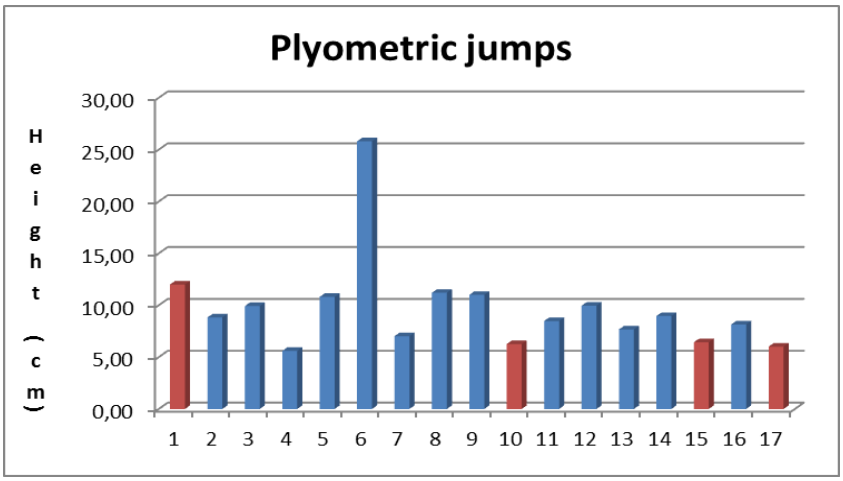

Figure 3 Results of PJ test – average values of 10 repetitions

Figure 3 presents results of Plyometric jumps test (PJ) in which our sample realized 10 repetitions. Results present the average of all repetitions. We monitored following data: Height (cm) and the parameter Time of Contact (ms). Male respondent no. 4 achieved the lowest height of jumps on the level of 5.6 cm. .Male respondent no.6 achieved the highest jumps with the average value of 25.8 cm. Female respondent no. 17 achieved the shortest time in the length in Time of Contract (86ms) and the male respondent no. 12 achieved the longest time (137.0 ms).

Table 3 Results of PJ test

Plyometric jumps	Height (cm)	Time of Contact (ms)	Reactivity	Stiffnes (kN/m)
Min	5.6	86.0	1.88	27.5
Max	25.8	137.0	4.06	165.0
SD	4.47	13.34	0.49	31.78
Medián	8.82	111.0	2.41	96.1
Priemer	9.65	110.54	2.5	93.63

Table 3 presents results of Plyometric Jumps test in which our sample achieved following average values: the height of the jumps were on the level of 9.65 cm while the values of SD = 4.47 and values of median = 8.82 cm. We found out that minimum value in Time of Contact parameter was on the level of 86 ms and maximum value on the level of 137 ms, the value of SD = 13.34 and the value of median = 111 ms and the average of all data was on the level of 110.54 ms. Reactivity was another monitored parameter where we denoted minimum value on the level of 1.88 and maximum value on the level of 4.06, SD=0.49, median= 2.41 and the average of all values was on the level of 2.5. Stiffness was the last monitored parameter in which we detected the average on the level of 93,63kN/m, while the minimum value was diagnosed in female proband no. 10 (27,5kN/m), maximum value was diagnosed in male proband who achieved the lowest jumps on the level of 165,0kN/m, value of SD = 31.78 and the value of median = 96.1 kN/m. All discovered results were put to correlation analysis where we monitored interdependence between all variables. We found out high amount of interdependence where the values of correlation coefficient were on the level from 0,913465 – 0,930023.

DISCUSSION and CONCLUSION

Present study focused on detection of current level of explosive strength of lower limbs of university students attending studies at Department of Physical Education and Sports, Faculty of Arts, Matej Bel University, Banská Bystrica. We realized three types of tests: counter movement jump test, squat jump test and test of 10 repeated plyometric jumps. Results point out on the following average values of monitored sample: the average values of height in CMJ test were on the level of 34.48 cm, the average values in SJ test were on the level of 30.74 cm and the average values in PJ test were on the level of 9.65 cm with the average time of contact with the ground on the level of 110.54 ms.

Discovered results were put to correlation analysis where we monitored interdependence between all variables. We found out high amount of interdependence where the values of correlation coefficient were on the level from 0,913465 – 0,930023.

According to our results we can state that the level of monitored parameters is almost on identical level when we compared mentioned results with results of previous researches realized in 2014-2016. Motor (physical) fitness of children and young people is on the low level and that is why this generation suffer from obesity. Despite of mentioned fact we found out that the level of chosen physical ability of our sample was on satisfactory level. We have to present the fact that our research oriented only on one physical ability and that is why we cannot state clear and definite conclusions.

I tis necessary and inevitable to realize more measurements of all physical abilities in children, young people and adults.

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ABSTRAKT

ÚROVEŇ VÝBUŠNEJ SILY DOLNÝCH KONČATÍN ŠTUDENTOV

Kľúčové slová: študenti KTVŠ FF UMB, pohybové schopnosti, testovanie

Predložená štúdia je zameraná na zistenie aktuálneho stavu úrovne výbušnej sily dolných končatín študentov Katedry telesnej výchovy a športu, Filozofickej fakulty Univerzity Mateja Bela v Banskej Bystrici, ktorí navštevovali predmet zameraný na diagnostiku a výskum v športe. Výskumný súbor tvorilo n = 17 probandov (n = 13 mužov, ktorých priemerný vek bol 20,14 roka, priemerná telesná výška bola 176,9 cm a priemerná telesná hmotnosť bola 71,4 kg a n = 4 ženy, ktorých priemerný vek bol 19,87 roka, priemerná telesná výška bola 168,4 cm a priemerná telesná hmotnosť bola 58,2 kg). Testovanie bolo realizované na začiatku letného semestra 2015/2016, dňa 11.marca 2016. Realizované boli testy vykonávané prostredníctvom diagnostického prístroja Myotest, pričom sme zisťovali príslušné hodnoty 10-tich plyometrických odrazov – Plyometric Jumps - PJ (Height, Time of Contact, Reactivity and Stiffnes), 3 opakovaní Squat Jumps -SJ (Height, Power, Force and Velocity) a 3 opakovaní Counter Movement Jumps - CMJ (H, P, F a V). Výsledky poukazujú na priemerné hodnoty: v teste CMJ boli priemerné hodnoty výšky vertikálneho výskoku z protipohybu na úrovni 34,48cm, v teste SJ boli priemerné hodnoty výšky vertikálneho výskoku bez protipohybu na úrovni 30,74cm a v teste PJ boli priemerné hodnoty 10 opakovaní u 17 probandov sledovaného súboru na úrovni 9,65cm s priemerným časom kontaktu s podložkou na úrovni 110,54ms. Zistené výsledky sme podrobili aj korelačnej analýze, kde sme zisťovali vzájomnú závislosť medzi všetkými premennými. Zistili sme vysoké miery vzájomne závislosti, kde hodnoty korelačného koeficientu boli na úrovni od 0,913465 – 0,930023

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ANALYSIS AND COMPARISON OF THE GAME PERFORMANCE OF GUARDS OF THE WOMEN BASKETBALL TEAM SC UMB BANSKA BYSTRICA IN THE SEASONS 2014/2015 AND 2015/2016

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Original scientific paper

Key words:

students, level, motor skills, testing

The paper presents the results of the analysis and comparison of game performance of two women-guards of the women basketball team SC UMB Banská Bystrica in the seasons 2014/2015 and 2015/2016. The main method we used to evaluate the game performance of the two women-players within both seasons, was observation, more specifically, it was the method of a direct structured long-term group observation. The observed indicators were recorded in the game statistics records after each match, which enabled us to obtain data related to total game productivity (TP) of the players. Game productivity is one of the main indicators of the game performance and in the records, it is calculated by means of a formula used in quantitative Manley's method. For qualitative evaluation of the data obtained from the game statistics records in both seasons, we have analyzed the game performance of each guard, and further compared the data. The shooting indicators have proved that it is not only the points made that matter, but the activity of a player in a number of points attempted is also extremely important. Similarly, the situation related to indicators of positive and negative critical cases appears to be relevant. We have found out that for the post of a guard, stable performance in individual indicators of the game statistics is essential, and there should not be significant differences in game performance within one season.

INTRODUCTION

There is no doubt that basketball is a constantly developing sport. The requirements for coordination of the player's moves, and the types of factors which affect the game itself, are extremely important. More specifically, it is the limiting, conditioning, and complementary factors, mainly from the biological, motoric, and psychological-social point of view (Vojčík et al., 1997).

Tománek (2010) sees the specifics of basketball in a relation between the dynamics of the moves and a gradually more frequent physical contact between players, which is typical mainly in professional basketball. The rules, however, do not allow many forms of contact. Basketball is developing to be more of a physical game which allows physical contact to a certain extent.

Basketball is a dynamic sport in which there is a constant change in the pace of the game, as well the game itself, its tactics, actions and reactions to the match development, and finally, the unpredictable situations. The course of the game can be divided into a defense and the offense phases. These phases are in a close relationship, because as one team is performing the offense, the other team is in the defense phase. Each phase is divided into smaller stages of the game, where various game situations occur (Táborský et al., 2007).

According to Horička (2014), a game situation is when in a given moment of the game there are

no changes in the structure of the game situation. On the basis of a specific game situation, an individual or the whole team enters a game role which needs to be solved. The game situations may be as follows:

- standard, which are limited by rules, and occur when the match is interrupted. It is for example throwing the ball in the game after a free throw, etc.
- typical, which result from the course of the game. It is the frequently repeated situations within the match, depending on the acts of the opponent, e.g. defense of a player with the ball, or handling the screen. There are different alternatives how to solve these situations.
- unique, or special game situations. There are other game situations which require variable, more complex solutions, and result from the acts of teammates and opponents.

The acts that are performed in the course of the game require high level of motoric skills and special skills, high level of coordination of the moves, precise differentiation, muscle coordination, cooperation in combinations, and many other factors. During the course of the game, a player must be aware of several factors: the immediate status of the game situation, ability to anticipate action, and the right choice of tools for playing, the extent of influencing the acts of the opponent, or the movement of the subject of the game (the ball). Besides, basketball develops determination, psychological resistance, and social cohesion (Horička, 2014).

The prerequisites for the high level of all chosen factors carried out during the game (sports activity), are created through the influence of natural abilities, external environment, and purposeful practice. The final result of a sports activity is sports performance. It is a complex presentation of the individuals' abilities, internal or external factors, which lead to a higher or a lower level of the achieved result (Peráček, 2004).

Basketball, such as the other team sports, uses the term game performance. Přidal, (2011), understands game performance as a specific case of the sports performance in specific parts of the sports games. The author therefore considers this term as a synonym to 'sports performance', where instead of the term 'sportsman' we use the term 'player'.

Game performance is often mistaken for the term game efficiency (Měkota, Cuberek, 2007). Feč and Feč (2013) understand sport efficiency as the ability of a team or an individual to perform in a stable way in a certain period of time. It is a long-term process which is divided from the development point of view into: macrocycles, mesocycles, microcycles, and training units. Via these cycles, we can achieve growth in the efficiency, and thus also successfulness. The efficiency is affected by the age as well as the load of the players. Therefore it constantly changes and has a dynamic character. There are three phases of sport efficiency:

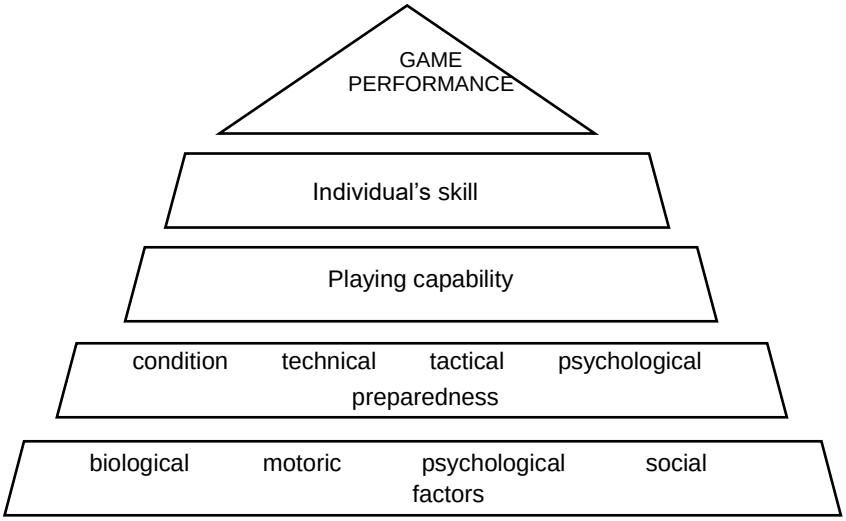
- the phase of increasing the sport efficiency,
- the phase of stabilizing the sport efficiency,
- the phase of decreasing the sport efficiency.

In basketball, game performance is understood as implementing the individual and group acts of players in a match, which are affected by the frequency of game task (Hůlka, Bělka, 2013). On the basis of this understanding of game performance, we distinguish between the individual and the team game performance.

All a player does in a match and all that is connected with fulfilling his/her roles in the match, can be classified as the individual game performance, or the game performance of an individual. The game performance of an individual is a very complex phenomenon, as many phenomena are happening inside the player's body, and therefore the performance is difficult to observe. It is psychological processes, e.g. perception, thinking, making decisions, attention, etc. On the outside, players manifest quality and a number of individual skills. On basis of this, players are judged and evaluated. Therefore the requirements for understanding players and having an individual approach towards them have become more and more frequent (Velenský, 1999).

The individual game performance in basketball is affected by many determinants and factors. In literature, we can find different classification of these factors. If we take into consideration the work of Choutka (1981), Dobrý and Semiginovský (1988), Hohmann and Brack (1983), or Přidal (2011), we distinguish the following factors:

- biological factors,
- motoric factors,
- psychological factors,
- social factors (Picture 1).

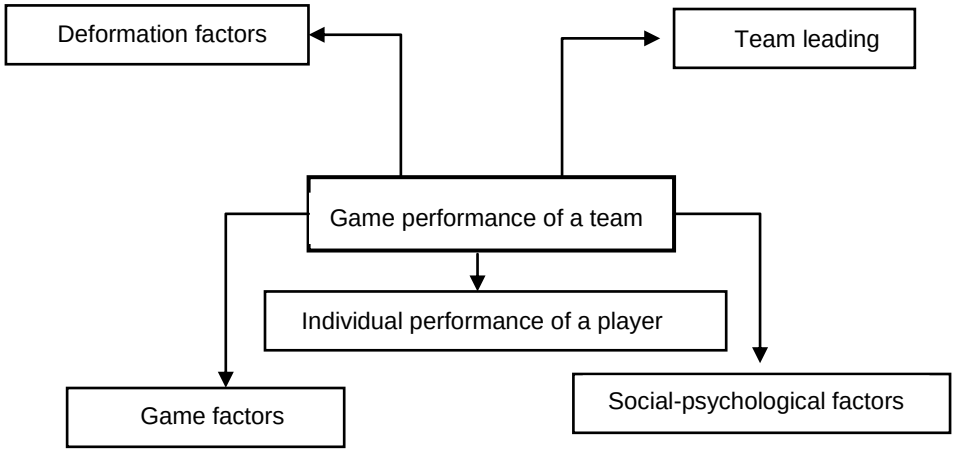


Picture 1 Model of a structure of an individual game performance
Source: Own elaboration according to Přidal (2011).

Picture 1 shows the hierarchy of the players' level, and their capability to play, i.e. game predisposition or skill, which includes the integration of condition, technical, tactical, and psychological preparedness. Game performance mainly depends on realizing the individual skills by the player.

Game performance of a team is based on the individual performances of players, which are subject to mutual regulation effect. The individuals influence the game of the team, and the team affects the individuals. Team performance is not a sum of performances of individuals; it is a qualitatively higher phenomenon which is influenced by social, psychological, and special game rules and regulations (Přidal, 2012).

Besides these rules and regulations, the game performance of a team is limited by the following factors (Picture 2):



Picture 2 Model of a structure of team game performance
Source: own elaboration.

The main expression of the team game performance is the result of a match; in basketball it is the final score, but also the ranking of the team in the given season. These are qualitative characteristics which we focus on when evaluating the team game performance, but we also consider the quantitative characteristics, which relate to the length of the match, standard situations, skill executions of an individual, etc. (Nemec, Adamčák, Izáková et al., 2014).

Besides evaluating the team game performance, we can also evaluate the game

performance of the individual players. All values can be obtained by direct observation of the match, watching a video, from the score sheet, or from the game statistics (Rose, 2013).

In our paper, we base our arguments on the results of evaluation of game performance obtained from the game statistics records. These are technical scores which are recorded by all teams during the matches.

According to Tománek (2010), since 2004, game statistics have been recording the number of minutes a match lasted, successful and unsuccessful attempts to score two or three points, and FT for one point, defensive rebound, offensive rebound, assistance, turnovers, personal fouls, blocked shots, and the final score. In our case, these statistics also include positive fouls, and the two-point shots are divided into under the basket shots and field shots.

To evaluate the whole team game performance, or the game performance of the individual players, we can use a number of methods. All methods, however, are based on observing the critical incidents: positive, or negative individual skill. These methods are used for preparing players' characteristics in the match, in the training process, as well as for the skills and analysis of the individual game performances (Sűss – Buchtel, 2009).

There are various methods of evaluating the game performance in basketball:

- Hluchý's method – evaluates each event with either a positive or a negative value (+1, -1),
- Iljaško's method – focuses on defense acts,
- Stéblo's method – evaluates by a coefficient of general activity of a player in the match,
- Válková's method – evaluates the difference between the positive and the negative values/data.
- GPAI method - The Game Performance Assessment Instrument, informs of tactical and technical abilities of a player in solving critical cases (Memmert, Harvey, 2008). The GPAI method was elaborated in the studies of Mitchell et al. (2006) with the focus on: football, basketball, rugby, and ice-hockey.

Evaluation according to the GPAI method consists of the following points (Table 1):

Table 1 Evaluation of the game performance according to the GPAI method

Components	Definition
Basics	Correct return to defense
Deciding	Early decision of what to do with a ball: driving in, shooting, passing
Coordination	Managing the transition phase of the game
Support	Freeing the player without the ball
Player's abilities	Effective manifestation of playing skills
Covering	Covering the player with the ball
Defending	Defending the player without the ball

Source: adapted from Mitchell, Oslin, Griffin (2006).

Table 2 Calculation of the final score according to the GPAI method

Index	How to calculate it
Support index (SI)	Number of appropriate and inappropriate supporting movements without the ball
Decision making index (DMI)	Number of appropriate/inappropriate decisions made
Skill execution index (SEI)	Number of efficient/inefficient skill executions

Source: adapted from Mitchell, Oslin, Griffin (2006).

Where the formula for calculating the game performance according to the GPAI method is:

$$\frac{(DMI + SEI + SI)}{3}$$

The result is then judged by the following criteria (Mitchell, Oslin, Griffin, 2006):
5 – Very efficient performance: the player is constantly active, available for team players, helps in critical situations,
4 – Efficient performance: the player attempts to cooperate with tem players, communicates often, requests the ball,
3 – Average efficiency: the player sometimes communicates with team players, is less available for them, is slower than others,
2 – Weak efficiency: the player rarely communicates with team players, seldom receives the ball, quits if ball is not received,
1 – Very weak efficiency: the player does not make him/herself available, does not obtain the ball, does not communicate with team players.
The last method we used to evaluate the game performance of our respondents for the purposes of this paper is Manley's method, which is considered to be the most frequently used method of game performance evaluation in basketball. Its main indicator is game efficiency, and it is evaluated by a formula used in NBA to determine the MVP (most valuable player of the season). This formula is further mentioned in the methodology part of this paper.

