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SOMATIC AND TYPOLOGICAL DIFFERENTIATION OF FIRST-YEAR MALE AND FEMALE STUDENTS FROM THE JOZEF PILSUDSKI UNIVERSITY OF PHYSICAL EDUCATION IN WARSAW

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Abstract University education is a period of human life when lifestyles or person's activity are critical to the development of somatic build, while identification of the somatotype allows for corrections or recommendation of effective physical activity programmes. The main aim of this study was to assess selected features of body build and to identify somatotypes of young people at early stages of education at Jozef Pilsudski University of Physical Education in Warsaw depending on the field of study. The study examined 394 students of physical education (PE) and sport (S). Anthropometric measurements were the main research method used in the study. Physical body build (somatotype) was identified using the Heath-Carter method. The ANOVA/MANOVA analysis of variance was employed to determine the significance of differences in values of anthropometric and somatic characteristics between the groups of students.

Students of physical education were characterized by a somatotype with a code of 3.08-4.6-2.62 (endomorphic mesomorph). In students of sport, the somatotype code was 3.0-4.58-2.37 (endomorphic mesomorph). Compared to S students, significantly ($p < 0.05$) higher values (by 10.5%) of the ectomorphy component were found in PE students.

The results revealed the need for more research into the somatic build of students of physical education, taking into account the changes in their living conditions (including socio-economic environment), since graduates are expected to promote physical activity in the future. It is also necessary to carry out identical research at the end of studies in order to evaluate the effect of university curricula on the somatic build of students.

Key words anthropometry, endomorphy, mesomorphy, ectomorphy, students

Introduction

Observation of changes caused by the onset of modern civilization and intergenerational changes provide researchers with a great deal of valuable information on the health status of successive generations. Research on university students has been carried out all around the world (Ekblom, Engström, Ekblom, 2007; Yıldız, Karakaş, Güneş, Köse, 2009) and in Poland for many years. It contributes to a better understanding of the determinants of the health status of a young generation (Milicer, Skibińska, Skład, 1974; Mleczko, Januszewski, 2009; Pasiut, 2012; Saczuk, Wasiluk, Wilczewski, Wilczewski, 2016; Stachoń, Burdakiewicz, Pietraszewska, Andrzejewska, 2012). Universities (particularly those which offer PE courses) are important institutions that promote active lifestyles in society. It is students of pedagogical and biomedical courses who, after graduation, will promote physical activity among both children and adults.

Research indicates that the specificity of particular university studies and courses affects students' lifestyles and health status (Maaroos, Landor, 2001; Pasiut, 2012). Studying at university is a time of dynamic changes related to a circadian rhythm which is different compared to earlier stages of education, attempting to combine work and study, and participating in university life. It is often stressed that during this period of life, students may be exposed to irregular lifestyles and addictions (Huang et al., 2003; Maaroos, Landor, 2001), whereas the prevalence of overweight and obesity is high (Phaswana, Ramalihana, Amusa, 2015; Truter, Pienaar, DuToit, 2010). Studies on the somatic build of students from different universities and courses have emphasized differences mainly in height and weight indices and body composition. Despite similar age and, in most of the students, living in big cities while studying, differences in musculature and body fat are considerable. They depend on the type of classes attended at university. Body size, proportions and body composition are crucial to physical fitness and are the subject of scientific research (Brničević, Duplančić, Jukić, 2014; Kaźmierczak, Bolesławska, Główka, Dzięcioł, Przysławski, 2012; Nikbakht, 2011; Peterson, Koskel, 2006; Raschka, Aichele, 2014; Tzarova, 2013; Vedat, 2013). Somatype, which represents the description of body build of an individual, is defined by one of the three types: endomorph, characterized as rounded body shape; mesomorph, with muscular body; and ectomorph, characterized as slim body build (Carter, 2002). Physical activity is an important causative factor in achieving the desired positive levels of physical health by students. It points to the need for promoting and enabling university students to participate in various forms of physical culture (Mirek, Mleczko, 2005).

University education is a period of human life when lifestyles or person's activity are critical to the development of somatic build, while identification of the somatype allows for corrections or recommendation of effective physical activity programmes (Cynarski, Obodyński, Litwiniuk, 2005). The university curricula for students of physical education and sports are characterized by a significantly higher number of practical activities with high-intensity exercises. This can lead to the differences in body build compared to students from other university majors. Knowledge in this field facilitates to determine the body profiles of future students as well as students who have to participate in many practical activities in accordance with the study programme.

The main aim of the study was to assess selected characteristics of body build and to determine somatypes of young people starting education at Jozef Pilsudski University of Physical Education in Warsaw in the field of physical education and sport. Furthermore, the research results were related to findings of similar studies in Poland and other countries.

Material and methods

The study examined 394 first-year students of physical education ($n = 316$) and sport ($n = 78$) from Jozef Pilsudski University of Physical Education in Warsaw. The students from each group were divided according to gender (female students: $n = 85$ and $n = 20$, respectively; male students: $n = 231$ and $n = 58$, respectively). General characteristics of students with regard to the field of study and gender are presented in Table 1.

Table 1. Baseline characteristics of the study participants

	Variable	Mean \pm SD	Median	Range
Course				
PE ($n = 316$)	age	20.4 \pm 5.2	19.8	17.2–27.0
	body mass	72.9 \pm 10.9	72.8	45.8–130.6
	body height	177.3 \pm 8.5	177.6	152.5–197.5
S ($n = 78$)	age	19.7 \pm 0.9	19.4	17.5–22.4
	body mass	75.4 \pm 10.4	75.4	52.9–98.0
	body height	178.2 \pm 8.6	178.7	161.0–196.3
Total ($n = 394$)	age	20.2 \pm 4.6	19.7	17.2–27.0
	body mass	73.5 \pm 10.9	73.6	45.8–130.6
	body height	177.5 \pm 8.5	177.8	152.5–197.5
Gender				
Females PE ($n = 85$)	age	19.9 \pm 1.2	19.6	18.8–27.0
	body mass	63.6 \pm 9.3	62.9	45.8–88.9
	body height	167.8 \pm 5.3	167.7	152.5–181.6
Females S ($n = 20$)	age	19.9 \pm 1.0	19.7	18.8–22.3
	body mass	64.6 \pm 7.2	65.7	52.9–75.7
	body height	168.7 \pm 6.2	167.2	161.0–184.4
Total ($n = 105$)	age	19.9 \pm 1.2	19.6	18.8–27.0
	body mass	63.8 \pm 8.9	63.1	45.8–88.9
	body height	167.9 \pm 5.5	167.5	152.5–184.4
Males PE ($n = 231$)	age	20.6 \pm 6.0	19.8	17.2–24.9
	body mass	76.4 \pm 9.4	75.5	54.8–130.6
	body height	180.8 \pm 6.5	180.9	161.2–197.5
Males S ($n = 58$)	age	19.6 \pm 0.9	19.3	17.5–22.4
	body mass	79.2 \pm 8.5	79.1	61.4–98.0
	body height	181.5 \pm 6.6	180.9	163.7–196.3
Total ($n = 289$)	age	20.4 \pm 5.4	19.8	17.2–24.9
	body mass	77.0 \pm 9.3	76.0	54.8–130.6
	body height	181.0 \pm 6.5	180.9	161.2–197.5

n – number of study participants. Age is presented in years, body height in cm, and body mass in kg.

The procedure was approved by the Ethics Committee for Scientific Research of the University of Physical Education in Warsaw. Examinations were carried out by the team of experts trained in measurement techniques between October and December 2015 at the University of Physical Education in Warsaw. Before the examinations, all the participants were informed about the research project, its aim, benefits and procedures, and about a possibility of withdrawal from participation in the research without giving reasons at any time. The study inclusion criterion was

a written informed consent provided by the participant. Anthropometry was the main research method used in the study. Body measurements were taken with participants wearing their underwear only (without outer garments) in accordance with general standards (Charzewska, Kopiczko, Bieńko, Pastuszak, 2017). The position of the body was in line with the recommendations of the International Biological Programme (Weiner, Lourie, 1969). The following variables were recorded: age (years), body mass (kg), body height (cm), skinfolds (triceps, subscapular, supraspinal, calf), girths (flexed arm, calf), and humerus and femur breadth. The measurements were made using anthropometric tools such as an anthropometer with a measuring range of 2.10 m (accuracy: 1 mm), a small calliper (accuracy: 1 mm), a tape measure (accuracy: 1 mm) and the Harpenden Skinfold Caliper (accuracy: 0.2 mm). Skinfolds were measured in all participants by one researcher three times (mean result was taken into account). The Heath-Carter method (Carter, Heath, 1990) and Somatotype 1.2.6 software (MER Goulding Software Development, Australia) were used to identify somatotypes. The Shapiro-Wilk test was employed to verify the distribution of results. The data were converted into numerical values using the following indices: arithmetic means (X), standard deviations (SD), maximum and minimum values (Min-Max) and medians (Me). The ANOVA/MANOVA analysis of variance (post hoc Tukey tests, with statistical significance set at $p < 0.05$) was employed to evaluate the significance of differences in values of anthropometric and somatic features between the groups of students. All the calculations and analyses were made using STATISTICA software (v.12, Stat. Soft. USA).

Results

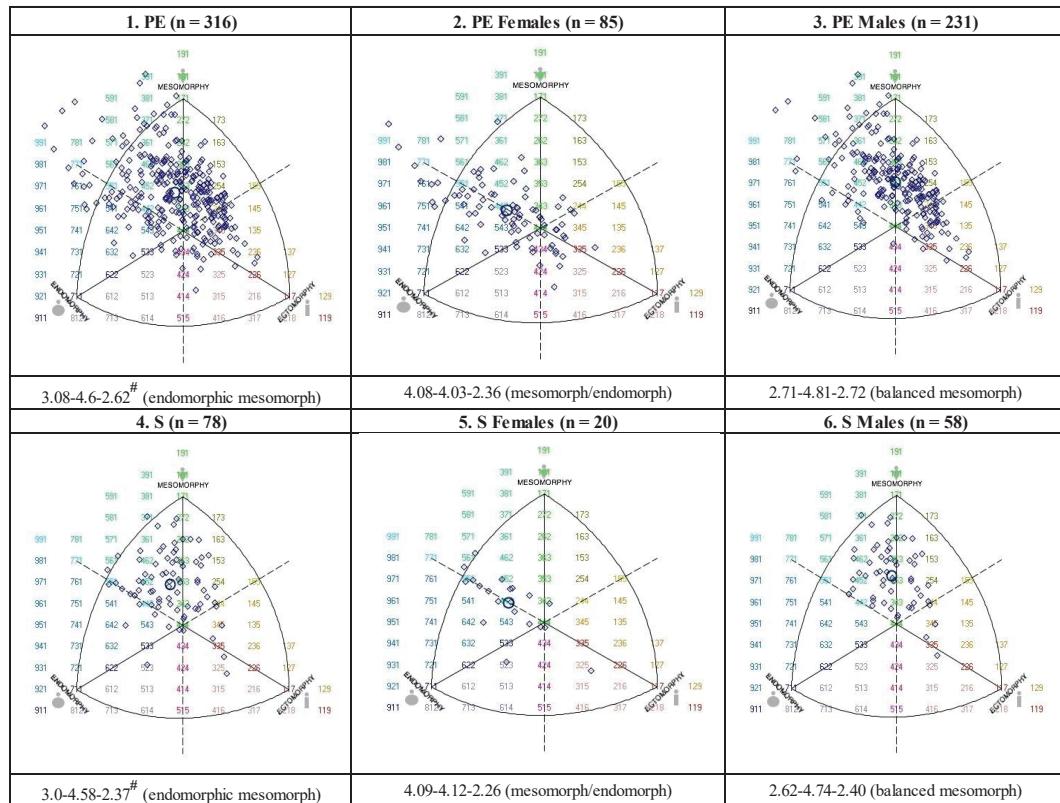
Research results were shown in tables and figures (with regard to somatotypes). Descriptive statistics of all the measurements are presented in Table 2, while individual somatotypes of students together with the mean profile (circle) are illustrated in Figure 2.

Table 2. Descriptive statistics of the measured anthropometric variables

Variables	Females PE (n = 85)		Females S (n = 20)		Males PE (n = 231)		Males S (n = 58)	
	M \pm SD	range	M \pm SD	range	M \pm SD	range	M \pm SD	range
Triceps SF	14.3 \pm 5.2	6.0–35.5	14.5 \pm 4.8	6.9–23.7	9.2 \pm 4.2	3.2–30.0	8.5 \pm 2.6	3.6–15.1
Subscapular SF	13.7 \pm 5.3	5.4–34.5	12.9 \pm 3.9	7.5–21.4	10.6 \pm 3.4	5.0–26.5	10.4 \pm 2.6	6.5–18.3
Supraspinal SF	12.5 \pm 5.4	5.0–35.0	12.8 \pm 3.5	7.2–19.8	9.2 \pm 4.6	4.0–31.3	9.1 \pm 3.4	3.7–18.8
Calf SF	13.4 \pm 6.5	4.0–41.5	14.6 \pm 5.7	4.5–24.1	9.2 \pm 4.5	3.0–28.5	8.7 \pm 3.0	4.5–16.0
Flexed arm G	28.6 \pm 2.7	23.0–38.0	29.0 \pm 2.4	25.4–33.5	33.5 \pm 2.9	26.5–45.5	33.8 \pm 30	29.0–40.5
Calf G	36.3 \pm 4.0	25.0–62.0	36.7 \pm 2.2	32.0–42.0	37.5 \pm 2.6	26.5–46.5	37.8 \pm 2.0	32.1–41.9
Humerus B	6.3 \pm 0.5	5.2–8.2	6.3 \pm 0.4	5.2–7.0	7.2 \pm 0.5	5.8–9.2	7.1 \pm 0.5	5.7–8.5
Femur B	9.0 \pm 0.6	7.5–11.5	9.0 \pm 0.5	8.4–9.9	9.6 \pm 0.6	8.0–11.4	9.6 \pm 0.6	8.3–10.8
HWR	42.2 \pm 1.7	37.9–45.3	42.1 \pm 1.7	39.2–45.8	42.7 \pm 1.6	37.5–46.8	42.3 \pm 1.2	40.1–46.1
BMI	22.5 \pm 2.8	18.0–30.4	22.7 \pm 2.4	18.3–27.1	23.3 \pm 2.5	17.9–34.5	24.0 \pm 1.8	18.9–28.0
% Fat	26.2 \pm 3.3	20.7–35.7	26.4 \pm 2.9	21.2–31.7	16.6 \pm 3.4	9.7–41.5	17.1 \pm 2.3	10.8–22.0
Endomorphy	4.08 \pm 1.3	1.7–7.9	4.09 \pm 1.0	2.5–5.6	2.71 \pm 1.0	1.2–6.9	2.62 \pm 0.7	1.3–4.3
Mesomorphy	4.03 \pm 1.4	1.6–8.7	4.12 \pm 1.1	1.5–6.1	4.81 \pm 1.3	1.6–9.0	4.74 \pm 1.2	2.3–7.3
Ectomorphy	2.36 \pm 1.1	0.1–4.6	2.26 \pm 1.3	0.2–5.0	2.72 \pm 1.0	0.1–5.7	2.40 \pm 0.9	0.9–5.1

M – mean, SF – skinfold, G – girth, B – breadth, HWR – height-weight ratio.

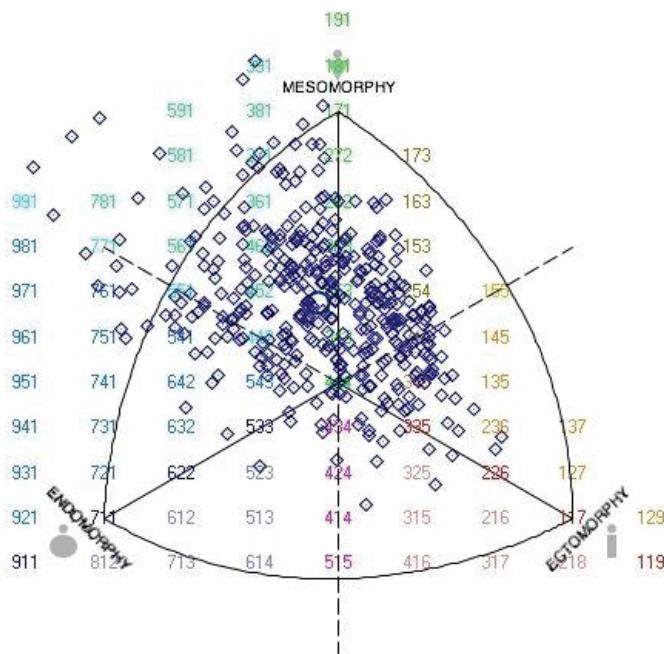
The analysis of values in terms of somatic build of students from Jozef Pilsudski University of Physical Education in Warsaw (Figure 1) depending on the field of study revealed that both physical education (PE) students and sport (S) students had endo-mesomorphic body build (3.08-4.6-2.62 and 3.0-4.58-2.37, respectively; the values represent endomorphy, mesomorphy and ectomorphy components). Compared to S students, significantly ($p < 0.05$) higher values (by 10.5%) of the ectomorphy component were found in PE students (Figure 1).



Significant differences between PE and S students (ectomorphic): * $p < 0.05$; the squares are individual somatotypes, and the circle is the mean profile.

Figure 1. Somatocharts of study participants according to a study course and gender

The anthropometric measurements were used to identify the somatotypes of all first-year students. Mean somatotype was defined by code 3.06-4.59-2.57 (Figure 2), which corresponds to the endo-mesomorphic type. Female PE students had meso-endomorphic somatotype (4.08-4.03-2.36). The same type was observed in female S students.



The squares are individual somatotypes, and the circle is the mean profile.