OBJECTIVE

The objective of this paper is to analyze and compare the game performance of guards of the women basketball team SC UMB Banska Bystrica in the seasons 2014/2015 and 2015/2016.

GOALS

1. Defining the problem and the objective of the survey.
2. Choice of a representative sample.
3. Data collection.
4. Data evaluation and analysis – analysis of the game performance of women guards with the use of game statistics records in the seasons 2014/2015 and 2015/2016.
5. Comparison of the game performance of female guards in the seasons 2014/2015 and 2015/2016.
6. Interpretation of the results and making conclusions.

METHODOLOGY

The analysis of the game performance was performed on a sample of the women basketball team SC UMB Banská Bystrica, at the Faculty of Arts, Matej Bel University in Banská Bystrica, in the seasons 2014/2015 and 2015/2016. The team meets in the gym at the Faculty of Arts, Matej Bel University, where it played its home championship matches of the First SBA Women's League, in both seasons. The game performance of two guards – K.M. and M.M. was observed, while these two women played in all matches of the first and the second parts[2] in both seasons (Table 1). In the 2014/2015 season, 15 matches were analyzed, and in the 2015/2016 season it was 14 matches.

[2] *In Slovakia the season is divided into the first (basic) part, played in the fall, and the second (extension) part, played in spring.*

Table 1 Somatic characteristics of two guards of the women basketball team SC UMB Banska Bystrica

Player	Age	Height (cm)	Weight (kg)	BMI	Number of years the player has played basketball
M. M.	21	166	67	24.3	8
K. M.	21	171	62	21.2	11

Note: cm – centimeter, kg – kilogram, BMI – body mass index

The players participated in the training process in the 2014/2015 season four times a week (Tuesday to Friday) in the afternoon, while Monday was free. All practices took place in the gym, Wednesdays being focused primarily on shooting. It must be pointed out that in the 2014/2015

season, the basketball team SC UMB was established, and therefore it was the first season for the team to play in the championship matches. In the 2015/2016 season, the players participated in the training process five times a week (Monday to Friday), in the afternoon, where Mondays and Wednesdays were focused on working out in the fitness and cross-fit studio, and on the other days the training process was based in the university gym. Besides this, during the first part of the season, both players took part in morning shooting practices twice a week (Tuesday, Thursday). The women basketball team SC UMB Banská Bystrica played 15 championship matches in the 2014/2015 season in the period between October 4, 2014 – April 18, 2015 and 14 championship matches in the 2015/2016 season, between October 17, 2015 – April 3, 2016.

The main method used to record and evaluate the game performance of the players in the individual matches in both seasons, was observation. The results of this observation were recorded in the observation sheets during the championship (technical scoring sheet of the championshimatches, http://www.slovakbasket.sk/page.php?id=30). We used the direct structured long-term group observation method. The direct observer was the assistant coach, while she was assisted by substituting players. The recorded data from the technical score sheets were written in the game statistics records after every match (http://www.slovakbasket.sk/page.php?id=30), which enabled us to access the data concerning the total game productivity (TP) of the players. Game productivity is one of the most significant indicators of game performance, and in the game statistics records it is calculated by means of the formula, via the above mentioned quantitative Manley's method:

TP = (RO + RD + ST – TO – (UBSA – UBSM + 2PA – 2PM + 3PA – 3PM)) * 0.791 + A * 1.209 – (FTA – FTM) * 0.7088 + BS + PTS

where RO – offensive rebound, DO – defensive rebound, ZL – steels, TO – turnovers, UBS – under the basket shot, A – total number of shooting attempts, M – point made, UBS+2P+3P – field goal shooting, 2P – two-point shooting, 3P – three-point shooting, FT – free throws, A – assists, BS – blocked shots, PTS – points. (http://www.slovakbasket.sk/page.php?id=30).

To perform qualitative evaluation of the game statistics records in the 2014/2015 and 2015/2016 seasons, we have analyzed the game performance of each guard, and following this we compared the figures. Finally, the outcomes of the research were interpreted and the conclusions were made.

RESULTS

The game statistics is one of the indicators used in evaluation of the player's or the team's performance. The numerical indicators of the game statistics belong among the main means for analyzing and evaluating the game performance, for the individual matches, first (basic) part, second (extension) part, or the whole season. In our paper, we have analyzed and evaluated the results of the game statistics of two women-guards in the seasons 2014/2015 and 2015/2016. The observed matches were analyzed and evaluated in total for each season and each guard, while firstly the data were analyzed individually for each player, and following this, the indicators of their game efficiency were compared.

By analyzing the indicators of the game statistics of the guard K.M. positive and negative critical cases, which form the basis for the observation of each method of game performance evaluation, as stated by Sűss – Buchtel (2009), we have found out that this player improved in the 2015/2016 season when compared to the previous season of 2014/2015 in all positive indicators of the game statistics, and also in one indicator of negative critical cases: turnovers – TO (highlighted in blue color in Picture 1). At approximately the same period of play time for both season, the player K.M. was more productive in the 2015/2016 season, which can be seen in Picture 1, mainly in the following indicators: offensive rebound (RO) and assists (A), in which this player's improvement tripled, as well as positive fouls (F+), where her activity improved by 33%. Besides positive critical cases, for this player (K.M.) we have also noted significant activity in the total number of three-point attempts (3PA), where the number of 3PAs increased by 66% in the 2015/2016 season. In the 2015/2016 season, this activity was the main indicator to have affected the improvement in the total number of points (PTS). Even though the player's total percentage in three-point shooting (3P%) and in other indicators related to shooting (UBS, 2P, FT) did not change in comparison with the 2014/2015 season, a significant activity of K.M.

in the number of three-point attempts and other positive indicators of the game statistics, along with a lower number of turnovers (TO), was essential for her significant 250% total improvement in the 2015/2016 season (Picture 1, the indicator TP – total game productivity).

GP K.M.	MIN	EVALUATION SHOOTING															+							-		
		UBS			2P			3P			FGS			FT			PTS	F+	RO	RD	ST	A	BS	TO	F-	TP
		UBSM	UBSA	%	2PM	2PA	%	3PM	3PA	%	FGM	FGA	%	FTM	FTA	%										
15 GP (2014/2015)	295	11	32	34	8	41	20	7	23	30	26	96	27	11	16	69	70	18	4	27	25	6	1	63	37	13,8
14 GP (2015/2016)	266	10	30	33	8	39	21	11	38	29	29	107	27	12	19	63	81	24	10	32	27	16	2	52	40	49,1
TOGETHER	561	21	62	34	16	80	20	18	61	30	55	203	27	23	35	66	151	42	14	59	52	22	3	115	77	62,9

Picture 1 Game statistics of the player K.M. in the 2014/2015 and 2015/2016 seasons

Note: GP – Played games, MIN – Minutes played, UBS – Under the basket shot, UBSA **-** Under the basket shot made, UBSA – Under the basket shot attempt, % - Shooting percentage, 2P – 2 points, 2PM - 2 points made, 2PA – 2 points attempt, 3P – 3 points, 3PM - 3 points made, 3PA – 3 points attempt, FGS - Field goal shooting, FGM - Field goal shooting made, FGA - Field goal shooting attempt, FT – Free throws, FTM – Free throws made, FTA – Free throws attempt, PTS – Points, F – Fouls, RO – Offensive rebounds, RD - Defensive rebounds, ST – Steals, A – Assists, BS – Block shots, TO – Turnovers, TP – Total game productivity, + = positive critical cases, - = negative critical cases

By analyzing the indicators of the game statistics of the second guard (M.M.), the positive and the negative critical cases, we have found out that this player improved in the 2015/2016 season, compared to the previous season (2014/2015) in only one of the positive indicators of the game statistics: the assists – A, and one of the negative critical cases: turnovers – TO (highlighted in blue color in Picture 2). More significant activity of the player M.M. has been observed in all indicators of shooting besides three-point shooting (3P). M.M. improved greatly in the effectivity of points made, which showed in her percentage of efficiency, where the percentage increased in the 2015/2016 season by almost 150% in under the basket shots (UBS%), by 86% in 2 point shooting (2P%) and by 130% in free throws (FT%). In picture 2 we can see that even with a lower pay time in the 2015/2016 season (by nearly 45%), the player M.M. was more productive in total in this season, which clearly shows her improvement in total game productivity (TP) by 70%. Compared to the previous season of 2014/2015, this player also improved in the number of points made, if we take into consideration the actual play time and the number of played matches in the 2015/2016 season. The weakest indicators in the 2015/2016 season, which greatly affected the possibility of a more significant improvement in total game productivity of M.M. in comparison with the 2014/2015 season, appeared to be the percentage of three-points made (3PM%), and the number of turnovers, while in positive critical indicators, it was mainly the number of offensive rebounds (RO) and assists (A).

GP M.M.	MIN	EVALUATION SHOOTING															+							-		
		UBS			2P			3P			FGS			FT			PTS	F+	RO	RD	ST	A	BS	TO	F-	TP
		UBSM	UBSA	%	2PM	2PA	%	3PM	3PA	%	FGM	FGA	%	FTM	FTA	%										
15 GP (2014/2015)	310	3	14	21	9	42	21	2	11	18	14	67	21	6	16	38	36	15	7	29	18	8	0	40	31	7,7
14 GP (2015/2016)	188	4	8	50	7	18	39	0	15	0	11	41	27	7	8	88	29	9	3	12	7	12	0	29	17	13,5
TOGETHER	498	7	22	32	16	60	27	2	26	8	25	108	23	13	24	54	65	24	10	41	25	20	0	69	48	21,3

Picture 2 Game statistics of the player M.M. in the 2014/2015 and 2015/2016 seasons

Note: GP – Played games, MIN – Minutes played, UBS – Under the basket shot, UBSA **-** Under the basket shot made, UBSA – Under the basket shot attempt, % - Shooting percentage, 2P – 2 points, 2PM - 2 points made, 2PA – 2 points attempt, 3P – 3 points, 3PM - 3 points made, 3PA – 3 points attempt, FGS - Field goal shooting, FGM - Field goal shooting made, FGA - Field goal shooting attempt, FT – Free throws, FTM – Free throws made, FTA – Free throws

attempt, PTS – Points, F – Fouls, RO – Offensive rebounds, RD - Defensive rebounds, ST – Steals, A – Assists, BS – Block shots, TO – Turnovers, TP – Total game productivity, + = positive critical cases, - = negative critical cases

When comparing the indicators of the game performance of two women-guards in the 2014/2015 season, we have found out that K.M. is a more productive guard, and a more successful player in shooting. Her total game productivity (TP) is mainly a result of her activity in shot indicators. At approximately the same amount of time played, the player K.M. achieved 18 more under the basket attempts in comparison with M.M., she was more active and successful in three-point shots (3P) as well as in free throws (FT). Activity and success in these indicators of shooting for K.M. (highlighted in red color in Picture 3) resulted in the difference of total points made, as well as in higher total productivity of this player. In two-point shooting and in the total number of free throws made (FTM), as well as in two positive critical cases (RO, A), both players were equally active and successful (highlighted in blue color in Picture 3). The only indicator in which M.M. was better that K.M. in the 2014/2015 season, was a lower number of turnovers (TO, as Manley's method does not take into consideration any fouls, F+, F-, in calculating the TP). This negative indicator, however, appears to be essential for the total result in game (total) productivity of both players, because this number is more than a 100% higher than the number of steals (ST), so the ratio of the positive (ST) and the negative (TO) critical cases is 1:2 in favor of turnovers, which is definitely a negative indicator of the game performance at the post of a guard.

2014/2015 15 GP	MIN	EVALUATION SHOOTING															+							-		
		UBS			2P			3P			FGS			FT			PTS	F+	RO	RD	ST	A	BS	TO	F-	TP
		UBSM	UBSA	%	2PM	2PA	%	3PM	3PA	%	FGM	FGA	%	FTM	FTA	%										
K.M.	295	11	32	34	8	41	20	7	23	30	26	96	27	11	16	69	70	18	4	27	25	6	1	63	37	13,8
M.M.	310	3	14	21	9	42	21	2	11	18	14	67	21	6	16	38	36	15	7	29	18	8	0	40	31	7,7

Picture 3 Comparison of the indicators of game performance of guards in the 2014/2015 season

Note: GP – Played games, MIN – Minutes played, UBS – Under the basket shot, UBSA - Under the basket shot made, UBSA – Under the basket shot attempt, % - Shooting percentage, 2P – 2 points, 2PM - 2 points made, 2PA – 2 points attempt, 3P – 3 points, 3PM - 3 points made, 3PA – 3 points attempt, FGS - Field goal shooting, FGM - Field goal shooting made, FGA - Field goal shooting attempt, FT – Free throws, FTM – Free throws made, FTA – Free throws attempt, PTS – Points, F – Fouls, RO – Offensive rebounds, RD - Defensive rebounds, ST – Steals, A – Assists, BS – Block shots, TO – Turnovers, TP – Total game productivity, + = positive critical cases, - = negative critical cases

We have also compared the performance of both guards in the 2015/2016 season, to verify the increase or the decrease in the indicators of their game performance in relation to the previous season. Picture 4 clearly shows that out of all indicators, there was only one in which they achieved a 100% identical value, and that was in the percentage of all shots made, as well as almost the same result in two-points made parameter (highlighted in blue color in Picture 4). The most significant difference as compared to the 2014/2015 season can be seen in the fact that while in 2014/2015, the player K.M. was more active and dominant, in all shooting attempts besides the two-point attempts where both players were equally active and successful, in the 2015/2016 season, this player (K.M.) was more active in the total number of all points attempted and made (UBS, 2P, 3P, FT, PTS), highlighted in red color in Picture 4). However, the player M.M. was more successful in the percentage of under the basket shots (UBS%), two-point shots (2P%) and free throws (FT%). (highlighted in yellow color in Picture 4). Despite her improvement, the low number of shots and no 3 point shots made resulted in the number of points made as low as 29 (2P/match), along with the low values of all indicators of positive critical cases, also due to a three times lower value of her game productivity (TP) compared to K.M. As in the 2014/2015

season, M.M. was more successful compared to K.M. in the 2015/2016 season in the indicator of turnovers (TO). What appears to be positive for M.M. is her improvement of this indicator in comparison with the previous season (40% improvement) – twice compared to K.M. (20 % improvement).

2015/2016 14 GP	MIN	EVALUATION SHOOTING															+							-		
		UBS			2P			3P			FGS			FT			PTS	F+	RO	RD	ST	A	BS	TO	F-	TP
		UBSM	UBSA	%	2PM	2PA	%	3PM	3PA	%	FGM	FGA	%	FTM	FTA	%										
K.M.	266	10	30	33	8	39	21	11	38	29	29	107	27	12	19	63	81	24	10	32	27	16	2	52	40	49,1
M.M.	188	4	8	50	7	18	39	0	15	0	11	41	27	7	8	88	29	9	3	12	7	12	0	29	17	13,5

Picture 4 Comparison of the indicators of game performance of guards in the 2015/2016 season

Note: GP – Played games, MIN – Minutes played, UBS – Under the basket shot, UBSA **-** Under the basket shot made, UBSA – Under the basket shot attempt, % - Shooting percentage, 2P – 2 points, 2PM - 2 points made, 2PA – 2 points attempt, 3P – 3 points, 3PM - 3 points made, 3PA – 3 points attempt, FGS - Field goal shooting, FGM - Field goal shooting made, FGA - Field goal shooting attempt, FT – Free throws, FTM – Free throws made, FTA – Free throws attempt, PTS – Points, F – Fouls, RO – Offensive rebounds, RD - Defensive rebounds, ST – Steals, A – Assists, BS – Block shots, TO – Turnovers, TP – Total game productivity, + = positive critical cases, - = negative critical cases

DISCUSSION AND CONCLUSIONS

During the many years of basketball development, there has been a need to quantify the game performance of the individual plyers as well as the whole team. Numerous methods were being created and developed, which enable us to objectively record the aspects of the game. These methods were improved from simple statistics recorded manually on paper (usually by assistant coaches or players) to currently used fully automated procedures which record significant variables (individual skill) of the match, and create necessary records of the game performance (Lorenzo, Gómez, Ortega et al., 2010; Oliver, 2004).

The analysis of game performance represents a feedback of the players' performance immediately after the individual matches, or later, and enables us to evaluate their performance for the whole season. It provides valid, precise, and reliable information about the game performance for the coach as well as for the player, it suggests what steps need to be taken, what changes should be done before and during the following season. This analysis should help players understand why things should or should not be done in order to improve their game performance.

The comparison of the indicators of the guards' game performance in the seasons of 2014/2015 and 2015/2016 suggests that for the post of a guard, more stable performance in the individual indicators of the game statistics are essential. The indicator of shots has proved that it is not only scoring that is important, but also the activity of the player related to the number of shots. This indicator noted a critical difference between our two observed players, because M.M., who improved significantly when compared to K.M. in the 2015/2016 season in the percentage of under the basket shots (UBS%), two-point shooting (2P%) as well as in free throws (FT%), reached no more than 30% of the shooting success (points made) of K.M. Therefore M.M.'s shooting indicator shows that it is essential to increase the activity in the number of shoots. Similar situation appears to be with the indicators of the positive and the negative critical cases, where the player M.M. showed a substantially lower activity compared to the player K.M. in the 2015/2016 season. While in the 2014/2015 season the players were approximately equal in numbers (besides two indicators – ST and TO), in the 2015/2016 season, their values were similar only in two indicators (A, BS). Lower values of M.M. in all positive critical indicators in the 2015/2016 season (besides the mentioned A and BS) resulted in significant differences between both players, in favor of K.M.

The only stable positive critical indicator for M.M., as compared to K.M., was turnovers (TO).

By analyzing and comparing the indicators of the game performance of our guards, we have come to a conclusion that to achieve a more productive game performance, for our guards, activity in all indicators of the game statistics is essential. As suggested by Benčiková (2013), activity is based on internal motivation which leads to motivating others, and thus to higher productivity. In total evaluation of the game productivity, as one of the important factors of individual game performance, it is not substantial to perform in positive indicators of chosen parameters, e.g. only being successful in points made, or in positive or negative critical indicators, but it is crucial for players who play at a guard post to achieve more stable results in the game statistics indicators without excessive fluctuation of the game performance values during the whole season.