Figure 2. Somatotype distribution for students from the University of Physical Education in Warsaw

In the case of male participants, both PE and S students had balanced mesomorphic body build (2.71-4.81-2.72) (Figure 1). No significant differences were revealed in values of other variables (body fat percentage, BMI and anthropometric features) depending on the university course.

Discussion

Body build and somatotype represent one of the basic biometric human features. In the context of physical activity and performance in different sports (as is the case with university students of sport-related courses), body build is extremely important in terms of movement efficiency and technique. Some studies conducted in various countries (Maaroos, Landor, 2001; Nikbakht, 2011) and in Poland have focused on determining characteristics of body build and somatotypes (often in relation to health status) typical of university students of sport-related courses (Mleczko, Januszewski, 2009; Pasiut, 2012). The present study of students from Jozef Pilsudski University of Physical Education in Warsaw revealed that the most common somatotype was 3.08-4.6-2.62. In this somatotype, the mesomorph component prevailed, endomorphy was on an average level, and there was a small component of ectomorphy, i.e. body build was muscular rather than round, slim or fragile. This type is often characterized as really plastic and responding well to physical exercise (both strength and endurance exercise). The smallest ectomorphy component may be due to the fact that during studying, students are involved more in general training than that focused on aesthetics and technique, with slender body build found in selected athletes. A review of studies

on university students of sport (Table 3) demonstrated correlations similar to those obtained in the present study. Somatic characteristics are determined by the field of study.

Table 3. Somatotypes of students noted in other studies

Study	Group	n	Endo	Meso	Ecto
N. Saritas et al. (2010)	Erciyes University, Turkey, males	61	4.03	4.44	2.98
	Erciyes University, Turkey, males	137	2.84	5.25	2.68
M. Nikbakht (2011)	Tehran University, Iran, males	45	6.95	3.01	2.28
R. Tzarova (2013)	Technical University, Sofia, Bulgaria	49	0.2	3.3	3.0
M.M. Brničević et al. (2014)	University of Split, females	115	4.56	3.55	2.86
A. Khasawneh (2015)	PE students, females, Jordan	27	6.0	2.7	1.8
	PE students, males, Jordan	44	4.3	2.6	2.8
M. Phaswana et al. (2015)	University of Venda, RSA, females and males	118	3.94	4.52	1.72
S. Saha (2015)	PE students in India	250	2.86	4.67	3.85

The study on PE students from Sports College of Erciyes University (Saritas, Özkarafaki, Pepe, Büyükkipekçi, Çoksevim, 2010) revealed significantly greater mesomorphy among young female and male students of sport-related courses compared to those from other faculties; however, the percentage of the ectomorph component was similar. National studies focused on the assessment of the biological state of male and female PE students compared to students of other faculties from the biggest state universities in Krakow (Pasiut, 2012). It was noted that PE students had significantly lower levels of body fat, which may result in a lower risk of cardiovascular diseases, obesity, diabetes or osteoporosis at a later age. Energy expenditure due to physical activity in young women significantly determines body mass and body fat, which highlights the role of physical activity in reducing obesity and its health consequences (Ekelund et al., 2005; Tjønna et al., 2008). Less active women are characterized by the highest levels of body fat and the lowest levels of lean body mass. The most active women are the most muscular and display the lowest levels of body fat (Hickner et al., 2001; Stachoń, Pietraszewska, Burdukiewicz, Andrzejewska, 2013). The findings of the study conducted by A. Stachoń et al. (2013) on female students from the University of Physical Education in Wrocław indicated that body fat percentage depends on the intensity of physical activity. Students who declared high-intensity physical activity had lower values of body fat percentage than their peers who performed moderate- and low-intensity physical activity (Stachoń et al., 2013). Mean value of body fat percentage in female students who participated in the present study was 20.3%, whereas this value in their peers from Rzeszow was 22.6% (Barabasz, Zadarko, 2010).

In the case of female students from the University of Physical Education in Warsaw declaring low and high levels of energy expenditure, mean values of body fat percentage were 24.7% and 23.2%, respectively (Czajkowska, Mazurek, Lutosławska, Żmijewski, 2010). Correlations between total body fat and subcutaneous fat were investigated by P.J. Teixeira et al. (Teixeira, Sardinha, Going, Lohman, 2001). Studies conducted by other researchers also revealed that women who declared high levels of physical activity (at least four times a week, one hour each time) displayed lower levels of subcutaneous fat. They also had a significantly lower thickness of subscapular, triceps, supraspinal, calf and abdominal skinfolds (Alizadeh et al., 2013; Kromhout, Bloemberg, Seidell, Nissinen, Menotti, 2001; Stachoń et al., 2013). These studies also confirmed women's tendency to reduce skinfolds together with an

increase in physical activity. There are examples in the literature of results of body skinfolds measurements highly correlated with the results of total body fat measurements (expressed in percentage values) (Teixeira et al., 2001).

The findings of the study carried out by U. Pasiut (2012) on a large random sample seem to confirm correlations between body build and functional indices of PE students showing their better physical performance. This appears to result from selection and lifestyle-related differences, particularly in the levels of physical activity connected with their university and sports university curricula.

Various studies have demonstrated a common tendency for more healthy body build and body composition found among students of sports universities and universities associated with broadly understood physical activity. Difficulties in performing comparative analyses of studies on somatic build may stem from applying different measurement methods (anthropometric measurement vs. analysis using body composition analysers) and different body build typologies (Heath-Carter and Wanke or Kretschmer). Such difficulties result mainly from measurement inaccuracy.

In the case of the present study, further research is needed due to some limitations. No analysis was carried out regarding factors such as motor abilities or information about previous physical activity (performed before university education) that may have involved sports training.

Different body build types can be observed in strength, endurance, technical or aesthetic sports. Students attending sports-related courses constitute a selected group as the majority of them have been physically active before. A multi-disciplinary analysis performed on a more heterogeneous sample within a longitudinal study would provide a full picture of the examined issues.

Conclusions

First-year students of the Jozef Pilsudski University of Physical Education in Warsaw from both PE and S groups were characterized by endo-mesomorphic somatotype. S students had significantly lower values of the ectomorphy component compared to PE students. The results revealed the need for more research into the somatic build of students of physical education, taking into account the changes in their living conditions (including socio-economic environment), since graduates are expected to promote physical activity in the future. It is also necessary to carry out identical research at the end of studies in order to evaluate the effect of university curricula on the somatic build of students.

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EVALUATION OF THE RELATIONSHIP OF THE CLIMBING LEVEL OF SPORT CLIMBERS WITH SELECTED ANTHROPOMETRIC INDICATORS AND DIET COMPOSITION

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Abstract Climbing is becoming more and more popular. During 2020 Olympic Games this discipline will be competed for the first time. Individualized diet plays a significant role among representatives of all sport disciplines. The aim of this research was to evaluate the correlation between the level of advancement of sport climbers, selected anthropometric indicators and diet composition. The study involved 36 women and 65 men practicing sport climbing who completed the food record and the survey on the most difficult climbing routes completed. Anthropometric measurements were collected. In the group of men statistically significant, positive correlation between the climbing level and the diet content of fiber, vitamin E, potassium, iron, zinc, and copper, was observed. In the group of women, a statistically significant positive correlation between the climbing level and the participation of vitamin C, potassium, magnesium and copper in the diet was observed. There was a positive correlation of protein, vitamin B2, B6, B12, D, phosphorus, magnesium, iron and copper content, and negative correlation between SFA content per 1,000 kcal of the diet and the climbing level of study participants. No statistical correlation was found between anthropometric parameters and advancement level.

Key words sport climbing, nutrition, exercise, sports

Introduction

Sport climbing has become one of the most popular extreme sports worldwide (Ginszt, Goniewicz, Ginszt, 2012). The increasing interest in this form of physical activity has made it an Olympic sport from 2020 on; it will consist of three disciplines: bouldering, speed climbing and lead climbing in a combined format (Lutter, El-Sheikh, Schöffl, Schöffl, 2017).

Bouldering and lead climbing are the most frequently practiced disciplines. Bouldering is climbing up short (usually 4–5 m) technical route, with mats on the ground for safety. Lead climbing is a discipline based on leading

long routes (usually 20–40 m) with the use of rope and quickdraws clipped to bolts placed in the rock or an artificial wall underneath (Ginszt et al., 2018).

According to the sports classification, climbing is categorized as a “complex sport” (Stanković, Joksimović, Aleksandrović, 2011). Because of the dynamics of the climber’s activity and the energetic work of the muscles used, this discipline has aerobic and anaerobic features (Verhosanski, Šestakov, Novikov, Nićin, 1992). An individual nutrition plan, matched with the specificity of training, increases the climber’s training capabilities, in addition to minimizing the risk of injury (Neufeld, Meyers, 2018).

Scientific studies involving this group of athletes have so far focused on the physiology of effort (Bertuzzi, Franchini, Kokubun, 2007), strength, and tension of the forearms and fingers (Vigoroux, Quaine, Labarre-Vila, Moutet, 2006) in comparison to the incidence of injuries (Neuhof, Hennig, Schöffl, Schöffl, 2011). The research carried out so far has also focused on determining the anthropometric parameters characteristic for the representatives of this discipline, such as percentage of fat tissue, muscle mass content and hand grip strength to body-weight ratio (Miadenov, Michailov, Schöffl, 2009). There are no studies that aimed to assess the nutritional habits of sport climbers in regard to their level of advancement and to identify the individualized nutritional needs of representatives of this discipline.

The aim of this research was to evaluate the correlation between the level of advancement of sport climbers, selected anthropometric indicators and diet composition.

Material and methods

The study was carried out in 2016–2017. The data was collected during the Academic Championships of Poland in Sport Climbing, taking place in Sosnowiec, and in the climbing gyms located in Wrocław. This study was approved by the Ethics Committee of Wrocław Medical University. All of the participants have given their informed consent for participation in the research study.

The study involved 101 individuals practicing sport climbing: 36 women and 65 men, 16 to 46 years old, with a climbing level assessed in accordance with the French scale from 5 to 8b+. The French scale uses numbers from 1 to 9, letters a, b and c, and plus (+) sign to grade the degree of difficulty of sport climbing routes, where the lowest numbers mean more difficult walks and the highest mean the hardest climbing routes done so far.

The criterion to qualify for the study was the declaration that sport climbing has been a regular form of physical activity for more than a year. The exclusion criterion from the study was the declaration of only an episodic training on the climbing wall treated as an additional, recreational form of physical activity.

Diet of study participants was evaluated on the basis of a three-day food recording of ordinary period that the subjects filled at home and sent via email. In order to clarify the amount of the consumed portion of the product, the participants received a list of graphic icons of household measures such as teaspoon, spoon, bowl, flat plate, deep plate, mug and glass.

The analysis of the subjects’ menu was made using the ESHA Food Processor program with Polish database (Kunachowicz, Nadolna, Przygoda, Iwanow, 2005). The content and percentage of nutrients (protein, carbohydrates, fat) and water in the studied diets, as well as the content of selected vitamins (A, D, E, C, B1, B2, B6, B12, folic acid), minerals (calcium, iron, copper, phosphorus, magnesium, zinc, iodine), and electrolytes (sodium, potassium), were calculated (Table 1, Table 2).

In addition to the food record, the subjects were asked to complete a survey on the frequency of training and the most difficult climbing routes completed. On the basis of the grade of the most difficult boulder or leading route completed, the participants were assigned to the test groups (Haciski, 2013).

Anthropometric measurements included: body weight, height, the percentage of adipose tissue and water, lean body mass, bone mass, the estimated value of Basic Metabolism Rate (BMR), and the index of visceral tissue in the body (Table 3). Anthropometric measurements of the subjects were collected using the TANITA HR-001 model and the TANITA BC 545 body composition analyzer.

The waist and hip circumferences were measured using a standard measuring tape with an accuracy of 1 cm. The waist was measured halfway between the upper part of the hip bone and the lower curve of the rib. The hip circumference was measured at the widest point below the hip plates, on the buttocks bulge.

The analysis of the obtained data allowed the assessment of the nutritional status of the tested climbers.

The participants of the study were divided into four groups (beginner-intermediate group and an advanced group for each gender) depending on their climbing level and sex in order to determine the correlation between the climbing level, the proportion of macroelements and micronutrients in the diet, and the value of anthropometric measurements. The beginner-intermediate group comprised people whose climbing level, according to the French scale, was between 5a to 6c+, to the advanced group comprised subjects whose climbing level on the French scale was between 7a to 8b+.

In order to investigate the correlation between the climbing level with the content of macroelements and micronutrients in the diet per 1,000 kcal of the daily food ration, participants were assigned to one of four groups (beginner group, intermediate group, advanced group and elite) depending on the climbing level. Beginner group included participants whose climbing level expressed in the French scale was between 5a to 6a+, intermediate for 6b to 6c+, advanced for 7a to 7b+, and elite for 7c to 8b+.

Statistical analysis

The statistical analysis of the results was carried out in the STATISTICA 13.1 computer program (StatSoft Inc., USA). The statistical significance level for all analyses was established at $p < 0.05$. The Spearman rank correlation test was used to assess the relationship between the climbing level of the subjects, the value of anthropometric measurements, participation in the energy diet of macroelements, and the content of vitamins and minerals in the diet. The strength of correlation compounds was assessed as trivial (0–0.19), small (0.20–0.49), medium (0.50–0.79) and large (0.80 and greater) (Cohen, 1992).

Results

Table 1 presents a comparison of the content of macro- and micronutrients in the diet of the participants based on their climbing level. In the group of men, a statistically significant positive correlation between the climbing level and the diet content of fiber ($r = 0.35$), vitamin E ($r = 0.25$), potassium ($r = 0.25$), iron ($r = 0.32$), zinc ($r = 0.25$), and copper ($r = 0.32$) was observed. In the group of women, a statistically significant positive correlation between the climbing level and the participation of vitamin C in the diet ($r = 0.38$), potassium ($r = 0.38$), magnesium (0.38) and copper ($r = 0.4$) was observed.

Table 1. Comparison of macro- and microelements content in the diet of the studied men and women depending on their climbing level

Component	Men			Women				
	beginner-intermediate group (n = 30)		advanced group (n = 35)	r	beginner-intermediate group (n = 22)		advanced group (n = 14)	r
	x ± SD	x ± SD	x ± SD		x ± SD	x ± SD	x ± SD	
Energy (kcal)	2543.0 ±565.9	2720.3 ±741.7	0.08	1882.3 ±402.9	1953.40 ±402.9	0.05		
Protein (g)	110.8 ±34.7	125.7 ±49.6	0.15	71.6 ±17.5	74.41 ±17.5	0.10		
Protein (g · kg⁻¹ BW · day⁻¹)	1.6 ±0.5	1.74 ±0.6	0.14	1.3 ±0.3	1.3 ±0.42	0.05		
Carbohydrates (g)	311.5 ±80.5	332.6 ±87.5	0.15	254.7 ±59.0	270.99 ±59.0	0.11		
Carbohydrates (g · kg⁻¹ BW · day⁻¹)	4.4 ±1.2	4.6 ±1.3	0.12	4.6 ±1.2	4.7 ±1.4	0.03		
Fibre (g)	27.1 ±13.4	33.2 ±11.4	*0.35	27.3 ±11.4	30.1 ±11.4	0.24		
Lactose (g)	15.5 ±16.4	12.3 ±8.4	-0.02	10.0 ±6.2	8.3 ±6.2	-0.18		
Fat (g)	100.9 ±36.5	107.5 ±46.5	0.04	72.9 ±20.6	70.1 ±20.6	-0.05		
Fat (g · kg⁻¹ BW · day⁻¹)	1.4 ±0.5	1.48 ±0.6	0.03	1.3 ±0.4	1.2 ±0.5	-0.08		
SFA (g)	36.3 ±10.9	37.0 ±18.0	-0.06	27.1 ±9.6	24.7 ±9.6	-0.07		
MUFA (g)	37.5 ±15.4	40.7 ±19.9	0.07	25.3 ±8.2	24.9 ±8.2	-0.07		
PUFA (g)	16.9 ±9.6	18.7 ±9.8	0.12	12.9 ±5.7	13.2 ±5.7	0.07		
Cholesterol (mg)	421.4 ±203.5	552.7 ±431.4	0.13	247.7 ±160.6	231.3 ±160.6	-0.07		
Water (g)	3052.8 ±1225.3	3019.5 ±922.4	0.00	2485.8 ±703.3	2887 ±725.0	0.10		
Vitamin A (mcg)	1458.3 ±1098.2	1617.2 ±1594.5	0.07	1359.4 ±857.7	1621.2 ±857.7	0.23		
Vitamin B1 (mg)	1.5 ±0.6	1.8 ±0.8	0.20	1.2 ±0.3	1.5 ±0.6	0.23		
Vitamin B2 (mg)	2.4 ±1	2.7 ±1.2	0.16	1.7 ±0.5	1.9 ±1.8	0.14		
Vitamin B6 (mg)	2.5 ±0.9	2.9 ±1.2	0.16	1.9 ±0.7	2.4 ±0.7	0.26		
Vitamin B12 (mcg)	5.9 ±3.9	7.35 ±4.61	0.17	3.2 ±2.3	3.89 ±2.33	0.13		
Vitamin C (mg)	123.5 ±90.6	150.8 ±81.3	0.21	130.9 ±78.2	185.4 ±78.2	*0.38		
Vitamin D (mcg)	3.7 ±3.3	5.3 ±4.4	0.24	3.0 ±2.7	4.2 ±2.7	0.12		
Vitamin E (mg)	13.0 ±5.1	16.5 ±8.0	*0.25	10.7 ±3.7	11.4 ±3.6	0.05		
Folate (mcg)	422.6 ±204.5	467.6 ±174.5	0.15	357.9 ±122.8	386.7 ±122.8	0.23		
Sodium (mg)	2757.0 ±1134.0	2886.0 ±1368.5	0.03	1869.1 ±760.4	1472.9 ±760.4	-0.26		
Potassium (mg)	3971.6 ±1293.5	4484.9 ±1212.9	*0.25	3328.6 ±935.8	4000.0 ±935.8	*0.38		
Calcium (mg)	1309.89 ±618.73	1227.7 ±426.0	-0.02	896.8 ±315.6	900.1 ±315.6	0.02		
Phosphorus (mg)	1874.4 ±586.1	2117.6 ±799.1	0.17	1253.5 ±311.9	1419.0 ±311.9	0.32		
Magnesium (mg)	469.7 ±158.3	553.3 ±210.3	0.17	352.1 ±95.9	447.9 ±95.9	*0.38		
Iron (mg)	15.42 ±5.00	19.6 ±7.5	*0.32	13.1 ±4.2	14.6 ±4.2	0.24		
Zinc (mg)	13.4 ±4.3	15.9 ±6.4	*0.25	9.7 ±2.4	10.5 ±2.4	0.12		
Copper (mcg)	1.8 ±0.8	2.3 ±1.0	*0.32	1.5 ±0.5	2.1 ±0.5	*0.40		
Manganese (mg)	7.5 ±5.0	8.0 ±5.4	0.11	5.9 ±2.3	6.3 ±2.3	0.13		
Iodine (mcg)	66.5 ±59.6	65.1 ±33.0	0.12	38.9 ±17.4	49.4 ±17.4	0.16		