The main reason for the insufficient and fluctuating level of game performance of our guards appears to be the following: of the negative critical cases it is the number of turnovers (TO), low frequency and effectivity of three-points made (3P%), and of the positive critical cases it is the offensive rebounds (RO). In case of turnovers, since the most common reason of losing the ball is the insufficient handling the ball by the player and the technique of the player while dribbling under pressure, or inaccuracies when passing the ball, we propose more attention be placed on the improvement of the given individual skills in the period after the end of a season. The effectivity of points made for every shooting, in our case the three-point shooting, can be increased only by increasing the shooting attempts, not only in the training process, but also, and mainly, on an individual basis and practice. In our case, the morning shooting practices in the 2015/2016 season appeared to be very efficient, while being conducted twice a week; for M.M. the practice was primarily focused on two-point shooting (UBS, 2P) and free throws (FT) and for K.M. it was three-point shooting (3P). With the last indicator – offensive rebounds (RO), it is to be decided how efficient the extra practice may be for the post of a guard, i.e. how much the coach will consider this indicator as essential for the improvement of the player's total game productivity. We need to realize that it is the post of a guard whose the role is to prevent fast offensive transition in offense, turnovers, or steals, and should most frequently be the one to return into defense. Therefore, a guard must consider his/her spacing, or the possibilities of a fast return, which often prevents the guard from actively participating in offensive rebounds of the team, and thus gaining these positive indicators of the game statistics for him/her as an individual, in relations to the other posts.

Analyzing and comparing the individual game performance in basketball is a very relevant issue and one of the main goals for coaches, players, sports scholars, and managers, the main significance of which is to make available detailed information about the players' individual game performance during a match or during the whole season, and thus create stimuli for increasing the effectivity of the training process. The evaluation of the individual game performance belongs among the basic theoretical and practical tasks. Even though there exists scientific knowledge related to this field, many coaches still tend to evaluate the game performance by observing the players, as well as using their coaching experience, without implementing any elaborate method of evaluation. The reason for this appears to be the complexity of the problem, which results from a large number of determinants of the individual game performance (Argaj, 2009). In our paper we have analyzed and compared two players – guards. We realize that this factor may have affected our general conclusions and recommendations, and therefore consider our findings to be a good starting point for further researches. By enlarging the sample of the research, or focusing or other age and performance categories, we may achieve more detailed analysis, recommendations, and generally valid and effective conclusions within the chosen problem of evaluating the game performance.

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ABSTRAKT

ANALÝZA A KOMPARÁCIA HERNÉHO VÝKONU ROZOHRÁVAČIEK DRUŽSTVA BDŽ ŠK UMB BANSKÁ BYSTRICA V SEZÓNACH 2014/2015 A 2015/2016

Kľúčové slová: basketbal, herný výkon, hra na produktivitu, štatistika

Príspevok prezentuje výsledky analýzy a komparácie herného výkonu dvoch rozohrávačiek univerzitného družstva BDŽ ŠK UMB Banská Bystrica v sezónach 2014/2015 a 2015/2016. Hlavnou metódou hodnotenia herného výkonu hráčok v priebehu oboch sezón bolo pozorovanie. Použili sme metódu priameho štruktúrovaného dlhodobého skupinového pozorovania. Pozorované ukazovatele sme po každom zápase vložili do záznamov hernej štatistiky, prostredníctvom ktorej sme získali údaje o hernej produktivite (HP) hráčok. Herná produktivita je jedným z hlavných ukazovateľov herného výkonu a v záznamoch hernej štatistike je vypočítaná prostredníctvom vzorca kvantitatívnej Manleyho metódy. Pre kvalitatívne vyhodnotenie údajov zo záznamov hernej štatistiky v oboch sezónach sme pristúpili k analýze herného výkonu každej rozohrávačky a následne k ich vzájomnému porovnaniu. V ukazovateli streľby sa ukázalo, že nejde len o jej úspešnosť, ale je dôležitá aj aktivita hráčky v početnosti striel. Podobná sa ukazuje aj situácia v ukazovateľoch kladných a záporných kritických prípadoch. Zistili sme, že pre post rozohrávačky sú dôležité stabilnejšie výkony v jednotlivých ukazovateľoch hernej štatistiky a nemali by mať prílišné výkyvy vo svojich herných výkonoch v priebehu celej sezóny.

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DIURNAL OSCILLATIONS OF THE SPRINT AND STRENGTH ABILITIES AND SHOOTING PRECISION IN BIATHLON

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Original scientific paper

Key words:

biathlon, diurnal rhythm, sprint abilities, strength abilities, shooting precision

The aim of the study was to determine the daily optimum and the daily pesimum of running speed performance, explosive strength of lower limbs and dynamic strength of upper limbs performance and performance of the shooting precision by the biathlete at the beginning of the preparation period of annual training cycle 2015/2016 (age 30.6, body height 170 cm, body weight 64.6 kg). The diagnostics we carried out in laboratory conditions, for 7 days in three-hour intervals (9 o`clock – 12 o`clock – 15 o`clock – 18 o`clock). Running speed was measured with the device Fitro Light Gates (FiTRONIC, Bratislava, Slovak republic). The criterion for the performance assessment was the running time, achieved over the distance of 30 m with the exactness of 0.01 s. The explosive strength of lower limbs was diagnosed by Myotest (Myotest, Switzerland). The criterion for the performance assessment was the average height of five vertical jumps in cm with the exactness of 0.1 cm. The dynamic strength of upper limbs was diagnosed by the training simulator Concept 2 SkiErg (Morrisville, USA). The criterion for assessing was the achieved power, presented in Watts, with an accuracy of 1 W. The shooting precision was diagnosed by electronic shooting simulator Scatt Professional (Scatt, Russian Federation). The criterion for the level assessment was the total point value of 10 shots with an accuracy of 0.1 point. Performances in shooting were diagnosed separately for shooting in prone and standing positions. In the running test we examined the optimum at 6 PM (5.19 ± 0.04 s) and pesimum at 3 PM (5,36 ± 0,12). In the shooting test we determined the optimum at 12 AM (prone position: 103.1 ± 1.2 points; standing position: 92.0 ± 6.1 points) and the pesimum at 9 AM (prone position: 99,9 ± 4,7 points; standing position: 89,7 ± 2,6 points). In both of tests of strength abilities we determined the optimum at 6 PM (Concept2 SkiErg: 222.1 ± 11.8 W; Myotest: 33.4 ± 1.1 cm) and pesimum at 3 PM (Concept2 SkiErg: 192 ± 13,1 W; Myotest: 32,1 ± 1,4 cm). The statistical analysis was realized by software IBM® SPSS® Statistics V19 (Statistical Package for the Social Sciences) a R Project. Significant differences were noticed in upper limbs strength abilities (Concept 2), where the measured values for power $p < 0.05$, Kendall´s W = 0.89, effect size very strong, running time in 30 m, where $p < 0.05$, Kendall´s W = 0.48, effect size moderate, vertical jump, where $p < 0.05$, Kendall´s W = 0.44, effect size moderate. In shooting skills there weren`t noticed the significant differences among four times during the day.

INTRODUCTION

The performance and the alertness change during the day. It depends on as the waking-up time as well as the internal circadian clock. Biorhythm is the part of dynamic organization, thereby contributes to the overall performance and stability of the body (Aschoff, 1981). According to several authors: Jančoková (1992, 1994, 2000), Roenneberg et al. (2007), Hastings et al. (2008), Homolka et al. (2010), Jančoková et al. (2011) and Jančoková et al. (2013), is the cycle "light – dark" the strongest external exogenous factor of the environment, that together with the internal endogenous factors organize the rhythmic changes in the organism activity. Rowland (2011) emphasizes, that the time of day when the athlete exercises is very important. Jančoková et al. (2011) argue, that for the top sport performance are the afternoon and the evening the most suitable parts of the day. Based on their findings, a typical diurnal rhythm of muscle strength and performance has the lowest figures in the early morning and, on the contrary, it culminates later during the day. Lipková (2002) found out the highest performance in agility, speed frequency, bench press and explosive power of the lower limbs in the afternoon and in the evening. Paugschová, Šulej & Ondráček (2010) demonstrated the best performance in the sprint and strength abilities also in the afternoon. Paugschová, Gereková & Ondráček (2010) determined the optimum in sprint abilities of the biathlete at 6 PM, in strength abilities at 9 AM. The optimum in shooting performance the authors found in the afternoon, at 3 PM. By the training group of young biathletes, Mojžiš (2014) verified the training program, focused on strengthening the deep stabilization system, to enhance the stability of the shooting position, realized in the morning. Kalinkova (2005) consider the morning as the most effective part of the day for training process for gymnastics. Reilly et al. (2007), Štulajter (2007) and Pivovarníček et al. (2013) made their research in football. First appointed, characterized the highest alertness and the lowest fatigue on the group of eight young footballers at 8 PM. Second appointed, came to interesting findings, when his training group reached two optimums during a day. The first one was at 9 AM and the second was reached late in the afternoon. Based on changes in body temperature, heart rate and lactate concentration in the blood, Edwards et al. (2005) noticed the changes in the performance of cyclists, by inclusion the warming up at the same time of day, at which they held the race. Optimum in sprint-strength abilities by ski jumper, found out Schlank & Pupiš (2007) at noon. From these studies, and also in line with the findings of Jančoková et al. (2011, 2013) we summarizes, that the performance of individual abilities and skills varies during the day and that the results of the findings differ one with another. Kazár (2011) found out, that the increases in performance by the biathlete don`t relate only with training process based on sensitive period, but also with the knowledge and acceptance of biologic rhythms. The study is part of grant project research VEGA Ministry of Education no. 1/0795/15 Biorhythms, an important phenomenon of population lifestyle.

AIM

The aim of the study is the diagnostics and the determination of daily optimum and daily pesimum of sprint and strength abilities performance and shooting precision performance by the biathlete at the beginning of preparation period.**TASKS**

1. To compile the testing battery.
2. To find out the level of sprint and strength abilities and shooting skills in diurnal rhythm.
3. To process the acquired data and to evaluate them objectively.
4. To determine the daily optimum and daily pesimum of selected parameters.
5. To draw the conclusions for sport practise and the science discipline development.

METHODS

Participant

We monitored the actual representative of Slovak republic in biathlon, J.G., the member of VŠC Dukla Banská Bystrica. She addicts herself to biathlon training for 15 years. Since 2005 she is the member of Slovak biathlon national team and she takes part the world cup races regularly. She participated the three Winter Olympic Games, for first in Turin in 2006, the second time in Vancouver in 2010 and the last one in Sochi in 2014. On the last mentioned she was the member of the MIX relay, that finished fifth. The highest position in total world cup score on that she was placed is the 19th place from the season 2014/2015. At the World Championships in Russian Khanty Mansyisk in 2011 she finished 8th in pursuit competition. In the series of the world cup races she finished totally eleven times in top ten and her best place in the world cup races is the 4th place in sprint competition from Antholz in the season 2014/2015. Since 2006 till 2014 she trained under the control of her personal coach Ing. M. G., owner of the 5th coaching qualification level. In the season 2014/2015 she trained in the group of woman national team, under the control of national coach PhDr. P. K. PhD. The next season, 2015/2016,

J.G. trained individually, the training process was led by her personal coach Mgr. L. D., owner of the 5th coaching qualification level. At the beginning of testing we investigated the basic somatic parameters (body height 170 cm, body weight 65,4 kg, index BMI 22,7 kg/m^2, body fat 21,6 % and muscle mass 74,4 %. The age of the athlete was in time of testing 30 years.

Procedure

The diagnostics we realised at the beginning of the preparation period, in the annual training cycle 2015/2016. The Investigation was realised in the laboratory area of the Department of Physical Education and Sport of Matej Bel University in Banská Bystrica during seven days, in three hourly intervals, while the first testing started at 9 AM and the last one started at 6 PM.

Methods of data acquisition

Methods for detection of the daily performance of selected physical abilities and shooting skills was a testing battery. The tests selection is based on the grant task methodology. We focused on the running speed measurement, explosive strength of lower limbs and dynamic strength of upper limbs measurement and shooting precision.

1. Running speed – running on 30 m

The level of athlete`s sprint abilities we diagnosed by the running test on 30 m in the hall of KTVS. The time measurement was done by means of photocells Fitro Light Gates (FiTRONIC, Bratislava, Slovak republic). The device automatically started trigger timing at a time, when the competitor had cut the photocell on the starting line and stopped it by cutting the second photocell. The competitor started from the high starting position. We conducted two control measurements, for evaluation we chose the better one.

2. Explosive strength of lower limbs (LL)

The level of lower limbs strength abilities we diagnosed by the device Myotest (Myotest, Switzerland). The device was placed on the left side of biathlete`s belt. She assumed an upright standing position with her hands on the hips. The recording started by signalisation of single beep. The competitor performed five, following continuously vertical jumps with minimal bending her legs and with an effort to reach the maximum height and minimum contact with a ground. After the 5th jump, the device indicated by double beep the end of testing. From the output values we evaluated the average height of five jumps.

3. Dynamic strength of upper limbs (UL)

The level of upper limbs strength abilities we diagnosed by training simulator Concept 2 SkiErg (Morrisville, USA). The exercise took 30 s during which the biathlete practised the maximal dynamic movement by 4th stage of load, imitating the double pole ski technique. She assumed an upright standing position, grasp the handles and then, after the movement initiation, the device started to record the 30 s long exercise interval. The level of upper limbs dynamic strength abilities we monitored through the power parameter in Watts.

4. Shooting precision

The biathlete performed the shooting test with her own competition rifle of German brand Anschütz Fortner 1827. The shooting performance was evaluated by the program of shooting training simulator SCATT Professional (Scatt, Russian federation). The device notes a score of shot. Maximum value of the shot is 10.9 points. Distance in laboratory condition was reduced from 50 m to 5 m from the muzzle to the electronic target. After assuming the shooting position, the competitor realized one shot to calibrate the device. Then she completed required number of shots to set the sight of a rifle. The diagnosis itself we started after the assuming the shooting position, when an examiner activated the shooting recording. The competitor realized 10 shots, with an effort to retire the race rhythm of the shooting. Test of the shooting precision we realised in two shooting positions, prone and standing.

Methods of data evaluating

For data evaluating we used the basic quantitative and qualitative methods. From the quantitative methods we used basic descriptive characteristics. From the rate of central tendency, we used the arithmetic average; from the rate of variability we used the standard deviation (SD). The arithmetic average of individual parameters was calculated from 7 measurements.

To determine the significance of differences between the performances, achieved at each hour during the day, we used the Friedman test for K dependent samples. For expertise subject analysis we used Kendall´s Coefficient of Concordance (W) for evaluation of effect size (Green & Salkind, 2008). The coefficient was interpreted as follows: 0 – 0.20 – very weak effect, 0.20 – 0.40 – weak effect, 0.40 – 0.60 – moderate effect, 0.60 – 0.80 – strong effect, 0.80 – 1.00 – very strong effect (Rovai, Baker & Ponton, 2014). The probability of

type I error (alpha) was set at 0.05 in all statistical analyses. Statistical analysis was conducted by IBM® SPSS® Statistics V19 (Statistical Package for the Social Sciences) a R Project.

RESULTS

The performance levels in all examined parameters in the entrance testing at the beginning of the preparation period are presented in Tab 1.

Chart 1 Average performance levels in examined parameters in daily rhythms, expressed in appropriate units

shooting precision	9 AM	12 AM	3 PM	6 PM
shooting in prone [p]	99.9 ± 4.7	103.1 ± 1.2	101.2 ± 3.0	101.7 ± 1.1
shooting in standing [p]	89.7 ± 2.6	92.0 ± 6.1	91.3 ± 1.2	90.3 ± 2.8
sprint abilities				
running on 30 m [s]	5.27 ± 0.07	5.29 ± 0.12	5.36 ± 0.12	5.19 ± 0.04
strength abilities UL				
Concept2 [W]	199.4 ± 16.6	194.0 ± 17.5	192.0 ± 13.1	222.1 ± 11.8
strength abilities LL				
height of 5 jumps [cm]	32.7 ± 0.8	32.5 ± 0.7	32.1 ± 1.4	33.4 ± 1.1

The Chart 1 presents the obtained data from the diagnostics of the performance level in selected parameters. The level of performance is expressed by the appropriate values, that are the averages of all 7 obtained values. Based on the obtained data from the research we established the daily optimum and daily pesimum for selected physical abilities and shooting skills development (Chart 2). In shooting, there is a consensus in optimum and pesimum as in prone position as well as in standing position. The highest level of shooting performance, the biathlete achieved at 12 AM, on the contrary, the weakest performance was recorded in the morning at 9 AM. However, the performance differences of measured values are not statistically significance. The most suitable time for sprint abilities development is in the evening, at 6 PM. Pesimum for sprint abilities development we noticed in the afternoon at 3 PM, when the biathlete reached an average of 0.17 s slower time than in daily optimum. The same conditions we recorded for dynamic strength abilities of upper limbs development. In the evening the competitor reached an average level of strength, presented in Watts, 222.1, what presents about 30.1 W more than in pesimum, at 3 PM. Based on the results of lower limbs strength abilities entrance testing we determine the optimum for their development at 6 PM, when the performance reached the average level of 33,4 cm. The lowest average height of five jumps, 32,1 cm, we diagnosed in the afternoon, at 3 PM.

Chart 2 Daily pesimums and daily optimums, determined for the selected parameters development

shooting precision	optimum	pesimum
shooting in prone	12 AM	9 AM
shooting in standing	12 AM	9 AM
sprint abilities		
running on 30 m	6 PM	3 PM
strength abilities UL		
Concept 2	6 PM	3 PM
strength abilities LL		
Myotest	6 PM	3 PM

CONCLUSION

The highest level of shooting performance in prone position, expressed in points, was 103.1 ± 1.2 points. It was measured while circadian rhythms, at 12 AM, at noon. The weakest performance, 99.9 ± 4.7 points, the competitor reached at 9 AM in the morning. In standing position, the competitor achieved the best performance, indicated by 92.0 ± 6.1 points, on the other hand, the lowest achieved score 89.7 ± 2.6 points was recorded at 9 AM in the morning. Optimum and pesimum for shooting skills development agree as in prone position, as well as standing position. However, with the statistical analysis we found out, that the performance level differences are not statistically significant. For future researches we recommend to realise the shooting test after an exercising. So we assume, that while the shooting in higher pulse frequency, the diurnal oscillations in shooting performance will be more significant. The highest level of sprint ability performance the biathlete achieved over time 5.19 ± 0.04 s, in daily optimum at 6 PM. A significantly lower level of the running speed, expressed by running time 5.36 ± 0.12, we noticed in daily pesimum, at 3 PM in the afternoon. The differences are statistically significant ($p < 0.05$, Kendall´s W = 0.48, effect size moderate). In the test of upper limbs strength abilities, the biathlete reached the best performance in the evening, at 6 PM, when the value, expressing the performance, reached on average 222.1 ± 11.8 W. Pesimum of the day we determined by the weakest performance, 192.0 ± 13.1 W in the afternoon, at 3 PM. The differences in upper limbs strength abilities performance are for power $p < 0.05$, Kendall´s W = 0.89 statistically significant. In the test of 5 vertical jumps, the highest level of lower limbs explosive power, indicated by the value 33.4 ± 1.1 cm, that the athlete achieved in daily optimum at 6 PM. In daily pesimum, at 3 PM in the afternoon, the biathlete achieved significantly lower average value of 32.1 ± 1.4 cm. The statistical significance of performances difference was confirmed by the statistical analysis $p < 0.05$, Kendall´s W = 0.44, effect size moderate.

We reccomend the biethlete to develope the selected physical abilities and shooting skills in their daily pesimum.

DISCUSSION

Similar results we investigated in the previous research, where we examined the biorhythmic changes of selected motion abilities: Gereková (2009), Paugschová, Gereková & Ondráček (2010). Optimum for sprint abilities development is the same in both investigations, but optimum for strength abilities development we determined previously at 9 AM. This phenomenon can be explained by change of using tests. In the previous research we investigated the level of strength abilities by these tests: sit-ups test, flexed arm hang test, standing long jump test. Optimum for shooting skills development, at first, we identified in the afternoon, at 3 PM. In case of next research, we recommend to change the methodology for shooting skills determining. We propose to include the shooting test after power load, which, in our point of view, can be more indicative of performance differences in performance during the day. Vančová et al. (2015) assayed by 18 university students the diurnal variation of performance (morning and evening) in dynamic strength of lower limbs. She concluded that the difference between performances in the morning and in the evening is insignificant (ES = 0.15 effect size is small). In our research the difference in lower limbs strength abilities performance while diurnal rhythm is statistically significant.

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ABSTRAKT

DIURNÁLNE OSCILÁCIE RÝCHLOSTNÝCH, SILOVÝCH SCHOPNOSTÍ A PRESNOSTI STREĽBY V BIATLONE

Kľúčové slová: biatlon, diurnálne rytmy, rýchlostné schopnosti, silové schopnosti, presnosť streľby

Cieľom štúdie bolo určiť optimum a pesimum výkonnosti v bežeckej rýchlosti, explozívnej sile dolných končatín, dynamickej sile horných končatín a v presnosti streľby u pretekárky v biatlone na začiatku prípravného obdobia ročného tréningového cyklu 2015/2016 (vek 30, telesná výška 170 cm, telesná hmotnosť 65 kg). Diagnostiku sme realizovali v laboratórnych podmienkach počas siedmych dní v trojhodinových intervaloch (9:00 - 12:00 - 15:00 - 18:00 hodine). Bežecká rýchlosť bola zisťovaná zariadením FITRONIC – FiTRO Light Gates (FiTRONIC, Bratislava, Slovenská republika). Kritériom hodnotenia výkonu bol dosiahnutý čas na vzdialenosť 30 m, s presnosťou 0,01 s. Explozívnu silu dolných končatín sme diagnostikovali Myotestom (Myotest, Švajčiarsko). Kritériom hodnotenia výkonu bola priemerná výška piatich vertikálnych skokov v cm, s presnosťou 0,1 cm. Dynamickú silu horných končatín sme diagnostikovali na trenažéri Concept 2 SkiErg (Morrisville, USA). Kritériom hodnotenia výkonu bol dosiahnutý výkon vo Wattoch s presnosťou 1 W. Presnosť streľby bola diagnostikovaná elektronickým streleckým trenažérom Scatt Professional. Kritériom pre hodnotenie výkonu bola bodová hodnota spolu 10 výstrelov, s presnosťou 0,1 bodu. Streleckú výkonnosť sme merali osobitne pre streľbu v polohe ľah a v polohe stoj. V teste bežeckej rýchlosti sme zistili optimum výkonnosti o 18 hod (5.19 ± 0.04 s) a pesimum o 15 hod (5,36 ± 0,12). V streleckom teste sme určili optimum výkonnosti o 12 hod (poloha v ľahu: 103.1 ± 1.2 bodov; poloha v stoji: 92.0 ± 6.1 bodov) a pesimum o 9 hod (poloha v ľahu: 99,9 ± 4,7 bodov; poloha v stoji: 89,7 ± 2,6 bodov). V oboch silových testoch sme optimum výkonnosti určili o 18 hod (Concept2 SkiErg: 222.1 ± 11.8 W; Myotest: 33.4 ± 1.1 cm) a pesimum výkonnosti o 15 hod (Concept2 SkiErg: 192 ± 13,1 W; Myotest: 32,1 ± 1,4 cm). Štatistickú analýzu sme realizovali pomocou IBM® SPSS® Statistics V19 (Statistical Package for the Social Sciences) a R Project. Významné rozdiely boli zaznamenané počas dňa v úrovni silových schopností horných končatín (Concept 2), kde namerané hodnoty p sú pre výkon $p < 0.05$, Kendall´s W = 0.89, effect size very strong. Štatisticky významné zmeny nastali aj v behu na 30 m, kde je $p < 0.05$, Kendall´s W = 0.48, effect size moderate a vo vertikálnom výskoku kde p má hodnotu $p < 0.05$, Kendall´s W = 0.44, effect size moderate. V jednotlivých úrovniach streleckej výkonnosti neboli počas dňa zaznamenané významné rozdiely.

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COMPARISON OF RESPONSE PARAMETERS OF THE ORGANISM TO THE LOAD IN SPORTS KARATE DISCIPLINES KATA AND KUMITE

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Key words:

load in sports karate, comparison, karate disciplines, kata, kumite, lactate

As part of the grant project VEGA 1/0414/15, we have decided to summarize the findings of the variability in the level of loading, in sports Karate-do disciplines Kata and Kumite, as the possibilities of using diagnostic load in the elite sports training. Sports Karate belongs to the group of combat, strength-speed sports where the load structure of sports performance is characterised by irregular interval oscillations of load intensity. Load intensity in both of its disciplines, however, ranges from medium to maximum duration and the time during which the load continues in one duel in Kumite is 3 min. for males, and 2 min. for females. In Kata, the average duration of one combat routine is 2 min. During such kind of load, the metabolic coverage of energy in the form of ATP-CP, anaerobic glycoses and aerobic phosphorylation takes place in both cases. We have measured the heart rate by means of a telemetry system Polar team 2 during sports performance in kata and kumite under training conditions. It was found that on average, the cardiovascular system underwent higher load in kumite. The average maximum heart rate values for kumite were higher by 4 n.min-1. Furthermore, the average HR values for kata were 188 n.min-1 while in kumite it reached 192 n.min-1. By measuring the blood lactate concentration using the the Biosen C-Line Lactate Analyser device, we found out that the average maximum LA values immediately after load were higher for kata competitors than kumite competitors, reaching a difference of 2.3 mmol.l-1. A comparison of maximum and minimum average LA values span during load showed that the difference between the maximum and minimum was higher for kata performance (9.8 mmol.l-1), while for kumite it amounted only to 5.7 mmol.l-1.

INTRODUCTION

As part of the grant project VEGA 1/0414/15, we have decided to summarize the findings of the variability in the level of loading, in sports Karate-do disciplines Kata and Kumite, as the possibilities of using diagnostic load in the elite sports training. We know that the intense muscular load resulted in the production of lactic acid, which dissociates to the lactate immediately, that is, the lactate anion (La-) and hydrogen cation (H +) which is the primary cause of distortion of the organism under load acidosis (Pupišová, Z. - Pupiš, M. - Jančoková, Ľ. - Pivovarníček, P., 2014). The lactate can be resynthesized by human organism into glycogen. Havlickova et al. (2008) confirms that, during (after) the anaerobic nature of the work, an adequate supply of oxygen is required to allow resynthesis of energy resources and the destruction of acidosis. An important factor in case of short-lasting intensive load is the phoshocreatine level which significantly increases beyond individual critical boundaries (Pupiš, M. - Pivovarníček, P. - Tonhauserová, Z. - Pavlovič, R.

2012). Sports Karate belongs to the group of combat, strength-speed sports where the load structure of sports performance is characterised by irregular interval oscillations of load intensity. Load intensity in both of its disciplines, however, ranges from medium to maximum duration and the time during which the load continues in one duel in Kumite is 3 min. for males (4 min. in medal bout), and 2 min. for females (3 min. in medal bout). In Kata, the average duration of one combat routine is 2 min. During such kind of load, the metabolic coverage of energy in the form of ATP-CP, anaerobic glycoses and aerobic phosphorylation takes place in both cases. According to Zemková et al. (2006), the range of maximum heart rate for men is 182-198 pulses and the average lactate concentration after the performance in training conditions is from 8.4 to 16.7 $mml.l^{-1}$. In strength-speed martial sports, one of the key factors affecting the performance of the athletes, is the adaptation to alternation of aerobic and anaerobic load, which is dependent on the regeneration rate between these loads.

Kata as a competitive discipline of sports karate.

In the second half of the twentieth century, the rules for assessment and evaluation of *kata* structured routine developed together with the *kumite* rules (sports *kumite* bout). From that moment on, *kata* was viewed also as a discipline of sports *karate* (Sližik, 2014). *Kata* competition is certainly interesting, aesthetic, but also a very challenging discipline, which offers karatekas of both sexes and all age categories a wide application of sport-combative nature. Many people describe *kata* as an “exciting competitive discipline,” which represents an equivalent altervative to a sports bout. The most important thing in this sports discipline is a professional performance of *kata*, which is assessed and evaluated by a judging panel on the grounds of a set of well-defined criteria based on rules (Sližik, 2014).

Kumite as a competitive discipline of sports karate.

Kumite – understood as a mutual bout of two contestants, is the oldest competitive discipline of sports *karate* whose roots go back to the first half of the twentieth century. Sports *kumite* bout is a regular competitive discipline, controlled by rules and organized in a system of mutual duels between individual contestants divided into categories according to age, sex and weight (Sližik, 2014). The aim of sports *kumite* is to obtain the greatest possible number of points for *karate* techniques performed against an opponent. These techniques are evaluated by referees who assign the points according to a precisely defined range of points and criteria based on the rules. Experience has shown that *karate* is able to keep up with the times and represents a constantly evolving system, built on deep-rooted traditions. *Karate* keeps its modern as well as traditional at the same time (Sližik, 2014).

Physiological characteristics of load in sports *karate*-do from the point of view of bioenergy coverage

According to Dzurenkova et al. (1996), *karate* load is mainly of anaerobic nature, which can be proved by the heart rate and blood lactate concentration values. The heart rate reached 180 – 199 pulses/min during competition bout and the blood lactate concentration after the bout was 4.5 – 5.6 mmol/l. Blood lactate concentration reaches considerably higher values during a training unit (using chronometer) when work is more intensive than during competition, more precisely 5.8-12.5 mmol/l, at the heart rate of 180-200 or more pulses per minute. The goal of this study was to detect a basic morphologic and functional profile of athletes representing Slovakia in *karate* by means of laboratory testing. (Hrubý, Polgár, 2004; Vanderka, Longová, 2011) examined the issue of *kata* structured routine in *karate* as one of its two sports disciplines. The authors focused on three most popular *katas*. The aim of their study was to monitor the extent of load via heart rate or overall blood lactate values in the elite national team members in *kata* during three advanced *katas* and also during training sessions and competitions. We will compare their results with our data in the results part. Blood lactate values measured during maximum intensity loads have methodological flaws as more lactate does not always have to be a positive fact. Lactate measurement can primarily help assess the intensity of load. Denis et al. (1990) discovered a very close link between the values of maximum anaerobic performance and maximum blood lactate concentration. We can point out the intensity of load and its volume by monitoring the heart rate. On the basis of the study and analysis of standardised load, we can also indicate the functional fitness level of the organism

in monitored subjects (Olšák, 1997). According to Apple and Rhodes (1988), Lieber et al. (1996) and Kampmiller and Vanderka (2006), lactate has nothing to do with delayed onset muscle soreness which arises several hours after non-standard load exceeding certain threshold. This is most prominent after eccentric muscle contractions when microdamages on sarcomere level take place because of overload during muscle contraction. The function of individual energy systems is reciprocal and overlapping. As a result, energy acquisition differs according to different types of load. In case of physical activity it is usually fatigue. It may be caused either by energy depletion or by accumulation of catabolites in the organism. In this respect, we often mention lactic acid or its salt, lactate. We can observe it in muscles during intensive (anaerobic) load when anaerobic glycolysis takes place, which is usually felt as tingling or pain (Pupiš, 2008). Lactate, the salt of lactic acid (CH3-CHOH-COO-) is created via reduction of pyruvate by lactate dehydrogenase (LDH). Its production is linked to involvement of fast-glycolytic muscle fibres and activation of anaerobic glycolysis at a higher intensity of load. It is the final product of anaerobic metabolism of glycogen taking place in muscle tissue. During absolute or relative hypoxia, phosphoenolpyruvate does not undergo oxidative decarboxylation reaction and the further reduction in citric acid cycle, but hydrolyses to pyruvate while energy is released (Suchý, J., Novotný, J., Tilinger, P. 2010). This is further reduced to lactate by LDH. The transformation of pyruvate into lactate is reversible, but LDH prefers lactate production to pyruvate production. Lactate is not further metabolized via any other mechanism. In opposite reaction, pyruvate must be removed quickly. Blood lactate concentration value is given by the ratio between its production mainly from blood elements and muscles and its metabolisation (Pupiš, Broďáni, 2007). ´

OBJECTIVES, HYPOTHESIS AND RESEARCH METHODS

Objective of the study

The goal of the our research project is to diagnose, analyse and compare selected indirect indicators of level of load intensity during competitive sports performance in terms of training conditions in the martial sport of *karate*-do.

Research questions of the project

- ☑ **Research question 1:** Will the average maximum values of blood lactate concentration be higher for *kumite* competitors or *kata* competitors immediately after load?
- ☑ **Research question 2:** Will the average maximum values of heart rate be higher for *kumite* competitors or *kata* competitors during competitive sports performance in terms of training conditions?

Method characteristics

We have used the following methods to achieve our set goal and to carry out all the predetermined tasks: Heart rate was recorded using the telemetry system Polar team 2. All information about the beginning and end of each test was recorded for easier evaluation. The programme automatically calculates the average and maximum heart rate values from the pre-recorded intervals. Blood lactate values (LA) were analysed with the Biosen C-Line Glucose and Lactate Analyser device, which measures the lactate concentration in capillary blood with high precision CV 1.5 % at 12 mmol/l and measuring range 0.5-50 mmol/L for glucose and 0.5-40 mmol/L for lactate.

Research situation, survey sample and research organisation charateristics

Ex-post-facto research design, intraindividual and global monitoring of selected load indicators, in the framework of the case study (casuistry) and mutual comparison of average values of the measured indicators were carried out in the research project I. Selected physiological and functional load indicators (HR – heart rate and LA – blood lactate concentration in capillary blood) were compared. Two survey samples composed of national team members of the Slovak Republic in *kumite* and *kata* and one national team member of France in *kata* were chosen for the monitoring and non-parametric mutual comparison of indirect load indicators in karate-do sports disciplines of *kata* and *kumite*. All the monitored competitors are shortlisted for the representation of SR and they are part of the elite in their respective categories in Slovakia with many medal positions in European and World Championships and also in cup tournaments. The survey sample for kata competitors included also a French national team member M. D. (multiple French champion, 10-times European championship medallist and bronze medallist from World Championship in Tokyo

2010), currently the third best competitor in the male *kata* category in the world. The survey sample for *kumite* was composed of 10 national team members of the SR older than 18 years competing in the U21 and Senior categories. The survey sample for *kata* was composed of 9 national team members (8 from Slovakia, 1 from France) older than 17 years competing in Junior, U21 and Senior categories. Research monitoring was carried out repeatedly (twice) during collective Slovak representation training camps as a part of training preparation for the European championship of 2011 and 2012 in Banská Bystrica. Load diagnostics of the French national team member M. D. was carried out in Paris during the training camp for the European championship 2011.

Methods of data processing

As this is a case study and a non-parametric comparison, statistic methods could not be used and the degree of generalization is low. Basic notions from statistics were used to compare the HR values since there was quite a large amount of data for this variable. Those included the arithmetic mean, maximum value and interval width, which together with the evaluation of the process itself helped us perform a more thorough analysis of cardiovascular system load. Pragmatic logic methods of thought experiment, comparison, analytical-synthetic and inductive-deductive methods were used for the interpretation of the recorded data.

RESULTS OF RESEARCH

In our research project, we focused on the diagnostics of load in sports *karate*, particularly in the *kata* (during 7 rounds with constant rest periods) in 8 Slovak national team members and 1 French national team member , M.D., and in *kumite* in 10 Slovak national team members (during 7 bouts with constant rest periods). The research was carried out in several stages. The monitoring of M. D. was carried out during training for the European championship 2011 in March 2011. The Slovak national team members in the Junior and Senior categories of *kata* were monitored during a two-year training cycle for the European championship 2011 and 2012. We focused on monitoring the heart rate before load, during load and after 4 minutes of regeneration and also on monitoring the blood lactate concentration value in capillary blood before load, immediately after load and 4 minutes later. The duration of *kata* in individual rounds was aslo monitored. The observed results are shown in Tables 1 and 2 and in Figures 8 and 9.

Table 1 Average heart rate and blood lactate concentration values in the group of *kata* competitors

Before load	HR	112	**1**	**2**	**3**	**4**	**5**	6	7
	L	**1.5**	Seipai (2.1 min.)	Seienchin (2 min.)	Hanan (3 min.)	Nipaipo (3.2 min.)	Ch. Kushanku (4 min.)	Suparimpei (4 min.)	Mat. Basai (2.5 min.)
average HR during load – Blood lactate concentration immediately after load	HR		176	176	179	180	188	185	186
	L		**6.4**	**10.8**	**8.2**	**9.0**	**16.2**	**12.8**	**15.0**
HR and Blood lactate concentration value after 4 min.	HR		110	96	109	106	120	120	126
	L		**9.0**	**8.1**	**10.9**	**8.4**	**12.1**	**11.7**	**12.6**
							after 7 min.	HR	128
								L	**11.3**

Legend: HR – heart rate ($n.min^{-1}$)

L – blood lactate concentrate ($mmol.l^{-1}$)

Table 1 shows the average results of *kata* competitors during 7 rounds. Heart rate before load was 112 n.min^{-1}. Blood lactate concentration value was 1.5 mmol.l^{-1}. Average heart rate during load reached 176 n.min^{-1} in the first round of compulsory (shitei) *kata* Seipai and Seienchin up until 188 n.min^{-1} in the fifth round in Ch. Kushanku, which means that the value range is 12 n.min^{-1}. Blood lactate concentration values immediately after load spanned from 6.4 mmol.l^{-1} in the first round of Seipai to 16.2 in the fifth round of Ch. Kushanku, which means that the value range is 9.8 mmol.l^{-1}. In our research, we also focused on monitoring of the heart rate and blood lactate concentration 4 minutes after load. We measured the heart rate after 4 minutes of rest. The results spanned from 96 n.min^{-1} in the second round of *kata* Seienchin to 126 n.min^{-1} in the seventh round of Matsumura Basai (the difference was 30 n.min^{-1}). The Blood lactate concentration values after 4 minutes spanned from 8.1 mmol.l^{-1} in the second round of Seienchin to 12.6 mmol.l^{-1} in the seventh round of Matsumura Basai (the difference in blood lactate concentration reached 4.5 mmol.l^{-1}). We also monitored these parameters after 7 minutes. The Heart rate reached 128 n.min^{-1} and a blood lactate concentration value of 11.3 mmol.l^{-1} was obtained in this case.