* Statistical significance if p < 0.05.

r – Spearman's range correlation coefficient; x – the arithmetic mean; SD – Standard Deviation; SFA – saturated fatty acids; MUFA – monounsaturated fatty acids; PUFA – polyunsaturated fatty acids.

Table 2 presents the comparison of the content of macro- and micronutrients per 1,000 kcal in the diet of the studied women and men depending on the level of climbing declared. There was a statistically significant positive correlation of protein content ($r = 0.22$), vitamin B2 ($r = 0.23$), vitamin B6 ($r = 0.2$), vitamin B12 ($r = 0.21$), vitamin D ($r = 0.21$), phosphorus ($r = 0.25$), magnesium ($r = 0.24$), iron (0.21) and copper ($r = 0.23$), as well as a statistically

significant negative correlation between saturated fatty acids content ($r = -0.22$) and the climbing level of study participants.

Table 2. Comparison of nutrients, vitamins and minerals per 1,000 kcal of the diet of the studied men and women depending on their climbing level

Component	Beginner group (n = 12)	Intermediate group (n = 40)	Advanced group (n = 35)	Elite group (n = 14)	r
	$\bar{x} \pm SD$	$\bar{x} \pm SD$	$\bar{x} \pm SD$	$\bar{x} \pm SD$	
Energy (kcal)	2,311.6 ±454.9	2,249.0 ±638.9	2,545.2 ±848.4	2,391.2 ±426.4	0.11
Protein (g)	37.2 ±5.0	42.61 ±8.81	42.3 ±10.7	47.6 ±9.6	*0.22
Carbohydrates (g)	127.3 ±18.7	128.8 ±18.5	128.2 ±25.0	130.4 ±17.7	0.06
Fibre (g)	13.8 ±6.9	12.0 ±4.4	13.4 ±4.6	13.8 ±3.5	0.17
Lactose (g)	4.4 ±2.8	6.0 ±4.9	4.6 ±3.5	4.6 ±4.2	-0.11
Fat (g)	42.3 ±7.3	37.9 ±7.3	39.0 ±8.9	34.7 ±6.7	-0.17
SFA (g)	14.5 ±2.9	14.2 ±3.2	13.6 ±4.3	11.9 ±4.1	*-0.22
MUFA (g)	16.2 ±3.8	13.3 ±3.5	14.7 ±4.2	12.4 ±3.7	-0.09
PUFA (g)	7.8 ±3.2	6.2 ±2.4	7.01 ±2.51	6.1 ±2.4	-0.02
Cholesterol (mg)	141.8 ±90.2	151.6 ±58.9	164.9 ±118.4	194.9 ±93.5	0.10
Water (g)	1,240.5 ±231.8	1,257.7 ±436.5	1,258.5 ±503.9	1,277.9 ±331.9	0.00
Vitamin A (mcg)	581.1 ±273.3	652.0 ±431.7	720.1 ±798.2	636.9 ±492.7	-0.01
Vitamin B1 (mg)	0.7 ±0.1	0.6 ±0.2	0.68 ±0.2	0.74 ±0.2	0.16
Vitamin B2 (mg)	0.8 ±0.2	0.9 ±0.2	1.0 ±0.3	1.1 ±0.3	*0.23
Vitamin B6 (mg)	1.0 ±0.2	1.0 ±0.3	1.1 ±0.34	1.3 ±0.4	*0.20
Vitamin B12 (mcg)	1.7 ±1.0	2.1 ±1.2	2.4 ±2.0	3.0 ±1.7	*0.21
Vitamin C (mg)	75.5 ±44.8	52.9 ±35.4	69.1 ±42.0	72.7 ±41.9	0.10
Vitamin D (mcg)	1.5 ±1.1	1.5 ±1.3	1.7 ±1.7	2.9 ±2.2	*0.21
Vitamin E (mg)	5.9 ±1.6	5.23 ±1.8	6.2 ±2.1	5.6 ±2.5	0.08
Folate (mcg)	181.9 ±68.1	178.2 ±69.3	175.7 ±56.2	203.5 ±73.7	0.07
Sodium (mg)	994.2 ±350.6	1,043.4 ±293.4	985.8 ±367.2	964.1 ±515.5	-0.10
Potassium (mg)	1,725.3 ±387.7	1,645.6 ±419.7	1,772.7 ±471.1	1,891.3 ±433.2	0.18
Calcium (mg)	418.3 ±101.6	528.8 ±194.2	478.3 ±111.8	413.8 ±75.4	-0.07
Phosphorus (mg)	644.8 ±106.1	729.7 ±135.9	754.0 ±153.9	800.5 ±177.8	*0.25
Magnesium (mg)	181.4 ±43.3	188.7 ±44.5	213.6 ±64.7	220.0 ±51.6	*0.24
Iron (mg)	7.1 ±1.9	6.3 ±1.4	7.2 ±1.7	7.7 ±2.0	*0.21
Zinc (mg)	5.2 ±0.8	5.3 ±1.1	5.6 ±1.3	6.0 ±1.5	0.19
Copper (mcg)	0.8 ±0.3	0.7 ±0.2	0.9 ±0.3	1.0 ±0.3	*0.23
Manganese (mg)	3.1 ±1.3	3.0 ±1.7	3.1 ±1.7	3.1 ±1.1	0.05
Iodine (mcg)	21.0 ±11.5	25.4 ±20.2	23.9 ±15.6	30.6 ±15.5	0.14

* Statistical significance if $p < 0.05$.

r – Spearman's range correlation coefficient; \bar{x} – the arithmetic mean; SD – Standard Deviation.

Table 3 presents the comparison of the values of anthropometric parameters of the participants depending on their climbing level. Male participants who belonged to the advanced group were characterized by higher values of the parameters of: body mass, percentage of water in the body and lean body mass, while lower value of the index of visceral tissue content, and a lower percentage of fat in the body in comparison with men from the beginner-intermediate group. Among the women in the advanced group, there was a higher value of various parameters such

as: body weight, percentage of fat in the body, index of visceral tissue content; while the percentage of water in the body was lower as compared to the beginner-intermediate group. In both groups – women and men – participants from the advanced group were characterized by a higher average BMI, compared to participants in the beginner-intermediate group.

Table 3. Comparison of the values of anthropometric parameters of the studied women and men depending on their climbing level

Parameter	Men			Women			
	beginner-intermediate group (n = 30)		advanced group (n = 35)	r	beginner-intermediate group (n = 22)		r
	x ± SD	x ± SD	x ± SD		x ± SD	x ± SD	
Age	26.2 ± 4.8	27.8 ± 6.1	0.08	25.4 ± 4.0	25.4 ± 3.5	-0.01	
Height (m)	1.8 ± 0.1	1.8 ± 0.1	0.01	1.7 ± 0.1	1.66 ± 0.05	0.07	
Waist circumference (cm)	78.5 ± 4.5	79.4 ± 4.2	0.13	69.0 ± 5.4	69.39 ± 3.90	0.21	
Hip circumference (cm)	94.8 ± 5.1	95.6 ± 5.5	0.12	89.4 ± 5.6	89.4 ± 8.0	0.1	
Fat percentage (%)	12.9 ± 11.6	10.0 ± 3.6	-0.14	19.3 ± 5.3	20.7 ± 3.3	0.17	
Body weight (kg)	71.1 ± 6.2	72.4 ± 7.5	0.12	56.3 ± 6.5	58.2 ± 5.3	0.16	
Basal Metabolic Rate (kcal)	1,847.9 ± 165.6	1,840.4 ± 378.2	0.12	1,300.5 ± 301.1	1,307.9 ± 353.0	0.13	
Water percentage (%)	64.1 ± 4.0	65.3 ± 3.5	0.14	60.0 ± 4.6	58.7 ± 2.7	-0.16	
Visceral fat tissue indicator	1.9 ± 1.2	1.7 ± 1.2	-0.05	1.3 ± 0.6	1.4 ± 0.9	0.07	
Bone mass (kg)	3.2 ± 0.3	3.3 ± 0.3	0.16	2.31 ± 0.23	2.3 ± 0.2	0.08	
Fat-free body mass (kg)	60.1 ± 5.8	62.0 ± 6.9	0.19	43.01 ± 4.45	43.7 ± 3.5	0.06	
BMI (kg/m ²)	22.9 ± 1.8	23.1 ± 1.7	0.03	19.73 ± 4.79	21.0 ± 1.3	0.14	
WHR	0.8 ± 0.1	0.8 ± 0.04	0.08	0.8 ± 0.1	0.8 ± 0.1	-0.11	

r – Spearman's rank correlation coefficient; x – the arithmetic mean; SD – Standard Deviation.

Table 4 presents the comparison of micro- and macroelements recommendations realization in the diet of the participants based on their climbing level. Among all participants deficient intake of vitamin D and iodine was observed. Dietary supply of the rest of vitamins and minerals was sufficient for AI or EAR recommendation level. In the diets of both male and female participants, the supply of phosphorus, copper and manganese has been exceeded. High intake with the diet of vitamin A among studied climbers was observed. Also, high intake of vitamin B12 with the diet among male climbers was recorded.

Table 4. Comparison of the implementation of the recommendation for micro- and macro elements in the diets of the studied women and men depending on the climbing level

Component	Men						Women				
	EAR	beginner-intermediate group	percent recom- men-dation reali-zation	advanced group	percent recom- men-dation reali-zation	EAR	beginner-intermediate group	percent recom- men-dation reali-zation	advanced group	percent recom- men-dation reali-zation	
1	2	3	4	5	6	7	8	9	10	11	
Vitamin A (mcg)	630.0	1,458.30	231	1,617.10	257	530.0	1,359.4	257	1,621.20	306	
Vitamin B1 (mg)	1.1	1.50	138	1.80	166	0.9	1.2	129	1.50	161	
Vitamin B2 (mg)	1.1	2.40	215	2.70	246	0.9	1.7	183	1.90	211	

1	2	3	4	5	6	7	8	9	10	11
Vitamin B6 (mg)	1.1	2.50	227	2.90	261	1.1	1.9	173	2.40	215
Vitamin B12 (mcg)	2.0	5.90	295	7.40	368	2.0	3.2	161	3.90	195
Vitamin a C (mg)	95.0	123.50	130	150.80	159	70.0	130.9	187	185.43	265
Vitamin D (mcg)	15.0*	3.69	24	5.30	36	15.0*	3.0	20	4.20	28
Vitamin E (mg)	12.0*	13.00	108	16.50	138	10.0*	10.7	107	11.40	114
Folate (mcg)	320.0	422.60	132	467.60	146	320.0	357.9	112	386.70	121
Sodium (mg)	1,500.0*	2,757.00	184	2,886.00	192	1,500.0*	1,869.1	125	1,472.90	98
Potassium (mg)	3,500.0*	3,971.60	113	4,484.90	128	3,500.0*	3,328.6	95	4,000.00	114
Calcium (mg)	800.0	1,309.90	164	1,227.70	155	800.0	896.8	112	900.10	113
Phosphorus (mg)	580.0	1,874.40	323	2,117.60	365	580.0	1,253.5	216	1,419.00	245
Magnesium (mg)	350.0	469.70	134	553.32	158	265.0	352.1	133	447.90	169
Iron (mg)	6.0	15.40	257	19.60	327	8.0	13.1	163	14.60	182
Zinc (mg)	9.4	13.40	143	15.90	169	6.5	9.7	149	10.50	161
Copper (mcg)	0.7	1.80	257	2.30	329	0.7	1.5	217	2.10	293
Manganese (mg)	2.3*	7.50	324	8.00	350	1.8*	5.9	327	6.30	352
Iodine (mcg)	95.0	66.50	70	65.10	69	95.0	38.9	41	49.40	52

EAR – Estimated Average Requirement.

*AI – Adequate Intake.

Discussion

Despite the growing popularity of sport climbing and knowledge about the impact of proper nutrition on the effectiveness of training in the available literature, there is no research assessing the relationship between climbing level and nutritional status and nutritional intake. However, some researchers have assessed the nutritional intake and nutritional status of climbers.

In the study (Kemmler et al., 2006) involving 15 elite female athletes training sport climbing, a similar magnesium content was estimated (445.7 ± 103.3 vs. 447.86 ± 95.87 mg), iron (15.3 ± 4.6 vs. 14.85 ± 4.18 mg), vitamin B1 (1.31 ± 0.31 vs. 1.89 ± 0.54 mg), vitamin C (154.6 ± 87.8 vs. 185.45 ± 78.19 mg) in their diets, as in the diets of climbers in the advanced group from own study. However, the diets of climbers from the own study were characterized by a lower content of calcium ($1,223 \pm 421$ vs. 900.06 ± 315.7 mg) and phosphorus ($1,630 \pm 504$ vs. 1418 ± 311.85 mg). These minerals in the study of W. Kemmler et al. (2006) were evaluated as correlating with bone density, an important parameter in injury-prone sports, such as climbing. Diets of women from the advanced group contained significantly more vitamin D (4.18 ± 2.72 vs. 1.69 ± 0.6 mcg) and potassium ($4,000.00 \pm 935.84$ vs. $3,603 \pm 1,025$ mg). In the W. Kemmler et al. study, there were no significant differences in the nutrient content of the diets between the test group and the control group, consisting of women of similar age and BMI, but with much lower physical activity. In contrast to our own study, in which lower vitamin C, Mg, K content in the diet correlated with a lower advancement level.

In another study (Pilis et al., 2014) evaluating the nutritional contents in the diet of weightlifters, in which anaerobic work prevails, the content of micronutrients – zinc and copper – were estimated. In own study, zinc and copper content in the diet correlated with a higher level of climbing. With a similar average energy value of powerlifter diets and diets of people from the group of advanced climbers (2,720.3 kcal vs. 3,327 kcal), a higher content of Zn (13.02 vs. 15.9 mg) and Cu (1.4 vs. 2.3 mg) were observed in the diets of people training climbing.

In the study by K. Pilis et al., in contrast to our results, there were no significant correlations between the content of zinc and copper in the diet and the level of physical activity in the studied group. Similar content of Cu (1,874 mcg) and Mn (3,200.2 mg), with a similar energy value of the diet (2,215.2 kcal) as in this study, was estimated in another group of athletes practicing sports characterized by anaerobic efforts (judo and sprint) (Maynar et al., 2018).

In the study by W. Kozirok and E. Babicz-Zielinska (2013), the water intake per day was assessed with particular emphasis on the time of training in the group of 396 athletes, including approximately 130 people training strength sports. Approximately 60% of the strength training participants reported consumption of nearly one to two liters of fluids during training. Both the diets of men and women from own study, regardless of the level of advancement, similarly to the athletes' diets assessed, were characterized by a high content of liquids, above two liters per day. Compared to the Czech climbers (Juriková, Alexová, Pluháčková, 2015) (9 women and 12 men), the group of Polish athletes had a higher percentage of diets that contained more than two liters of fluids a day (84 vs. 60%).

E.E. Neufeld and M.C. Meyers (2018), as in the own study, assessed the daily content of nutrients in a group of 50 rock climbers, based on the record of consumption from three days. The content of nutrients in the diets of women from own study (beginner-intermediate group and advanced group) and women practicing rock climbing did not meet the standards for vitamin D intake (respectively: 3.0, 4.2 and 3.8 vs. 15 mcg) and potassium (3,328.6, 4,000.0 and 1,992.2 vs. 4,700 mg). In own-study group, insufficient iodine content was additionally assessed (38.9, 49.4 vs. 95 mcg), which was not shown in the study by Neufeld and Meyers. In addition, the diets of women practicing rock climbing did not meet the standards for vitamin E (5.7 vs. 15.0 mg) and Mg intake (219.7 vs. 310 mg) and significantly exceeded the norm for the sodium content in the diet by approx. 80% (2,689.1 vs. 1,500 mg). In our own study only in the diets of participants classified into the beginner-intermediate group average sodium content exceeded this norm by 25% (1,869.1 vs. 1,500 mg).

The implementation of standards in both groups of men was similar. Insufficient content of nutrients concerned vitamin D (group of beginner-intermediate and advanced – 3.69, advanced group – 5.3, group of rock climbers – 3.5 ± 3.8 vs. 15 mcg), potassium (3,971.6; 4,448.9; 2,467.3 vs. 4,700 mg), and excessive sodium (2,757; 2,886.0; 2,658.5 vs. 1,500 mg), vitamin B2 (2.4; 2.7; 1.8 vs. 1.3 mg) and iron (15.4; 19.6; 16.2 vs. 8.0 mg). In the diets of men from our study, higher content of these nutrients and higher, excessive supply with the diet were estimated. Assessed sodium content was higher by 7% and 15%, in beginner-intermediate and advanced groups, respectively; the standard for vitamin B2 intake was exceeded by 46% and 79% and Fe content in advanced group exceeded recommendations by 43%.