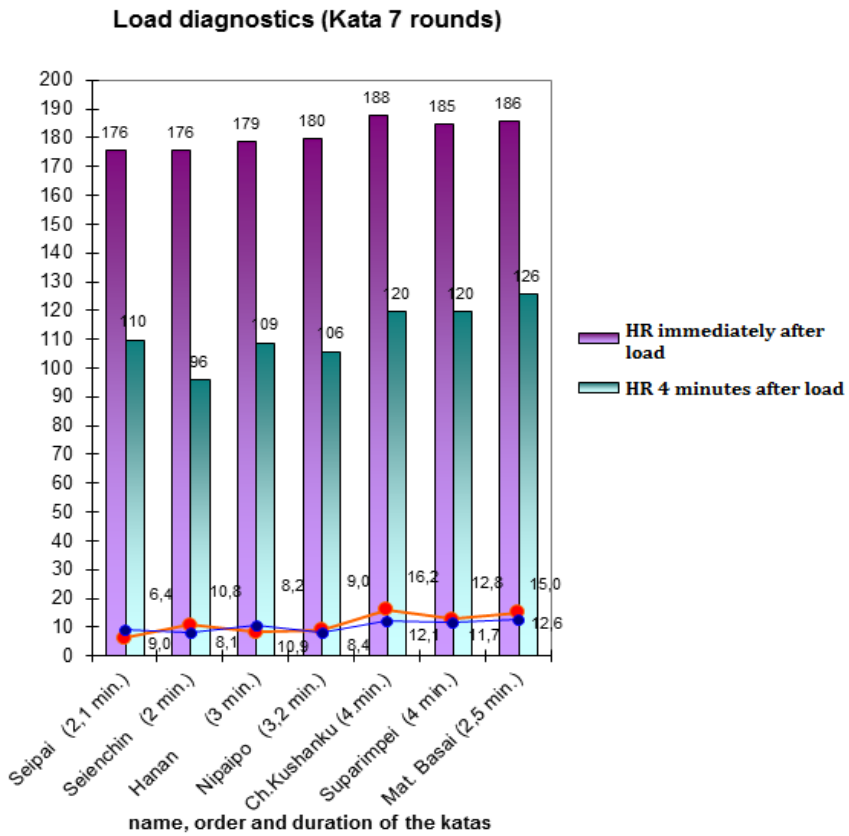

Figure 1 Average heart rate and blood lactate concentration values in the group of *kata* competitors

Figure 1 shows a graphic representation of the extent of the load during 7 rounds of *kata*. We can observe that the heart rate immediately after load was increasing until the fifth round but started decreasing in the sixth and seventh round by 2 – 3 n.min^{-1}. As for the heart rate after 4 minutes, we can see a decreasing tendency of the parameter from the first round to the second, whereas it gradually increases to the maximum level in the last round; the seventh round (126 n.min^{-1}). The Lactate curve represented in the Figure 3 by a red colour was measured immediately after load. We can see that the lactate values have mostly increasing tendency (until the 5th round inclusive) and then they undergo a slight decrease before they increase again. The Blood lactate concentration gradually increased 4 minutes after load (blue curve). The Average lactate value after

the first round was 9.0 mmol.l^{-1} whereas after the last seventh round it was 12.6 mmol.l^{-1}.

Table 2 Average heart rate and blood lactate concentration values in the group of *kumite* competitors

HR before load	HR	102	1	2	3	4	5	6	7
	L	**2.7**	Bout 1 (3 min.)	Bout 2 (3 min.)	Bout 3 (3 min.)	Bout 4 (3 min.)	Bout 5 (3 min.)	Bout 6 (3 min.)	Bout 7 (3 min.)
average HR during load – Blood lactate concentration immediately after load	HR		180	182	176	171	188	192	186
	L		**10.2**	**11.4**	**8.2**	**13.9**	**9.3**	**12.8**	**11.5**
HR and average blood lactate concentration after 4 min.	HR		115	105	121	133	120	120	126
	L		**9.8**	**12.8**	**10.9**	**13.7**	**12.1**	**11.2**	**12.6**
after 7 min.	HR							118	
	L							**10**	

Legend: HR – heart rate (n.min^{-1})

L – blood lactate concentration (mmol.l^{-1})

The second monitored sample were a group of *kumite* competitors, more precisely n = 10 ten Slovak national team members during 7 bouts. The diagnostics was carried out during a training camp in January 2012. The obtained results are shown in Table 2 and graphically represented in Figure 9. We can observe the average heart rate and blood lactate concentration values before load, during load, immediately after the load (applicable only to lactate), 4 min. after and 7 min. after. The Heart rate before load reached the average value of 102 n.min^{-1} while the lactate value was 2.7 mmol.l^{-1}. The Heart rate during load reached average values ranging from 171 n.min^{-1} in the 4th bout to 192 n.min^{-1} in the 6th bout. The difference between the minimum and maximum values was 21 n.min^{-1}.

The Blood lactate concentration immediately after load spanned from 8.2 mmol.l^{-1} (3rd bout) to 13.9 mmol.l^{-1} (4th bout). The difference between the minimum and maximum blood lactate concentration values was 5.7 mmol.l^{-1}. The Measured average heart rate values, four minutes after individual bouts spanned from 105 n.min^{-1} after the second bout to 133 n.min^{-1} after the fourth bout (the difference between the minimum and maximum values was 28 n.min^{-1}). The Blood lactate concentration values spanned from 9.8 mmol.l^{-1} (1st bout) to 13.7 mmol.l^{-1} (4th bout) after 4 minutes. The difference between the minimum and maximum values was 3.9 mmol.l^{-1}. The average heart rate 7 minutes after all bouts was 118 n.min^{-1} and average blood lactate concentration reached 10 mmol.l^{-1}.

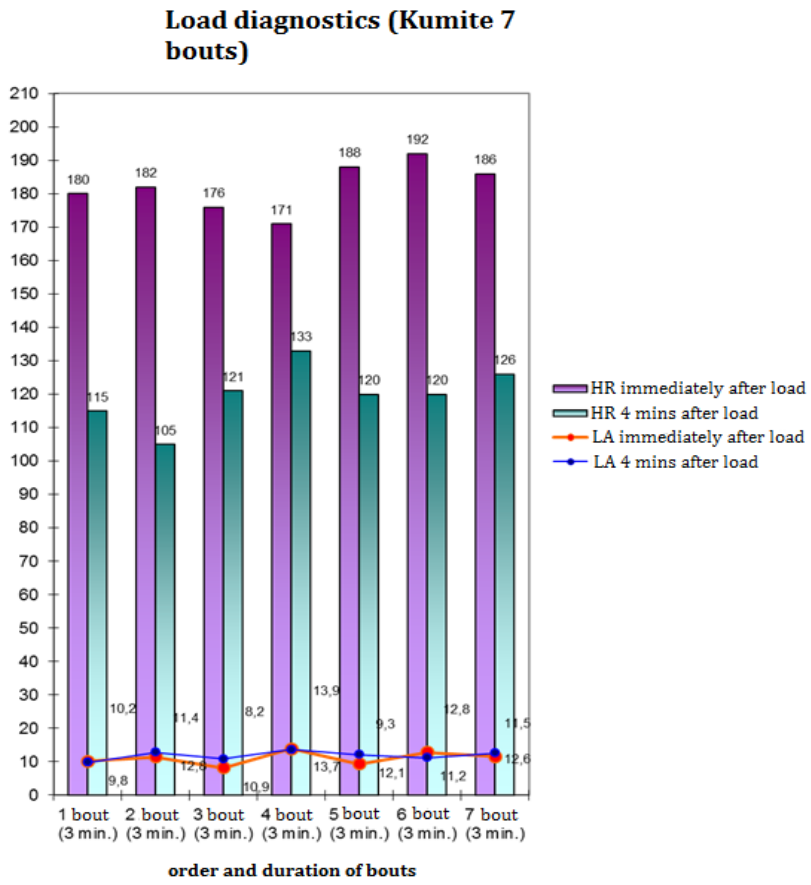

Figure 2 Average heart rate and blood lactate concentration values in the group of *kumite* competitors

Figure 2 shows a graphic representation of heart rate and blood lactate concentration values of the Slovak national team members in *kumite* (sport bout) during and after 7 bouts. We can see that the heart rate immediately after load had an increasing tendency from the first bout to the second, and then it decreased and increased again after the fifth bout. Figure 9 shows that the heart rate measured after 4 minutes is represented by a curve opposite to the one representing the values immediately after load. We can observe a decline from the first bout to the second, then an increase of the parameter after 4th bout, decrease after the 6th bout and an increase again after the last bout. The lactate curve immediately after load is represented by a red colour and after 4 minutes by a blue colour. We can see that the blood lactate concentration values immediately after load were mostly of the same nature as those measured 4 minutes after individual bouts.

Table 3 Comparison of the HR and LA values in *kata* and *kumite* competitors

		Heart rate (n.min^{-1})			**Blood lactate concentration** (mmol.l^{-1})		
		Min.	**Max.**	**Difference**	**Min.**	**Max.**	**Difference**
Kata	HR during load/L immediately after load	176	188	12	6.4	16.2	9.8
	HR and L after 4 minutes	96	126	30	8.1	12.6	4.5
Kumite	HR during load/L immediately after load	171	192	21	8.2	13.9	5.7
	HR and L after 4 minutes	105	133	28	9.8	13.7	3.9

The observed differences along with the minimum and maximum values and the dispersion of the measured average values are shown in Table 3. We can observe that the minimum heart rate during load reached 176 n.min^{-1} for *kata* and 171 n.min^{-1} for *kumite*, which means that the value for *kata* was higher by a value of 5 n.min^{-1}. The maximum heart rate value during load reached 188 n.min^{-1} for *kata* and 192 n.min^{-1} for *kumite*, which means that the HR value for *kumite* competitors were higher by a value of 4 n.min^{-1}. The minimum blood lactate concentration in the capillary blood, immediately after load reached 6.4 mmol.l^{-1} for *kata* and 8.2 mmol.l^{-1} for *kumite competitors*, which means that the lactate value for *kumite* was higher by 1.8 mmol.l^{-1}. The maximum blood lactate concentration immediately after load reached 16.2 mmol.l^{-1} for *kata* and 13.9 mmol.l^{-1} for *kumite competitors*, which means that the lactate value for *kata* was higher by a value of 2.3 mmol.l^{-1}. The minimum heart rate 4 minutes after load was 96 n.min^{-1} for *kata* and 105 n.min^{-1} for *kumite competitors*, which means that the HR value for *kumite* was higher by a value of 9 n.min^{-1}. The maximum average heart rate 4 minutes after load reached 126 n.min^{-1} for *kata* and 133 n.min^{-1} for *kumite*, which means that the HR value for *kumite* was higher by a value of 7 n.min^{-1}. The minimum blood lactate concentration in capillary blood 4 minutes after load reached 8.1 mmol.l^{-1} for *kata* and 9.8 mmol.l^{-1} for *kumite competitors*, which means a difference of 1.7 mmol.l^{-1}. The maximum blood lactate concentration 4 minutes after load reached 12.6 mmol.l^{-1} for *kata* and 13.7 mmol.l^{-1} for *kumite competitors*, which means a difference of 1.1 mmol.l^{-1}. When comparing the maximum heart rate values during competition load under training conditions for *kata* with the values measured in a study by Long (2009), we discover that our average maximum HR values are higher by 3 n.min^{-1}. However, major difference was discovered when comparing average minimum heart rate values before the competition performance of the individual *kata*s, particularly during the first rounds before the so-called (compulsory) *kata*s, precisely by 21 – 30 n.min^{-1}.

CONCLUSION OF RESEARCH

The goal of our research project was to diagnose, analyse and compare selected indirect indicators of intensity of load during competition performance under training conditions in the two disciplines of the martial sport of *karate*-do. We have set two fundamental research questions to closer specify the research situation since it was not a field experiment, but an ex-post-facto case study.

Research question 1: Will the average maximum values of blood lactate concentration be higher for *kumite* competitors or *kata* competitors immediately after load?

By measuring the blood lactate concentration using the the Biosen C-Line Lactate Analyser device, we found out that the average maximum LA values immediately after load were higher for *kata* competitors than *kumite* competitors, reaching a difference of 2.3 mmol.l^{-1}. A comparison of maximum and minimum average LA values span during load showed that the difference between the maximum and minimum was higher for *kata*

performance (9.8 mmol.l^{-1}), while for *kumite* it amounted only to 5.7 mmol.l^{-1}.

Research question 2: Will the average maximum values of heart rate be higher for *kumite* competitors or *kata* competitors during competitive sports performance under training conditions?

We have measured the heart rate by means of a telemetry system Polar team 2 during sports performance in *kata* and *kumite* under training conditions. It was found that on average, the cardiovascular system underwent higher load in *kumite*. The average maximum heart rate values for *kumite* were higher by 4 n.min^{-1}. Furthermore, the average HR values for *kata* were 188 n.min^{-1} while in *kumite* it reached 192 n.min^{-1}. The observed difference between maximum and minimum HR values during competition load is a very interesting fact when comparing the load curves based on average HR values. In *kata*, it was 12 n.min^{-1} and even more in *kumite*, precisely 21 n.min^{-1}.

Recommendations for practice:

Based on the aforementioned information about the monitored load levels in *kata* and *kumite*, we recommend to include the following points into training practice:

- ☑ In the transition phase and at the beginning of the preparation phase, we recommend focusing on the training of general aerobic abilities in order to increase the capacity and functional conditions of cardiovascular and respiratory system, to enhance endurance potential during anaerobic high-intensity load as well as to improve the potential to use and distribute oxygen for repeated resynthesis of the produced LA as one of the major components of the energy coverage of an organism.This is recommended for both kata and kumite disciplines.
- ☑ At the end of the preparation phase, we recommend focusing on non-specific high-intensity load types which stimulate the building of essential energy potential, but also on simulating excessive acidosis (increased acidity) of the organism and increased natural lactate tolerance.
- ☑ It is necessary to transfer the already acquired general motor skills into specific exercises which are technically demanding. This is possible via multiple repetitions of selected parts of *kata* routine, or attack and defense *kumite* combinations with gradually increasing intensity and rest intervals in the first phase. In the second part of the pre-competition phase, we advise lengthening the duration of the individual *kata* progressions or increasing the number of combinations in *kumite*. This gradually leads to the sports performance completion and further to competition load with shorter rest intervals and continuously monitored HR.
- ☑ We also suggest the combination of overall strength exercises and specific equipment (striking shields, bags, etc.) to maintain the specific strength-speed abilities during competitive phase.

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ABSTRAKT

POROVNANIE PARAMETROV REAKCIE ORGANIZMU K ZÁŤAŽI V ŠPORTOVÝCH DISCIPLÍNACH KARATE KATA A KUMITE

Kľúčové slová: zaťaženie v športovom karate, porovnanie, karate disciplína kata, kumite, laktát

Vedecký príspevok bol spracovaný ako súčasť výskumnej grantovej úlohy VEGA 1/0414/15, je zameraná na sumarizáciu poznatkov o variabilite úrovne zaťaženia v bojovom športe karate-do v ich jednotlivých disciplínach kata a kumite, ako aj možností využitia diagnostiky zaťaženia vo vrcholovej športovej príprave. Športové Karate patrí do skupiny bojových, silovo-rýchlostných športov, ktorých štruktúra zaťaženia športového výkonu má charakter nepravidelnej intervalovej oscilácie intenzity záťaže. Pričom intenzita zaťaženia v oboch jeho disciplínach je od strednej až po maximálnu a dĺžka trvania zaťaženia v jedného duelu je v Kumite u mužov 3 min., u žien 2 min. a v Kata je priemerná dĺžka jednej bojovej zostavy 2 min. Výskumný experimentálny súbor tvorili vrcholoví športovci na úrovni národnej reprezentácie. Meraním pulzovej frekvencie prostredníctvom telemetrického zariadenia Polar team 2 počas výkonu v disciplíne kata a v kumite v tréningových podmienkach sme zistili, že v športovom zápase kumite dochádzalo k priemerne vyššiemu zaťaženiu srdcovocievneho aparátu z hľadiska priemerných maximálnych hodnôt PZ až o 4 $n.min^{-1}$. Pričom v kata sme namerali priemernú hodnotu PZ 188 $n.min^{-1}$, zatiaľ čo v kumite bola zistená hodnota 192 $n.min^{-1}$. Meraním hladiny laktátu pomocou prístroja Lactate Pro LT-1710 sme zistili, že bezprostredne po záťaži boli priemerné maximálne hodnoty LA vyššie u pretekárov kata ako u pretekárov kumite a to o 2,3 $mmol.min^{-1}$. Pri porovnaní rozdielov maximálnych a minimálnych priemerných hodôt hladiny LA počas záťaže sme zistili, že pri zaťažení v športovom výkone v kata bol tento rozdiel vyšší až 9,8 $mmol.min^{-1}$ a pri

zaťažení v športovom výkone v kumite bol tento rozdiel minimálnych a maximálnych hodôt PF iba 5,7 $mmol.min^{-1}$.

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THE EFFECTS OF FITNESS BALL EXERCISE PROGRAMME ON FEMALE STUDENTS' POSTURE

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Original scientific paper

Key words:

motion program, musculoskeletal system, body posture, adolescent girl

The prevalence of lifestyle diseases and the contemporary hypokinetic lifestyle have an impact on the health of female students at secondary schools. The teenage girls support this negative effect by their passive presence or absence in sports and physical education lessons due to several objective and subjective reasons. Therefore, the partial research was aimed at determining an effect of fit ball exercise programme on their body posture and at widening the knowledge concerning the significance and impact of exercise programmes in sports and physical education lessons. Our sample experimental and control group consisted of the teenage girls studying the third grade at one secondary school in the town of L. Mikuláš. We used a standardized body posture assessment method and the qualitative and quantitative data were processed by means of a non-parametric statistical hypothesis test (Wilcoxon signed-rank test/W_{test}). The results and findings significantly ($p < 0.01$) confirmed the impact of our exercise programme on the monitored determinant of the musculoskeletal system in experimental group. Consequently, we proved the effectiveness of the fit ball exercise programme and its utilisation in sports and physical education lessons.

INTRODUCTION

The number of Slovak students and pupils who are excused from compulsory physical education classes due to various diseases and health disorders is rising. Authors of several studies, which were focused on poor body posture and muscle imbalance in the preschool age (Javůrek, 1990; Thurzová, Kováčová, Medeková, 1993) and the school age (Medeková et al., Chudá, 1999; Přidalová, 2000; Vargová, Veselý, 2002; Kania, Gudzio - Wiernicka, 2002; Kopecký, 2004; Riegerová, 2004; Kováčová, Medeková, 2005; Vařeková, Vařeka, 2006; Kokavec, Novorolský, 2007; Tuzinek et al., 2009; Jurašková, Bartík, 2010), point to negative trends associated with children's musculoskeletal health. These trends often lead to excusing pupils and students from physical education.

The increase in functional disorders of the musculoskeletal system in children and adolescents has been confirmed by other studies conducted by Kopecký, Ely, (2007), Medeková, Bekö (2009), Bendíková (2010), Bendíková, Stacho (2010), Bendíková, Šmída, Rozim (2014).

Véle (2006) adopts a holistic approach to the musculoskeletal system and sees it as the system that fulfils its basic functions – locomotion, postural, communication, manipulation (creative) – as well as basic life functions, such as respiration and nutrition. In addition, the musculoskeletal system is a sensitive mirror that reflects dysfunctions of individual body systems as viscerovertebral syndromes (Novotný, 2008). On the other hand, the musculoskeletal system disorders are reflected in other body systems as vertebrovisceral syndromes (Vaňasková, Tošnerová, 2006).

Body posture accompanies each human activity and it is itself an activity and a habit that we can control. Moreover, it is a resultant curve of a certain shape and the function of the spine, especially the postural muscles and the postural reflexes, where the body posture encompasses genetic predispositions, physical dispositions, environmental effects, mental conditions and social

relationships (Salmon, 2001; Labudová, Vajcziková, 2009; Ihász, Rikk, 2010; Nemček et al., 2012; Nemček, 2013).

Kinesiology describes body posture as a resultant force of arrangement of individual body parts. Any change in one motion segment automatically results in a chain of further changes. Good body posture is defined economically rather than aesthetically. It is perceived as optimum vector centred position in joints with minimum muscle activity of a particular person (Véle, 2006). The opposite of good body posture is poor posture, which Buran (2002) defines as breaking of good posture habits that leads to temporary deviations, which disrupt optimum vertical body axis. Static bad posture is, to a certain extent, compensated by dynamic abilities of individuals (Dickson, 1998; Véle, 2006). The effects of poor posture habits cannot be reversed by so-called spontaneous movement. As a result, letting body posture develop naturally is unreliable.

Poor and improper body posture, back pain, stereotypic movement disorders and development of premature degenerative changes (Kollář, 1997, 2001; Buran 2002) most often occur due to disruption and changes in muscle balance, which result in the muscle shortening. This is based on the concept of the musculoskeletal function disorders developed by Janda (1982) and Lewit (1998). Muscle imbalance is caused by postural deviations and limited movement of joints. One of the reasons of muscle imbalance is also inadequate, single-sided and excessive overloading of certain muscle groups, which shorten, while other muscle groups get weaker due to insufficient activity (Čermák et. al, 2005). The weakened muscles then lead to functional and morphological impairments in adulthood, which often cause the person's disability.

The study is the part of the grant assignment titled: VEGA No. 1/0376/14.

AIM

The study aimed to verify the effects of the fitness ball exercise programme, which was applied in physical and sport education lessons, on female students' posture. The students from the experimental group performed the fitness ball exercises for the period of 12 weeks. We suppose that within such a period of time the exercise programme can bring positive results concerning the students' body posture.

METHODOLOGY

According to the aim and extent of the study, the experimental group (EG) consisted of 12 third-year female students at one secondary school in the town of Liptovský Mikuláš. The average age of this group was 17.4.The control group (CG) comprised 11 students, whose average age was 17.1. The study was conducted in three phases in the school year 2014/2015. In September 2014, the students underwent an initial medical examination the purpose of which was medical diagnosis focused on selected determinants of the musculoskeletal system. The examination was based on the standardised methods for medical and physical education practice according to Jaroš, Lomíček (Vojtaššák, 2000). Afterwards, the EG members participated in the fitness ball exercise programmes 3 times per week during their physical and sport education classes. The purpose of these programmes was to improve their musculoskeletal system. Continuous evaluation of the monitored factors was conducted in December 2014 and final measurements were performed in April 2015.

Table 1 Characteristics of EG (n = 12) and CG (n = 11)

Group	n	Decimal age	Body height (cm)	Body weight (kg)	BMI
A Group (EG)	12	±17.4	166.3	61.3	22.2
B Group (CG)	11	±17.1	168.2	61.9	22.3

Legend: BMI – Body mass index, EG – experimental group, CG – control group

Each component (I.–V.) is given points (1, 2, 3, 4) according to quality of posture. The overall body posture is expressed by total points and the quality level (I.-IV.). The assessment is focused on:

I. Head and neck posture

II. Chest (shape)
III. Abdomen and pelvic tilt
IV. Spine curvature
V. Front posture (assessment of posture of shoulders – shoulder girdle)

Classification of postures:

I. Perfect posture .....5 points
II. Good (almost perfect) posture .....6 – 10 points
III. Poor posture .....11 – 15 points
IV. Bad posture .....16 – 20 points

The qualitative and quantitative data concerning the assessment of body posture and the musculoskeletal system functions (Labudová, Vajcziková, 2009) in the experimental and control groups were processed on the basis of intra-individual medical assessment.

The qualitative and quantitative traits were processed by means of the clinical case study (Vojtaššák, 2000), including application of the logical analysis and synthesis theoretical methods, induction and deduction, comparison and generalization as well as arithmetic mean (x), extent of variation ($R_{max - min}$), standard deviation (s) and median (m). The statistical significance of the difference in monitored indicators (posture and individual segments) between initial and continuous and initial and final assessments was determined by means of the nonparametric test for dependent monitoring, Wilcoxon signed-rank test (W_{test} $p < 0.01$; $p < 0.05$). We used the Wilcoxon-Mann–Whitney test (M_{WWtest} $p < 0.01$; $p < 0.05$) to verify the agreement of the level of two independent groups.

RESULTS AND DISCUSSION

Following the partial aim and assignments, we present the part of results that require further and more exact monitoring and processing within the project. The presented results cannot be generalized. They need to be perceived as orientation and source data related to lifestyle and health of adolescents. We selected the data, which characterize the monitored groups, that are significant for the specified aim.

The initial measurements showed that none of the students from the experimental (A) and the control (B) group had the perfect posture belonging to the first quality level of 5 points. This can be seen from the posture assessment (Table 2 and 3), which shows the posture of the experimental (Table 2) and the control (Table 3) group before and after application of the exercise programme.

Table 2 Overall body posture of the experimental group (EG) (n = 12)

Factors/EG	**1.**	**2.**	**3.**	**4.**	**5.**	**6.**	**7.**	**8.**	**9.**	**10.**	**11.**	**12.**
Initial	8	8	11	12	14	12	13	15	13	16	16	18
Continuous	6	6	6	6	8	6	7	8	7	10	10	12
Final	5	5	5	6	7	5	6	6	6	9	9	11
$W_{test =}$ $p < 0.01$												

We did not discover any significant changes between the initial, continuous and final assessments in the control group ($W_{test =}$ $p > 0.05$).

Table 3 Overall body posture of the control group CG (n = 11)

Factors/CG	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
Initial	9	9	10	14	14	13	13	15	14	13	15
Continuous	9	9	10	14	13	13	12	15	15	13	15
Final	9	9	10	13	14	13	13	14	15	14	15
W_{test} = (p >0.05)											

The assessment of the statistical significance of the difference between the experimental and control groups proved the positive impact of the exercise programme in favour of the experimental factor (M_{WWtest} = 9.33; p < 0.01).

The study proved the positive effect of the fitness ball exercise programme on overall body posture in the experimental group. The comparison shows that the difference – improvement – between initial (13.0±2.94) and final (6.9±1.98) assessments (the difference was 6.1±1,44) was statistically significant (W_{test} = 3.0594; p < 0.01) (Table 4).

The statistically significant improvement (W_{test} =3.0594; p < 0.01) is proved also by the mean of the difference 5.3±1.55 between initial (13.0±2.94) and continuous (7.7±1.93) assessments of the overall body posture.

Table 4 Impact of fitness ball exercises on the students' overall posture EG (n = 12)

Values/measurements (n = 11)	V1	V2	R_1 (V1 and V2)	V3	R_2 (V1 and V3)
x	13.0	7.7	5.3	6.9	6.1
min.	8.0	6.0	2.0	5.0	3.0
max.	18.0	12.0	7.0	11.0	7.0
$R_{max - min}$	10.0	6.0	5.0	6.0	4.0
s	2.94	1.93	1.55	1.98	1.44
median	13.0	7.0	6.00	6.0	7.0
Wilcoxon index	V1 – V2	**p < 0.01			
			V1 –V3 **p < 0,01		

Legend: V_1 – initial measurement, V_2 – continuous measurement, V_3 – final measurement, R_1 – difference between V_1 and V_2 , R_2 – difference between V_1 and V_3, ** - statistical significance, x – arithmetic mean, s – standard deviation, $R_{max - min}$ – extent of variation, EG – experimental group

The postural assessment in terms of individual body parts has the results as follows. The difference between initial (3.2±0.72) and final (1.4±0.48) assessment of the head and neck posture (1,8±0.39) was statistically significant (W_{test} = 3.059; p < 0.01). Assessment of the abdomen and pelvic tilt also resulted in a statistically significant (W_{test} = 3.059; p < 0.01) difference with the mean difference 1.9±0.64 between initial (3.2±0.69) and final (1.3±0.43) assessment. Exercises with fitness ball also led to positive and statistically significant (W_{test} =2.366; p < 0.05) changes in the spine curvature, with the initial (1.9±0.76) and final assessment (1.3±0.43) and the mean difference 0.7±0.62. Assessment of posture of shoulders – shoulder girdle – resulted in a statistically significant (W_{test} = 3.059; p < 0.01) difference (1.5±0.50) between initial (3.0±0.71) and final (1,5±0.65) assessment. There were also significant differences between individual assessments (p < 0.05) of the chest.

The above-mentioned results show that application of the fitness ball exercise programme in physical and sport education classes resulted in significant improvements in overall posture as well as its individual segments. As a result, four students were reclassified to the quality level I, seven students to the quality level II and one student, who had the highest points after initial medical examination, was reclassified to the quality level III. All the students improved their posture.

Initial assessments revealed that the most problematic area in all the students from the experimental and control group was the head, shoulders and abdomen. Poor posture in this area results in unphysiological spine curvature. According to Kania – Gudzio, Wiernicka (2002), children and adolescents have the most deviations from proper posture in these postural segments.

We suppose that greater curvatures of the cervical and lumbar regions the students were diagnosed with after the initial measurements were not caused by the primary functional condition of muscles and muscle groups. As Lewit (1998) and Véle (2006) claim, these curvatures are generally caused by improper postural stereotype, which results from inadequate control of movement and low neural and muscle coordination. Other internal and external factors include the number of hours spent in one-sided and statically overloading positions, ergometric design of the workplace, movement and postural habits developed in childhood, insufficient regeneration and recuperation, overall inactivity, genetic predispositions and age. Furthermore, the initial measurements of both groups showed that none of the assessed muscles and muscle groups separately bring about pain in the cervical and lumbar regions of the spine. As Véle (2006) and Lewit (1998) claim, such pain is caused by individual muscles and muscle groups working together. These findings correspond with the conclusion made by Bendíková and Stacho (2010) that improper forward head posture is caused by functional disorders of m. trapezius – pars descendens and m. levator scapule, including local imbalance between m. sternocleidomastoideus and deep head and neck flexors. In addition to pain, the aforementioned muscle groups also cause higher occurrence of trigger points in the nape region (Buran, 2002). We, therefore, think that physical and sport education must purposefully affect development and improvement of the proper body posture by means of exercises performed during each school lesson. The ideal space for such exercises is in the warm-up general part and in the final cool-down part of physical education lessons. The truth is that these parts are often omitted and their absence or improper structure often leads to various injuries. In contrast, their proper organization focuses on prevention.

Another important factor is cooperation of theory and practice, where physical and sport education directly or indirectly provides the space for diversification and implementation of innovative syllabi (Bendíková, 2009; Dobay, 2015). Authors such as Bebčáková (2000), Labudová (2004), Šimonek (2006), Majerský, Hellebrandtová (2006), Antala (2012), Holzweg et al. (2014) also point to liberalization of physical and sport education syllabi. Nowadays, physical education teachers are increasingly forced to select and apply new and untraditional exercises and activities, which gives them space to diversify physical education lessons. Diversified PE lessons that include application of various traditional and untraditional tools can have positive effects on students' physical and functional development as well as health-oriented fitness. Insufficient diversification and innovation of physical and sport education syllabi leads to students' lack of interest in sports and physical education. What is more, it can be one of the factors causing the prevalence of lifestyle diseases in pupils and adolescents.

Nowadays, physical and sport education needs innovation and revival leading to higher quality so that it can become more attractive for students and teachers and bring all the important benefits that it undoubtedly has. Therefore, it is necessary to point out that the latest innovative trends in education provide teachers with more freedom to select particular exercises and apply specific didactic methods. At the same time, the teachers are now more responsible for pupils' and students' health and study results and the syllabi have to correspond with pupils' and students' real abilities and interests.

CONCLUSION

The presented empirical study helps to broaden the knowledge of applying the fitness ball exercise programme in physical and sport education, with focus on monitored determinants of the musculoskeletal system. The study proved the positive effect of the programme ($p<0.01$), with the significant difference ($p<0.01$) between the experimental group and the control group. Our results show that adequate physical activities can influence the factors influencing the body posture and support proper development and growth in pupils and students. The study findings are the subject of further and more exact monitoring.

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ABSTRAKT

ÚČINKY PROGRAMU CVIČENÍ S FITNESS LOPTOU NA DRŽANIE TELA ŠTUDENTKY

Kľúčové slová: pohybový program, muskuloskeletálny systém, držanie tela, stredoškoláčky

Prevalencia civilizačných ochorení a hypokinetický spôsob života sa aktuálne prejavujú na zdraví žiačok stredných škôl, ktoré ich podporujú aj svojou pasívnou neúčasťou na hodinách telesnej a športovej výchovy z viacerých objektívnych a subjektívnych dôvodov. Preto cieľom parciálneho sledovania bolo zistiť vplyv pohybového programu s fit loptou na úroveň držania tela žiačok vo vyučovaní telesnej a športovej výchovy, ako aj rozšíriť poznatky z oblasti účinku a významu pohybových programov v obsahu telesnej a športovej

výchovy. Nami zvolený experimentálny a kontrolný súbor tvorili žiačky tretieho ročníka strednej školy mesta L. Mikuláš. Z hľadiska metód získavania údajov sme použili štandardizovanú metódu hodnotenia držania tela, kde získané kvalitatívne a kvantitatívne údaje sme spracovali neparametrickým testom pre závislé pozorovanie (Wilcoxonový poradový test). Rezultáty a zistenia signifikantne ($p < 0,01$) preukázali vplyv nami zvoleného pohybového programu s fit loptou na sledovaný determinant pohybového systému v experimentálnom súbore, čím sme potvrdili účinnosť realizovaného pohybového programu s fit loptou na držanie tela a možnosti jeho využitia aj v obsahu vyučovania telesnej a športovej výchovy.

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IDENTIFICATION OF CHRONOTYPE AND DIURNAL PERFORMANCE

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Key words:

counter movement jump, evening chronotype, evening performance morning chronotype, morning performance

The aim of the study was to compare the chronotype and diurnal performance from the point of view of explosive leg – muscle strength of lower limbs. The experimental sample consisted of female and male university students (n = 18) attending various study programmes and study fields at faculties of Matej Bel university in Banská Bystrica during the academic year 2014/2015. The chronotype was identified and assessed by standardised chronotype´s questionnaire (Horne & Ostberg, 1976). The parameter of the diurnal performance (the morning and the evening performance) was the explosive leg – muscle strength of lower limbs. Variations of explosive leg – muscle strength of lower limbs were detected by the vertical jump –countermovement jump (CMJ) by the device Myotest PRO (Myotest, Switzerland). The morning and the evening performance were evaluated as the mean performance of five morning and five evening measurements which were realized during the week. The significant difference in diurnal performance was not detected in the sample ($p < 0.05$). The results of the chronotype´s questionnaire showed that 13 probands tended to be the intermediate chronotype (n = 13), moderate morning chronotype was identified in three probands (n = 3) and the moderate evening chronotype was identified in two probands (n = 2). Definitely morning and definitely evening chronotype were not identified.

INTRODUCTION

The diurnal rhythms and their impact on sport performance is the most explored and examined sphere from the point of view of the sport chronobiology. The diurnal rhythms come within the abmit of circadian rhythms. According to the diurnal rhythms we recognize two phases of the day: the morning phase lasting from 3.00 am to 3.00 pm and evening (afternoon) phase lasting from 3.00 pm to 3.00 am (Jančoková, 2000). The phases are characterized by typical oscillations from the point of view of biochemical and psychological processes, physiological functions and sport performance (Jančoková, 2000). These oscillation caused the division of general population in chronotypes whose organism is more active in specific time of the day. We recognise in general population the morning chronotype ("lark") which wakes up early in the morning and is more active in the morning and in this type of person is able to reach the maximal physical and psychological performance. People with the morning chronotype usually go sleep earlier in the evening. The second type is the evening chronotype ("owl") which is obviously more active in the afternoon or in the evening hours. This type finds difficult to wake up early in the morning and people with this chronotype
usually go sleep in the late evening hours (often after midnight). There is also one more chronotype which is presented in the literature – intermediate (neutral) chronotype. This chronotype has balanced performance and other characteristics during the day and there is no preference in any part of the day. This classification can be found in researches made by Horne & Ostberg (1976), Reilly et al. (2007), Harada et al. (2011), Muro et al. (2011), Roenneberg (2012), Waterhouse & Fukuda & Morita (2012), Pupiš & Pivovarniček & Tonhauserová & Pavlovič (2012); Pupišová (2013);

Pupišová & Pupiš & Jančoková & Pivovarniček (2014); Papantoniou et al., (2014).

Many researchers are interested in problem of exogenous rhythms and their oscillations. Schlank & Pupiš (2007) examined that significant better results in speed- strength abilities were achieved by ski jumper at 12.00 pm. Paugschová & Jančoková & Šulej (2009) denoted that soldiers achieved better sport performance (strength – speed preconditions) in the afternoon (at 4.00 pm) and the best sport performance was denoted at 6.00 pm. Rošková & Demjan (2011) denoted that female university students (n = 24) reached better results in psychological and physical performance at 5.00 pm . Gereková (2009) presents that the female biathlonist achieved the best level of speed abilities at 6.00 pm but the best level of the speed abilities were achieved at 9.00 am. Elghoul et al. (2014) examined the impact of the time of the day on dart – throwing performance at 7.00 am and 5.00 pm. The results of the sample consisted of young boys (n – 12, age = 9.8 ± 0.5 years) showed better psychomotor performance at 5.00 pm. The research made by Edwards (2007) showed that the performance in dart – throwing was influenced also by strength and throwing accuracy. Facer & Childs & Brandstaetter (2015) examined the sport performance not only in individual but also in collective sports. Athletes achieved better performance in the evening but the authors present that the most significant predictor of the performance was not the time of day but the „waking“ time. Chin et al. (2015) examined the impact of diurnal variation in cardiovascular performance of the athletes (n = 35). Many endogenous parameters were measured in their study of which results confirmed the impact of time of the day on performance at noon (the highest impact of VO2 max was found at this hour). The authors also present the fact that the athletes should have trainings at hours which relate to VO2max to achieve and reach effectivity in sport performance. Rae & Stephenson & Roden (2015) examined the relationship between the chronotype and sport performance in sample consisted of professional swimmers. The swimmers of the morning chronotypes reached the best performance in the morning and the swimmers of the evening chronotypes achieved better performance in the evening hours.