In addition, male group diets from the E.E. Neufeld and M.C. Meyers (2018) study did not meet the established fiber recommendation (27.6 ± 12.3 vs. 38 g). Its content was similar to the average value of diets from the beginner-intermediate group from our study (27.1 ± 13.4 g), where the intake of this component positively correlated with the advancement level.

The content of macronutrients in the diet of athletes, i.e. proteins, fats and carbohydrates, is important in the development of muscle mass, increasing training efficiency and proper regeneration. In 2016, the Academy of Nutrition and Dietetics, Dietitians of Canada and American College of Sports Medicine indicated the intake of protein at $1.2\text{--}2 \text{ g} \cdot \text{kg}^{-1} \text{BW} \cdot \text{day}^{-1}$ and carbohydrates at $3\text{--}12 \text{ g} \cdot \text{kg}^{-1} \text{BW} \cdot \text{day}^{-1}$ as appropriate for athletes. Emphasizing that the higher level of their consumption should depend on the advancement, quantity, and quality of training (Thomas, Erdman, Burke, 2016). The authors of nutritional recommendation for practicing one of the climbing types – bouldering, proposed a slightly higher level of protein intake, i.e. $1.4\text{--}2 \text{ g} \cdot \text{kg}^{-1} \text{BW} \cdot \text{day}^{-1}$ for this

group of athletes (Smith, Storey, Ranchordas, 2017). Additionally, according to other researches results (Tipton, Jeukendrup, Hespel, 2007), consuming carbohydrates at the level of 5g / kg BW may be associated with the proper maintenance of glycogen stores in the muscles.

In our own study, only diets of men were characterized by such protein content per kilogram of body weight ($1.57\text{ g} \cdot \text{kg}^{-1} \text{BW} \cdot \text{day}^{-1}$ and $1.74\text{--}2\text{ g} \cdot \text{kg}^{-1} \text{BW} \cdot \text{day}^{-1}$). The diets of women contained approximately $1.3\text{ g} \cdot \text{kg}^{-1} \text{BW} \cdot \text{day}^{-1}$ protein. These contents did not exceed $2\text{ g} \cdot \text{kg}^{-1} \text{BW} \cdot \text{day}^{-1}$. Both diets of women and men, regardless of the climbing level, on average contain from about $4.4\text{ g} \cdot \text{kg}^{-1} \text{BW} \cdot \text{day}^{-1}$ to about $4.73\text{ g} \cdot \text{kg}^{-1} \text{BW} \cdot \text{day}^{-1}$ carbohydrates. In the advanced group, regardless of sex, higher average content of proteins and carbohydrates per kg body weight was assessed. The lower intake of protein in the studied climbers' diets, than the recommendations for bouldering (Smith et al., 2017), may result from the heterogeneity of the studied group in terms of training types of climbing, such as bouldering, lead climbing, speed, and the advancement level.

In addition, the content of macronutrients in diets may be the result of lower values of energy in diets of some climbers in relation to the total daily requirement. The authors of studies assessing the body composition and diets of people practicing climbing have been observing the use of energy-reduced diets in this group of athletes. In order to reduce the body fat percentage and improve the strength-to-weight ratio, athletes reduced energy supply, exposing themselves to nutritional deficiencies (Stanković, Ignjatović, Puletić, Raković, Mladenović Čirić, 2013). In addition, a significant majority of participants (about 98%) of their research did not practice climbing on a professional level, requiring extremely intensified training and resulting in the supply of protein and carbohydrates at the upper limits of the standards. Half of the participants were included in the beginner-intermediate group, therefore the average protein consumption at a low level in relation to the recommendations seems to be adequate to the level and advancement of training. In addition, climbers' expectations of maintaining low body mass and low body fat content, as well as avoiding excessive muscle hypertrophy, increasing their own weight, do not require increased protein supply to approx. $2\text{ g} \cdot \text{kg}^{-1} \text{BW} \cdot \text{day}^{-1}$. In addition to dietary proteins, athletes' diets contained smaller amounts of carbohydrates. Lower intake of protein with such a supply of calories and carbohydrates seems adequate, due to the possibility of muscle protein regeneration. Optimizing this process with a higher protein intake would require an increased supply of carbohydrates (Tipton et al., 2007).

In own study lower body fat content and BMI index characterized male climbers from advanced group compared to beginner-intermediate group. These results are similar to the research led by M.F. Novoa-Vignau, O. Salas-Fraire, K. Salas-Longoria, G. Hernández-Suárez, M. Menchaca-Pérez (2017), where differences between elite, recreational climbers and non-climbers group were observed. Similar fat content in advanced group of climbers were observed in research led by C. Mermier, J. Janot, D. Parker, J. Swan (2000) and W. Kemmler et al (2006), but participants of the other studies presented lower values such us 6.0 ± 0.9 (Sheel, Seddon, Knight, McKenzie, Warburton, 2003), 6.2 (Schöffl, Möckel, Köstermeyer, Roloff, Küpper, 2006) and 5.8 ± 1.8 (Michailov, Mladenov, Schöffl, 2009). In the advanced female group of climbers in our own study body weight, BMI value and fat content were higher compared to beginner-intermediate group. Those results are similar to those obtained in the research led by C. Mermier et al. (2000). In the study led by P. Watts, D. Martin, S. Durtschi (1993) and M. Michailov, L. Mladenov, I. Schöffl (2009), world class female boulderers characterized with much lower fat content (9.6 ± 1.9 and 16.6 ± 3.6 respectively). The participants of the studies where the fat content values were lower represented much higher level of advancement compared to the advanced group from the own study, which could be the reason for such differences. It is suggested that the performance in sport climbing is affected by many factors (Michailov,

Mladenov, Schöffl, 2009), so anthropometric parameters, such as fat content themselves, may not be the main determinant of the level of advancement in sport climbing.

Conclusions

The association between the level of advancement and the content of selected micro- and macronutrients in the diets of studied group of climbers was observed. The diets characterized with rather low intake of protein and carbohydrates compared to recommendations for athletes. That can be explained with overall low energy intake that is often practiced by sport climbing representatives to maintain low body weight. Further studies must be conducted to create nutritional recommendations specific for this discipline representatives. The anthropometric parameters differed between participants representing various level of advancement, but the differences were not statistically significant.

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THE GENESIS AND DEVELOPMENT OF POLISH EQUESTRIANISM IN THE INTERWAR PERIOD

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Abstract Although the traditions of equestrianism in Poland goes back a long way, it was not until 1880 that the first equestrian competitions were organized in Warsaw. In the following years, the interest of the Polish society in equestrian competition had been growing and led to the creation of equestrian-breeding associations, which actively conducted sports activities. However, it was Poland regaining independence in 1918 that enabled the dynamic development of Polish equestrianism, especially in military circles among cavalry and horse artillery officers.

The creation of the Polish Equestrian Association in 1928 had an undoubted impact on the popularization of equestrian sport among civilians. The Association became the organizer of many sports competitions for both military and civilian riders. Moreover, it undertook a number of initiatives aimed at the development and popularization of equestrianism in Polish society. Polish riders participated in the most important sports competitions organized in the interwar period, both in the country and internationally. They took part in the Olympic Games three times (1924, 1928 and 1936), in which they won four medals. Furthermore, they achieved success in equestrian competition around the world (the United States, Italy, France, the United Kingdom, Germany and others).

Key words equestrianism, show jumping, eventing, dressage, the Olympic Games

Introduction

After the war ended, equestrian sport quickly revived, especially in military circles such as cavalry and horse artillery, and aroused great interest among civilians. Associations that existed before the war resumed their activities, and numerous new organizations were also created. They had a regional character and dealt with the organization of equestrian competitions and hunting races, thus popularizing equestrian sport in society. Local associations conducted the competitions according to their own rules. The method of assessing competitors limited the ability to compare the skills of individual riders and the selection of the most talented of them, and, above all, hindered the selection of the national team from among competitors for competitions organized abroad in which Poles had participated since 1923 (*Przegląd Kawalerii i Broni Pancernej*, 1978a).

Establishment and activity of the Polish Equestrian Association

In order to further properly develop equestrian sport and its representation on the international arena, it was necessary to establish an organization that would bring together all equestrian associations and clubs existing in the country. On February 18, 1928, an organizational meeting was convened in Warsaw, during which representatives of 18 sports clubs adopted the statute and formed the Polish Equestrian Association (PZJ) (*Jeździec i Hodowca*, 1929). Col. Zbigniew Brochwickz-Lewiński was appointed the president and held this position throughout the interwar period (*Jeździec i Hodowca*, 1929).

The main objectives of the PZJ were: a) agreeing on the activities of all associations promoting equestrian sport in its various forms, with the exception of horse racing; b) unifying the classification and conditions of competitions; c) representing Polish equestrianism abroad; d) preparing and organizing equestrian teams for the Olympic Games; e) joining the International Federation for Equestrian Sports (Fédération Equestre Internationale – FEI) (*Jeździec i Hodowca*, 1929).