METHODOLOGY

The standardised questionnaire was used for the chronotype´s identification (Horne & Ostberg, 1976) which contains of 19 closed questions. Each answer in the questionnaire (A, B, C, D and in some cases E) has specific number of points (Horne & Ostberg, 1976). Firstly we counted points according to answers when we assessed somebody´s questionnaire and then we assigned concrete chronotype according to stated scale which consists from five following possibilities (Horne & Ostberg, 1976):

•Definitely morning chronotype – 70- 86 points
•Moderate morning chronotype – 59- 69 points
•Intermediate chronotype – 42- 58 points
•Moderate evening chronotype – 31- 41 points
•Definitely evening chronotype – 16- 30 points

The indicator of the diurnal performance was the explosive leg – muscle strength of lower limbs. Its morning and evening changes were examined by vertical jump – countermovement jump (CMJ) by the device Myotest PRO (Myotest, Switzerland). According to producer´s agreement (Myotest, Switzerland) the result of one measurement was the mean height from five realized countermovement jumps in cm with accuracy 0.1 cm. According to producer´s agreement (Myotest, Switzerland). The morning and the evening performance of each student are assessed and evaluated as the mean performance from five morning and five evening measurements during five days. The statistical significance of differences between the morning and the evening performance of each proband was determined by Wilcoxon signed – rank test on the level $\alpha = 0.05$. The statistical analysis was realized by the software IBM® SPSS® Statistics V19 (Statistical Package for the Social Sciences). We used arithmetic mean (x) and standard deviation (SD) from the point of view of descriptive statistics.

RESULTS

According to the questionnaire we identified the intermediate chronotype in 13 students. The moderate morning chronotype was identified in 3 students and the moderate evening chronotype was identified in 2 respondents. The significant difference was not examined and denoted ($p > 0.05$) in countermovement jumps´ test. Based on the results we can state that in 13 cases exists the

relationship between identified chronotype and balanced diurnal performance.

Table 1 Physical and age characteristics of examined respondents with results of identified chronotype and diurnal performance

N	G/S	DA	H (cm)	W (kg)	CH	MP (cm)	EP (cm)	W test
1	f	19,7	170	57,3	v	27,2±0,8	27,0±1,2	T = 3, n = 4, p > 0,05
2	f	22,6	164	52,2	v	22,7±0,2	23,2±1,0	T = 3, n = 4, p > 0,05
3	f	19,6	176	57,2	v	22,8±2,6	25,0±1,8	T = 3, n = 5, p > 0,05
4	f	21,9	166	56,2	v	26,0±0,9	26,2±1,1	T = 3, n = 5, p > 0,05
5	f	20,1	176	47,1	v	24,8±2,6	25,4±2,4	T = 1, n = 5, p > 0,05
6	f	20,4	166	66,1	v	20,7±1,5	21,8±1,4	T = 0, n = 4, p > 0,05
7	f	20,3	157	49,6	mv	23,4±0,6	23,3±0,8	T = 4, n = 4, p > 0,05
8	f	19,9	171	56,9	v	27,7±0,8	27,7±1,2	T = 7,5, n = 5, p > 0,05
9	f	19,5	163	54,9	v	24,3±0,4	23,6±0,8	T = 1, n = 4, p > 0,05
10	f	19,9	162	74,1	mv	22,3±1,0	23,0±0,4	T = 0, n = 5, p > 0,05
11	f	22,0	157	51,7	mr	24,7±1,9	25,3±2,0	T = 0, n = 4, p > 0,05
12	f	21,4	168	54,4	v	27,1±1,1	27,2±2,6	T = 6,5, n = 5, p > 0,05
13	f	23,2	171	59,3	mr	26,5±0,8	25,7±0,8	T = 2, n = 5, p > 0,05
14	m	20,1	180	81,6	v	31,2±1,0	32,9±2,1	T = 1, n = 4, p > 0,05
15	m	24,1	181	80,5	mr	22,7±0,2	23,2±1,0	T = 3, n = 4, p > 0,05
16	m	18,9	172	60,6	v	36,6±1,9	36,3±1,5	T = 4, n = 4, p > 0,05
17	m	24,0	181	91,0	v	34,5±1,5	34,8±2,5	T = 4, n = 4, p > 0,05
18	m	20,0	181	69,4	v	42,0±1,7	41,5±1,6	T = 6, n = 5, p > 0,05

Legend:
N – number of the respondent; **G/S** – gender/sex[f – female, m – male]; **DA** – decimal age; **H** – height; **W** – weight ; **CH** – identified chronotype [n – intermediate, mm – moderate morning, me – moderate evening]; **MP** a **EP** – the mean diurnal [the mean morning x±SD and the mean evening x±SD] performance from the point of view of explosive leg – muscle strength of lower limbs in countermovement jump test; **W test** – evaluation of difference of diurnal performance [morning – evening] by Wilcoxon Signed – Rank test

DISCUSSION and CONCLUSION

The questionnaire´s results have shown that our sample of university students tend to be the intermediate chronotypes. This fact can be argued and reasoned by the existence of the precondition that the university students have not got stated and organized exact schedule of activities. Of course, their lives is influenced by school which is on the other hand organized variously- The lectures and seminars are stated in various time of the day – in the morning hours, in the afternoon and even in the evening hours. Each day is specific and different from the point of view of time requirements. It can be stated that the exact hour of the sleep of university students is not determined and specified and it is changed according to mentioned demands of the study, leisure time and university “night” life. The dominance of the intermediate chronotype was confirmed by the study made by Vančová et al. (2013) a Vančová & Palovičová (2013) in which they identified the chronotypes to female university students (n = 62) from which 77.4 % tended to be the intermediate chronotype. The present study has shown that no proband tends to be the definitely morning or the definitely evening chronotype.

Biss & Hasher (2012) present that the definitely morning chronotype is very unique and rare among university students. Werner et al. (2009) present in the research that the chronotype can be changed and it unstable up to the time when the human – being becomes self – depended and has regular work and own home. The varying chronotype is specific and characteristic manly for pubescence and adolescence up to 26 year. The results of the research made by Hagenauer & Ku & Lee (2011) agreed with the previous arguments and statements.

Barbosa & Albuquerque (2008) were dealing with problem of chronotypes´ relationship with diurnal performance. They divided students according to chronotypes and they examined training effect on long-term explicit memory of

undergraduates who were classified as morning, intermediate, or evening chronotypes. The students who trained in the afternoon achieved better performance. The authors presented that the long-term explicit memory performance was not affected or depended by chronotype or time –of- day. Brown, Neft & LaJambe (2008) divided young in three groups according to the identified chronotypes: the morning chronotypes, the intermediate chronotypes and the evening chronotypes. The athletes´ performance was examined in the morning from 5 am to 7am and in the afternoon from 4.30 pm to 6 pm. The authors did not detect any significant difference in athletes´ performance according to chronotype´s typology from the point of view of time- of – day and they stated that the results of athletes were influenced by training and time- stereotypes. Atkinson et al. (2005) presented very interesting results. The professional cyclists who tended to be the morning chronotypes achieved significant better performance in the evening. Also Pivovarniček et al. (2012, 2013) present detections related to balanced diurnal performance of young soccer players in the morning and in the evening. The authors state that there is the existence of time – training stereotypes which is presented also in researches made by in Pivovarniček (2009a,b,c). Our university students were not interested in sport and were not active and that is why there is no evidence to predicate the existence of created time – training stereotype what was confirmed in their balanced diurnal performance from the point of view of the explosive leg – muscle strength. Mentioned detections in our sample of university students showed the existence of the relationship between identified chronotype and diurnal performance.

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ABSTRAKT

IDENTIFIKÁCIA CHRONOTYPU A DIURNALNEJ VÝKONNOSTI

Kľúčové slová*:* vertikálny výskok z miesta, večerný chronotyp, večerný výkon, ranný výkon

Predložená štúdia prezentuje výsledky výskumu, cieľom ktorého bolo zistenie vzťahu medzi identifikovaným chronotypom a diurnálnou výkonnosťou u vysokoškolských študentov. Výskumný súbor tvorili študenti I. a II. stupňa vysokoškolského štúdia rôznych študijných programov a študijných odborov na fakultách Univerzity Mateja Bela v Banskej Bystrici (n = 18) v akademickom roku 2014/2015. Chronotyp bol identifikovaný dotazníkom (Horne – Ostberg, 1976). Rozdiely diurnálnej výkonnosti (ráno – večer) boli zisťované prostredníctvom Wilcoxonovho testu v parametri explozívnej sily dolných končatín v teste vertikálny skok s protipohybom (CMJ), meraný zariadením Myotest PRO (Myotest, Švajčiarsko). Ranná a večerná výkonnosť bola vyhodnocovaná ako priemerná výkonnosť piatich ranných a piatich večerných meraní. Štatistická analýza bola realizovaná pomocou softwaru IBM® SPSS® Statistics V19. Výsledky identifikácie štatistickej analýzy diurnálnej výkonnosti a chronotypu ukázali, že u najväčšej skupiny probandov bola zistená vyrovnaná diurnálna výkonnosť ($p > 0,05$) a rovnako sme u väčšiny probandov identifikovali vyrovnaný chronotyp (n = 13). Traja probandi (n = 3) inklinovali k viac rannému chronotypu a dvom probandom (n =2) bol dotazníkom identifikovaný viac večerný chronotyp. Rozhodne ranný a rozhodne večerný chronotyp nebol identifikovaný u žiadneho z probandov (n=0).

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THE IMPACT OF LUNAR RHYTHMS ON CROSS-COUNTRY SKIING ATHLETE'S LOCOMOTOR PERFORMANCE

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Original scientific paper

Key words:

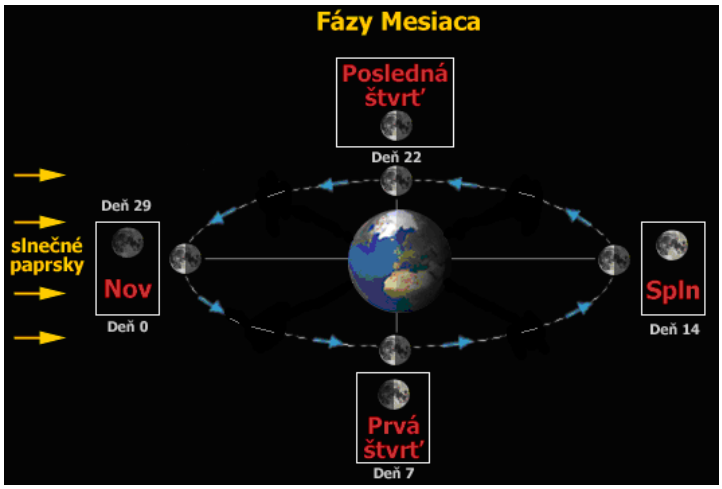
biological rhythms, lunar rhythms, locomotor performance

The aim of the study was to determine the effects of lunar rhythms on the course of oscillation of locomotor performance of a cross-country skiing athlete. The object of the research was a member of the Academic National Team, a student of Physical Education and Sports, Faculty of Arts, Matej Bel University in Banska Bystrica. She was born on August 4, 1991, her body height was 175cm and body weight was 65kg. She has been cross-country skiing since 1997. The diagnostics were performed by five tests during six lunar cycles from July to December RTC 2013/2014. The following test were used: the Ruffier test, 30m sprint, CrossFit sit-ups, the Home Step Test and Medicine Ball Throw (2kg). Based on the results of the research, we found that in the first phase of the lunar rhythm the proband achieved the best results in four tests – the Ruffier test, 30m sprint, sit-ups, and Home Step Test. In the dynamic strength of the upper limbs, we have recorded the best results in the third phase of the lunar rhythm. Based these findings, we conclude that the phases of the lunar rhythm are suitable for the development of the individual locomotorabilities.

INTRODUCTION

Mankind has always been paying attention to phases of the Moon. Rigorous observation of nature, the world of animals and plants made, out of many of our ancestors, the masters of the right time. Tasks, such as wood chopping, cooking, eating, cutting of hair, gardening work, fertilization or surgery are affected by the Moon. Even plants harvested at the right time are more potent than those harvested some other time. Many other natural phenomena, such as tides, the alteration between daylight and night during the day, change of the seasons, weather, menstrual cycles and childbirth are related to the path of the Moon. Over time, some physiological functions in human have begun to be observed and recorded, for example the effects of sleep on body temperature, health and its relationship to light frequency, studying oscillation of physical and psychological performance of human during daytime (Jančoková, 2013). The basis of life establishment on the Earth is formed by rhythmicity and is one of the main features of living systems.

Alteration of lunar phases is caused by the Sun always illuminating different parts of the Moon (Figure 1). During new Moon, the dark side of the Moon is facing the Earth and the Moon is not visible from the Earth. In the first quarter, half hemisphere of the Moon is visible (similar to letter D). Further, the illuminated part of the Moon is increasing. During full moon, the entire hemisphere facing the Earth is illuminated. It shines all night, because it is facing directly the Sun. Then, the Moon wanes again. Last quarter – the Moon "reverses" to the final quarter, in the form of "C". It appears in the morning sky heading back to the new moon, which marks the beginning of a new cycle (Wikipedia).



Fibure 1 Phases of the Moon (amended accoring to www.meteo.sk)

In general, according to Homolka et al. (2010) lunar external rhythms are applied in synchronization of exogenous biorhythms especially in invertebrates, while in higher organisms it is discussed whether residuals of the direct impact of lunar rhythms still persist in them. This is the case of, for example human sexual cycles. Also the average circa 28-day period of the female menstruation cycle has a duration within the range of the synodic month (from 27.3 to 29.5 day). It is impossible to reject that during development of various species were the real sexual cycles, including the human cycle, synchronized with lunar phases; according to other authors, it can be a mere coincidence. It is believed that moonlight can the signal for tuning of the lunar rhythm (Jančoková, 1998).

In the research by Amina (2006), in which the author examined the impact of changes in body temperature of the circadian rhythm on locomotor and psychological performance, he examined the impact of the lunar rhythm on performance, as a partial task. He monitored locomotor performance by the static strength test of the upper limbs, psychological performance was evaluated by non-standard questions and by filling out numerical series (Sudoku). In the results he indicates that he has not found correlation with the full-moon phase compared to the other days. The limitation of the research was, however, that he did not monitor the whole period of the lunar rhythm but only 10 days peaking in the phase of the full moon, and the number of probands was also too low to make general conclusions.

Roveský et al. (1998) examined whether lunar rhythms occur in a sequence of 74 cases of articular chondrocalcinosis attacks (a congenital metabolic disorder with crystallization of calciumpyrophosphatedihydrate in articular cartilage) registered between 1954 and 1995.

He stated that attacks of chondrocalcinosis may be more associated with natural and heliogeophysical factors (geomagnetic activity, lunisolar gravity) and less with social factors compared to another disease – gout. The coefficient of determination of gout with synodical month was 0.969 peaking around the full moon and new moon (Mikulecký et al. 1996).

METHODOLOGY

The proband currently operates in Ski Team JASE Látky (STJL) and the coach is a former member of the National Cross Country Ski Team Bc. M. K. In the preparatory period RTC 2013/2014, she trained 5-6x a week in two stages.

Table 1 shows the phases of the lunar rhythm and the testing dates. The testing was performed under equal conditionals in the sports complex of an elementary school in Hriňová, with the assistance of coach M.K. The testing was performed between 9:00AM and 11:00AM.

Table 1 Phases of the lunar rhythm and dates of the testing (www.polovacka.com)

Lunar Rhythms (Year 2013)	I. Phase (New Moon)	II. Phase (First Quarter)	III. Phase (Full Moon)	IV. Phase (Last Quarter)
July	7.7.2013	14.7.2013	22.7.2013	29.7.2013
August	6.8.2013	13.8.2013	20.8.2013	28.8.2013
September	4.9.2013	11.9.2013	19.9.2013	26.9.2013
October	4.10.2013	11.10.2013	18.10.2013	26.10.2013
November	2.11.2013	9.11.2013	17.11.2013	25.11.2013
December	2.12.2013	9.12.2013	16.12.2013	24.12.2013

The testing battery consisted of five tests: the Ruffier test, 30m sprint, CrossFit sit-ups – sit in 30 seconds, the Home Step Test and Medicine Ball Throw (2kg) (Šimonek, 2012). The individual results were recorded on a tracking sheet.

The Ruffier test – determines the functional status of the cardiovascular system and the readiness of the organism to load.

Tools: metronome, sport tester, stopwatch, bench.

Procedure:

Step 1 – after about 5 minutes of relaxation in seated position, we recorded SF – S1 at rest.

Step 2 – 30 squats for 45 seconds, followed by recording SF – S2.

Step 3 – 1 minute relaxation in seated position and recording – S3.

Assessment: according to the formula: **RI = [(S1 + S2 + S3) - 200]/10**

Table 2 Index assessment of the Ruffier test (www.aos.sk/struktura/katedry/ruffier).

Ruffier test Index	Assessment
below 3,0	excellent functional status
3,1 - 7,0	good functional status
7,1 - 12	average functional status
12,1 - 15,0	below average functional status
above 15,1	poor functional status

CrossFit sit-ups (30sec.) – evaluates dynamic and endurance strength of abdominal and hip-thigh muscles.

Tools: mat.

Procedure: supine starting position, legs slightly bent, feet on the mat, arms next to the body, trunk movement forward and back through the abdominal muscles in 10cm range marked on the mat.

Assessment: number of repetitions within 30 seconds.

The Home Step Test – evaluates cardiovascular endurance.

Tools: stair step, 30.5cm high platform, stopwatch, sport tester.

Procedure: 3-minute ascents and descents in a four-beat rhythm. After completion, SF is recorded standing after 1 minute.

Assessment: according to indicative standards given in Table 2. The lower SF value after load, the higher aerobic endurance.

Table 3 Assessment of cardiovascular endurance

Age	18-25	26-35	36-45	46-55	56-65	65+
Excelent	< 85	< 88	< 90	< 94	< 95	< 90
Good	85-98	88-99	90-102	94-104	95-104	90-102
Above Average	99-108	100-111	103-110	105-115	105-112	103-115
Average	109-117	112-119	111-118	116-120	113-118	116-122
Below Average	118-126	120-126	119-128	121-129	119-128	123-128
Fair	117-128	118-128	120-130	123-132	121-129	121-130
Poor	> 140	> 138	> 140	> 135	> 139	> 134

30m Sprint – evaluates the level of speed capability

Tools: running track, measuring tape, stopwatch.

Procedure: full-standing start on the command "On your marks – Ready – Set – Start".
Assessment: time in seconds (sec.), accuracy of time-recording 0.1sec.

Medicine Ball Throw – evaluates the level of explosive strength of upper limbs and trunk.
Tools: medicine ball (2kg), measuring tape.
Procedure: standing with feet shoulder width apart, holding the ball with both hands behind the head, repeatedly perform three attempts.
Assessment: distance from the throwing mark to the point of impact. The longest throw in centimeters (cm) of three attempts is measured.

When processing the results of the study, we used quantitative and qualitative methods. Arithmetic mean (x) and standard deviation (SD) were the descriptors of descriptive statistics (SD). To determine the significance of differences between the individual phases of the lunar rhythm, we used the non-parametric Friedman's test at the 5% level of significance ($p<0.05$). MedCalc (version 13.2.2.0) software was used. Qualitative methods (analysis, synthesis, induction, deduction and comparison) were used when interpreting the results and when looking for causalities of the studied phenomena.

RESULTS

The performance of the cardiovascular system and the readiness of organism to load was evaluated by the Ruffier test. The results obtained are presented in Table 4. According to the Ruffier test index (Table 1) we note that J.G. achieved in all four phases of the lunar rhythm same level of functional state of the body – good functional status. Nadir (index value of 3.5) was recorded in October and November in the I. Phase of the lunar rhythm. The acrophase of the functional state of the athlete's organism was recorded in July in the IV. Phase of the lunar rhythm. We assume that this was caused by a preexisting disease. After summarizing of the results and on the basis of the curve we conclude that the most appropriate phase for the performance of the cardiovascular system and readiness of the organism to load is the I. Phase, conversely, the most inconvenient is the IV. Phase of the lunar rhythm.

Table 4 Results of **the Ruffier test** in phases of the lunar rhythms of J.G.

Lunar Phases (rok 2013)	I. Phase (New Moon)	II. Phase (First Quarter)	III. Phase (Full Moon)	IV. Phase (Last Quarter)
July	3,9	4,2	4,5	4,9
August	3,8	4,0	4,2	4,5
September	3,6	3,8	4,0	4,0
October	3,5	3,6	3,9	3,9
November	3,5	3,7	3,8	3,9
December	3,7	3,6	3,8	3,9
x	**3,67**	**3,82**	**4,03**	**4,18**
min	**3,5**	**3,6**	3,8	3,9
max	**3,9**	4,2	4,5	4,9
SD	**0,16**	**0,24**	**0,27**	**0,42**

Legend:
x – arithmetic mean
max – maximum value
min – minimum value
SD – standard deviation

The findings are also presented in Figure 1. The curve exhibits, from I. Phase to IV. Phase, a gradual decline in the level of functional ability of the body, as recorded by a simple functional test. On that basis, we conclude that the I. Phase is the most appropriate and most important for developing performance of the cardiovascular system and readiness of the organism to load. From the data of J.G.'s health we found that the value of the index in the 1st testing in the IV. Phase of the lunar rhythm could have been affected by the mentioned illness. However, we conclude that it

may have not had such a considerable impact because all values were the worst in the IV. Phase of the lunar rhythm. It is also documented by the level of the standard deviation of the individual lunar rhythm phases. The result of the Friedman's non-parametric test showed that there are significant differences ($p<0.05$) between the individual phases.

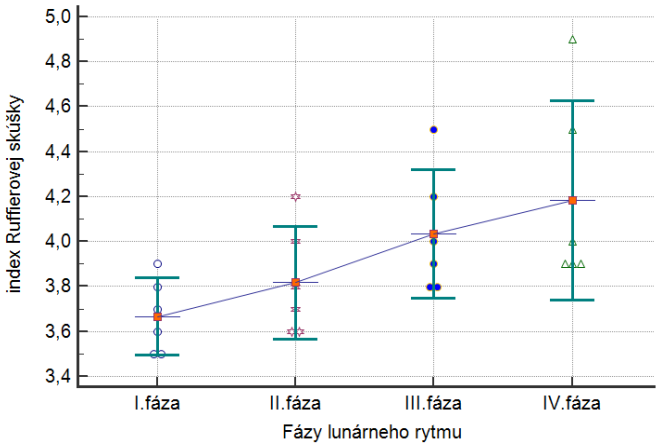


Figure 1 The Lunar rhythm index of the Ruffier test in proband J.G.

Test T (2) CrossFit sit-ups

By testing, we examined the dynamic and endurance strength of abdominal and hip-thigh muscles in 30-second intervals. The results are presented in Table 5 and Figure 2.

Table 5 Results of the CrossFit sit-ups test of J.G.'s lunar rhythm (number of repetitions)

Lunar Rhythm Phases	I. Phase	II. Phase	III. Phase	IV. Phase
July	23	23	21	22
August	23	22	21	22
September	23	23	22	22
October	23	23	23	22
November	23	23	23	22
December	23	23	23	22
x	**23**	**22,83**	**22,17**	**22**
min	**23**	**22**	**21**	**22**
max	**23**	**23**	**23**	**22**
SD	**0**	**0,41**	**0,98**	**0**

Legend:
x – arithmetic mean
max – maximum value
min – minimum value
SD – standard deviation

Nadir was again recorded in the I. Phase of the lunar rhythm with average performance at 23 ±0. This means that in the I. Phase of the lunar rhythm (from July to December 2013) J.G. achieved identically 23 repetitions, in II. Phase she achieved average performance of 22.83. In the III. and IV. Phase of the lunar rhythm, we recorded a gradual loss in performance to the level of 22 repetitions – acrophase. In the III. Phase, we also recorded two of the worst results from all the testing (21 repetitions).

In Figure 2 we see a decreasing curve, which represents the decline from the best to the worst phase. The curve of J.G. shows a slight decline from the I. to the II. Phase and from the III. Phase to the IV. Phase. A slightly greater decline was recorded from the II. to the III. Phase, where the average performance decreased from 22.83 to 22.17, which already is a significant difference. From the given curve, we assume that for improved performance of the dynamic and endurance strength of the abdominal and hip-thigh muscles is the I. Phase the most appropriate, in which J.G. achieved the best results in all months of testing, whereas the least desirable is the IV. Phase of the lunar rhythm. The lowest standard deviation was recorded two times ±0 in the I. and the IV. Phase. The results of the Friedman's non-parametric test showed that there were significant differences ($p<0.05$) among the individual phases.

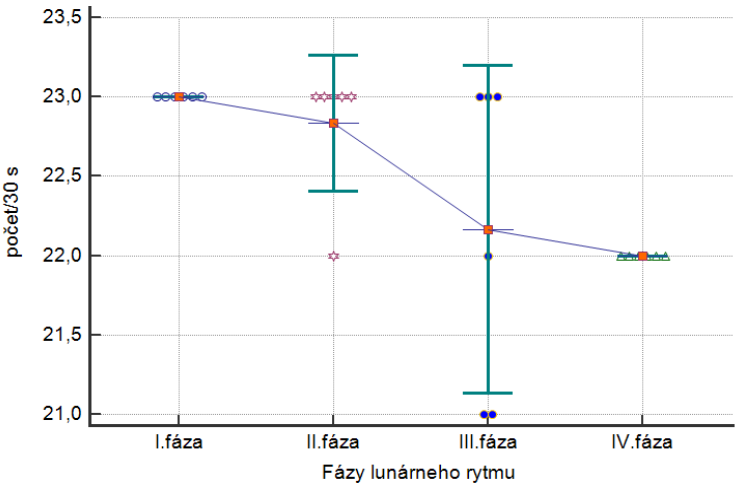


Figure 2 Lunar rhythm of CrossFit sit-ups (number of repetitions)

Test T (3) Home Step Test

By this test, we examined the level of cardiovascular endurance and aerobic fitness. J.G. achieved excellent heart rate, since her performance in neither phase did not exceed 85 SF (heart rate), which is the threshold of excellent heart rate. Although results across the individual phases varied, they never exceeded the excellent level of heart rate. The lower the heart rate values after testing, the level of aerobic fitness was higher (Table 6). Nadir was again recorded in the I. Phase of the lunar rhythm (72.83 ±0.75). the Acrophaes was recorded in the III. Phase with average performance at level of 78 SF. In month of July during this phase, J.G. achieved the worst result of 82 SF.

Table 6 Results of the Home Step Test of J.G.'s lunar rhythm (number of repetitions)

Moon Phases	I. Phase	II. Phase	III. Phase	IV. Phase
July	72	75	82	79
August	73	75	79	78
September	72	74	75	76
October	73	74	77	75
November	74	75	76	78
December	73	76	79	77
x	**72,83**	**74,83**	**78**	**77,16**
min	**72**	**74**	**75**	**75**
max	**74**	**76**	**82**	**79**
SD	**0,75**	**0,75**	**2,53**	**1,47**

Legend:
x – arithmetic mean
max – maximum value
min – minimum value
SD – standard deviation

Based on the curve in Figure 3, we conclude that for the performance of the cardiovascular endurance and aerobic fitness is the most appropriate the I. Phase of the lunar rhythm, when J.G. achieved the best average performance of 72.83 and also two of the best performance readings among all four phases. Conversely, the least desirable if the III. Phase of the lunar rhythm. The results of the Friedman's non-parametric test showed that there were statistically significant ($p<0.05$) differences between the individual phases.

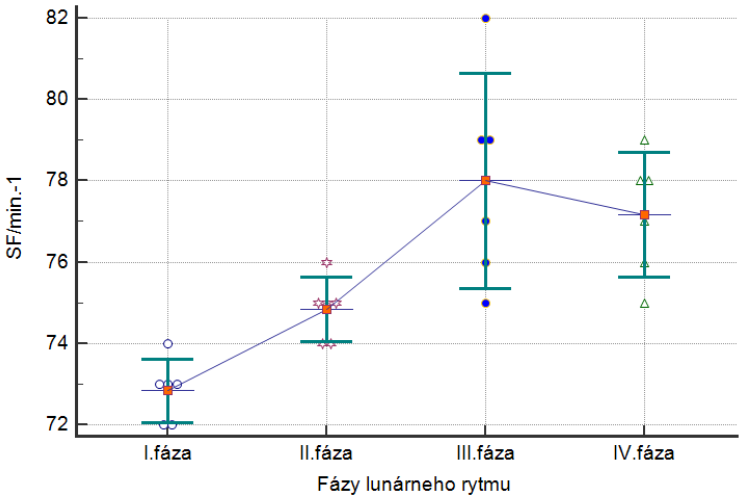


Figure 3 Lunar rhythm of the Home Step Test of J.G. (SF)

Test T (4) 30m Sprint

By the test we assessed the level of running speed capability. Table 7 implies that J.G. recorded fluctuating performance in the speed of running. Nadir was again established in the I. Phase of the lunar rhythm (5.64sec.). Also the individual performance in this phase were among the best. Subsequently, J.G. achieved a decline in performance to the average level of 5.99sec., and averge performance of 5.77sec. in the III. Phase, and the best result of 5.54sec. in July. We found the acrophase of the lunar rhythm in the IV. Phase (6.00sec.).

Table 7 Results of the 30m Sprint of J.G.'s lunar rhythm (sec.)

Moon Phases	I. Phase	II. Phase	III. Phase	IV. Phase
July	5,52	6,11	5,54	6,07
August	5,48	6,01	5,60	6,03
September	5,50	5,74	5,72	5,83
October	5,75	5,80	5,89	5,90
November	5,85	5,93	6,03	6,00
December	5,75	5,90	5,83	6,15
x	**5,64**	**5,92**	**5,77**	**6,00**
Min	5,48	5,74	5,54	5,83
max	5,85	6,11	6,03	6,15
SD	**0,16**	**0,14**	**0,18**	**0,12**

Legend:
x – arithmetic mean
max – maximum value
min – minimum value
SD – standard deviation

Based on the presented results in Figure 4, we conclude that for the performance of speed capabilities of the organism is the I. Phase optimal, whereas the IV. Phase of the lunar rhythm is the least suitable. The results of the Friedman's non-parametric test showed that there were statistically significant ($p<0.05$) differences between the individual phases.

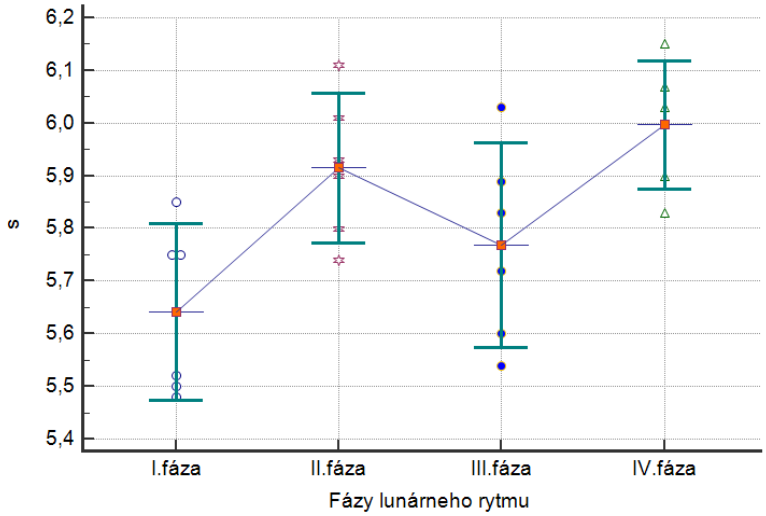


Figure 4 Lunar rhythm of 30m Sprint of J.G. (sec.)

Table 8 Results of the Medicine Ball Throw test of the lunar rhythm of J.G. (cm)

Moon Phases	I. Phase	II. Phase	III. Phase	IV. Phase
July	754	770	820	811
August	755	786	800	800
September	765	780	807	791
October	785	773	795	812
November	785	790	787	800
December	779	813	800	790
x	**771**	**785**	**802**	**801**
min	754	770	787	790
max	785	813	820	812
SD	**140**	**160**	**110**	**90**

Legend:
x – arithmetic mean
max – maximum value
min – minimum value
SD – standard deviation

Test T (5) Medicine Ball Throw

With this test we examined the level of explosive capability of upper limbs and trunk. The results are presented in Table 8. Exactly at this level of capability we first found the acrophase of the lunar rhythm in the I. Phase with average performance of 771cm. Nadir was detected in the III. Phase with average performance of 802cm.

The achieved results are, for better depiction, presented also in Figure 5. The performance curve

shows increasing tendency from the I. to the III. Phase. The average performance soared from 771cm to 802cm. In the IV. Phase, we recorded a decline in the average performance of 1cm. On this basis, we conclude that for the performance of explosive capability of the upper limbs and trunk is the III. and IV. Phase suited the most and the I. Phase of the lunar rhythm suitable the least. The results of the Friedman's non-parametric test showed that there were statistically significant ($p<0.05$) differences between the individual phases.

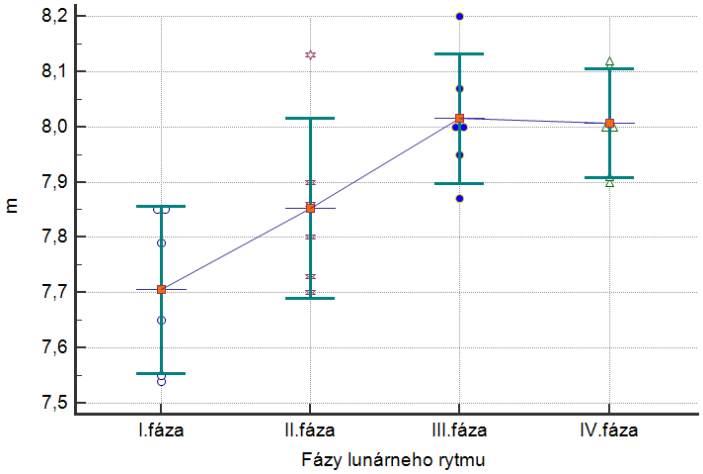


Figure 5 Lunar rhythm of Medicine Ball Trow of J.G. (m)

DISCUSSION and CONCLUSION

The aim of the study was to investigate the effect of lunar rhythm on the course of oscillations of locomotor performance of cross-country skiing female athlete in the preparatory period RTC 2013/2014. Based on the distribution of the lunar rhythm phases, we determined the days of testing. The object of the research was J.G., academic representative in cross-country skiing. The testing was performed on the promises of an elementary school in Hriňová during a six-moth period. Repeatedly, we performed measurements of physical performance in the different phases of the lunar rhythm. The locomotor performance was diagnosed by five tests: the Ruffier test, 30m sprint, CrossFit sit-ups, the Home Step Test and Medicine Ball Throw (2kg). The level of locomotor performance varied at each stage of the lunar rhythm. By analyzing the achieved results, we found that a curve with different amplitude and with an uneven distribution of acrophases and nadirs exists in the area of locomotor performance. Overall, we consider the I. Phase the most performance-favorable phase of the lunar rhythm. In this phase, we recorded the best results in the proband in the tests T (1), T (2), T (3) a T (4). In the test T (1), the curve depicts a gradual decline in performance from the I. Phase to the IV. Phase of the lunar rhythm.

Compared to the work of Mojžiš (2011) who considers the I. Phase the most favorable phase of the girls' lunar rhythm, our results match significantly. The least favorable phase, according to Mojžiš (2011) is the IV Phase of the lunar rhythm, which is a comparable result with our study. However, practicing only a couple of days a month around the I. Phase would, for active and elite athletes be ineffective because they would not improve their performance this way. We can, however, take into account the individual results and utilize them in the training process so that the muscle group with deficit that is most negatively reflected in the performance, would be trained the most during the most favorable phase. We recommend to take different oscillation of physical and mental performance in different phases of the lunar rhythm into account. One of the options of streamlining the training process for athletes we see in utilization of natural biological rhythmicity of

the organism and its interactions with the external environment. Our research of the lunar rhythms, we aimed to contributing with novel findings in the field of biological rhythms, as multi-day rhythms are still little explored.

The external environment affected by several external factors lined to exogenous rhythms (lunar in our case) cause in the human organism arrangement of endogenous functions in a way that the organism is able to maintain the homeostasis state in under any conditions. Additionally, to achieve performance and resistance to all kinds of strain the body is exposed to. It is therefore vital exposing the body to a sufficient amount of stimuli, which it gradually adapts to and builds protective mechanism. On the contrary, in the absence of a sufficient amount of stimuli from the external environment, disorders in the body occur, which have negative impact on the overall locomotor performance. In our research, we investigated the effects of the lunar rhythm, as the complex biological rhythm on locomotor and psychological performance in schoolchildren. It was not in our interest to deny or not to deny the myths and speculation about the effects of the full moon, or another phase of the Moon on humans.

The study is part of a solution of a grant task (research) VEGA 1/0795/15 Biorhythms, an important lifestyle phenomenon of the population

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ABSTRAKT

VPLYV LUNÁRNEHO RYTMU NA POHYBOVÚ VÝKONNOSŤ BEŽKYNE NA LYŽIACH

Kľúčové slová: biologické rytmy, lunárne rytmy, pohybová výkonnosť

Cieľol štúdie bolo zistiť vplyv lunárneho rytmu na priebeh oscilácií pohybovej výkonnosti bežkyne na lyžiach. Objektom výskumného zamerania bola členka akademického reprezentačného družstva, študentka Katedry telesnej výchovy a športu, Filozofickej fakulty Univerzity Mateja Bela v Banskej Bystrici. Narodila sa 4.8.1991, jej telesná výška bola 175cm a telesná hmotnosť 65kg. Bežeckému lyžovaniu sa venuje od roku 1997. Diagnostika bola realizovaná pomocou piatich testov počas šiestich lunárnych cyklov od júla do decembra RTC 2013/2014. Použili sme nasledovné testy: Ruffierova skúška, šprint na 30, crossfitový ľah - sed, domáci step test a hod plnou loptou (2 kg). Z výsledkov výskumu sme zistili, že v I. fáze lunárneho rytmu probandka dosiahla najlepšie výsledky v štyroch testoch - Ruffierova skúška, šprint na 30 m, ľah-sed a

domáci step test. V dynamickej sile horných končatín sme zaznamenali najlepšie výsledky v III. fáze lunárneho rytmu.

Na základe uvedených zistení konštatujeme, že uvedené fázy lunárneho rytmu sú vhodné pre rozvoj jednotlivých pohybových schopností.

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