At the turn of the 1920s and 1930s, Polish equestrianism was going through a crisis. At that time, the PZJ focused mainly on interesting the greatest number of citizens in equestrian sport, as well as to inspire young people and encourage them to learn to ride a horse. The Management Board undertook a number of initiatives aimed at achieving this goal, while accepting the help of other institutions, such as: the State Office of Physical Education and Military Training, the Supreme Association of Horse-Breeders Union and military authorities (*Jeździec i Hodowca*, 1938d).

The issue of stagnation and even a certain underdevelopment of civilian equestrian sport in Poland were raised many times in the national press. A growing number of horse riding enthusiasts pointed out that with the passive attitude of government spheres, civil equestrianism would cease to exist. Poles, about whom the old Slavic proverb said: *Lach without a horse is like a body without a soul*, when compared to any European nation, performed very badly in terms of popularizing civilian equestrianism (Urban, 2002).

It was not until the early 1930s, when a profound crisis affected not only civilian, but also military representative equestrian sport, the Department of Cavalry of the Ministry of Military Affairs and the Polish Equestrian Association took decisive action to rectify the situation. On the initiative of the president of the PZJ, Col. Zbigniew Brochwickz-Lewiński, the Polish Equestrian Championships were organized in 1931. The aim of the championships was to stimulate riders to greater efforts in equestrian sport by awarding the best with the title of "Champion" and to arouse interest among the public (*Jeździec i Hodowca*, 1932). The Polish Equestrian Association continued its efforts to find the right method to promote equestrian sport among the widest social classes (*Jeździec i Hodowca*, 1933). A positive effect of the meeting of club presidents was the decision to organize the so-called "Popular Meetings", whose goal was primarily to make it easier for civil riders and schoolchildren to participate in competitions that required lower technical skills.

In agreement with school authorities, inexpensive horse riding lessons for youths were organized in 1934. Initially, the courses were conducted only in Warsaw, but later also in other cities. Lessons in Warsaw were organized not only for schoolchildren, but also for officials and students, as well as older amateurs of horse riding (*Jeździec i Hodowca*, 1938d). Over time, this type of inexpensive horse riding lessons was also introduced in the "Sokół" Mounted Troops in Lviv and Sosnowiec (Urban, Płaczek, 2000).

It should be emphasized that while male youths were initially reluctant to participate in equestrian sport, females had always shown a great interest in horse riding. The amazons outnumbered men at not only horse riding

courses and lessons organized by the PZJ, but also were a majority in equestrian clubs. While in 1930 there were only 30 competitors regularly participating in the competitions, by the end of the 1930s there were almost 200, including 124 amazons and 69 riders. The increase in the number of active civilian riders was proportional to the increase in interest in mass equestrian sport (*Koń Polski*, 1977).

After 1937, the Polish Equestrian Association strengthened its position not only in Poland, but also internationally. It was often the case that Polish initiatives gave cause to a change in the FEI regulations, establishing new and more modern regulations of international equestrian sport, and adapting them to changing conditions. As a token of appreciation for the contribution and merits of Poles in the development of international equestrian sport and active participation in the FEI sessions, Lt. Col. Tadeusz Machalski, was elected to the board of this organization in 1936 as the first and only Pole until the outbreak of the Second World War (*Jeździec i Hodowca*, 1939).

The prestige that Polish equestrianism enjoyed in the international arena and the importance of the activities of Polish representatives in the International Federation for Equestrian Sports were also evidenced by the fact that Warsaw was chosen as the organizer of the next FEI Congress in 1938. The meeting took place during the international equestrian competition from 1 to 7 June that year (*Koń Polski*, 1978). The Congress focused mainly on the detailed elaboration of the text of the new international regulations, according to which equestrian competitions were to be held at the 1940 Olympic Games. Olympic issues were an important topic during the FEI meeting. The Japanese delegate, General Kaba, who was present at the Congress, officially gave the President of the Republic of Poland an invitation to participate in the 1940 Olympic Games in Tokyo.

Polish Equestrian Badge

Despite the noticeable positive effects in popularizing equestrianism in society, the PZJ did not stop working on its further development. At the beginning of 1934, an initiative to establish the Polish Equestrian Badge (PEB) for the best riders and the most distinguished activists for the development of horse riding was started (*Konie i Rumaki*, 1995). The aim of the badge was, above all, to promote equestrianism far and wide among the society, maintain efficiency of a wide range of riders and amazons in riding skills and to encourage young people to horse ride. The PEБ was established in seven categories: Badge of Honour, Great Gold, Gold, Great Silver, Silver, Great Bronze and Bronze. Its regulations included all branches of equestrian sport: show jumping competitions, off-road competitions, as well as par force hunting and horse races (*Jeździec i Hodowca*, 1935).

The first badges were awarded in May 1935. Honorary Equestrian Badges were awarded to the Polish Marshal Józef Piłsudski, the President of the Republic of Poland Ignacy Mościcki – for outstanding service to the development of equestrian sport, and Lt. Col. Karol Rómmel, Maj. Michał Antoniewicz, Maj. Adam Królikiewicz, Maj. Józef Trenkwald, Rittmeister Kazimierz Szosland and Lt. Kazimierz Gzowski – for winning Olympic medals (in 1924 and 1928). Honorary Badges were also awarded to an amazon and riders who contributed to the development of equestrianism and represented it in the international arena even before Poland regained independence, namely: Maria Zandbangowa and Tadeusz Dachowski, Rittmeister Bronisław Peretiatkowicz, Paweł Popiel and BEng Zdzisław Sznuk (*Jeździec i Hodowca*, 1936). Whereas, for participation and completion of Olympic competitions, the Golden Badge was awarded to: Col. Tadeusz Komorowski, Maj. Zdzisław Dziadulski and Maj. Kazimierz Rostwo-Suski (*Przegląd Kawalerii i Broni Pancernej*, 1977).

In the interwar period, the PZJ awarded 19 Honorary Polish Equestrian Badges. In addition to the above-mentioned ones, Honorary Badges were also given to Count Andrzej Morstin and Count Andrzej Żółtowski, as well

as medallists of the Olympic Games (9) (*Jeździec i Hodowca*, 1938c and d). The Polish Equestrian Badge was one of the few that soldiers of the Polish Army could wear on a military uniform (*Konie i Rumaki*, 1995).

Horse-Riding Championships of the Polish Army – Militari

The most important equestrian event in the Polish cavalry of the interwar period was the Horse-Riding Championships for the Polish Army, also called the Army Championships or, colloquially, Militari. The goal of the Militari competition was to maintain a high level of riding skills among cavalry officers and their ability to use bladed weapons and firearms when riding a horse. Therefore, the Polish Army Championships served a training function for the participating riders; and were also an attempt at breeding selection of a military horse (Central Military Archive (CAW), Department of Cavalry of the Ministry of Military Affairs, ref. no. I 300.30.187).

Lt. Tadeusz Daszewski was the initiator of introducing these competitions to the training program of the cavalry, which gained the approval of the then head of the Department of Cavalry of the Ministry of Military Affairs, Gen. Eugeniusz Ślaski, who permanently introduced them as compulsory for all horseback weapons (*Konie i Rumaki*, 1994). The first Horse-Riding Championship for the Polish Army was held in 1923 in Warsaw. Initially, it was held only in the capital, and from 1929, each year the event was organized by another large cavalry unit (*Koń Polski*, 1974), who chose the city in its territory as the place of competition. In 1929, the Militari competition took place in Poznań, in 1930 – again in Warsaw, and in the following years – in Vilnius (1931), Kraków (1932), Baranowicze (1933), Hrubieszów (1934), Suwałki (1935), Łuck (1936), Białystok (1937) and Lviv (1938), and just before the outbreak of the Second World War – in Bydgoszcz (1939).

Both the preliminary and central competitions for the Army Championships consisted of four separate tests: dressage in a quadrangle, proficiency in bladed weapons and firearms use, cross-country riding, and show jumping, preceded by an inspection of horses. Detailed conditions of individual test were specified in instructions issued each year by the head of the Cavalry Department of the Ministry of Military Affairs. During 17 years, the rules of organizing these competitions had changed many times with the main goal – to achieve high riding efficiency of the rider and the horse in combat conditions – remaining the same (Central Military Archive (CAW), Department of Cavalry of the Ministry of Military Affairs, ref. no. I 300.30.187).

Out of 40 cavalry regiments, 11 mounted artillery divisions and the representation of the Border Protection Corps' cavalry, only nine cavalry regiments and the team of the Border Protection Corps managed to win the title of team army champion. The teams of the 15th and 16th Uhlan Regiments won the titles three times, and the teams of the 17th Uhlan Regiments and the 3rd Mounted Rifle Regiment and the Border Protection Corps – twice. In the individual classification, the best results were achieved by representatives of the 15th Uhlan Regiment, who won the individual army championship four times, and the 16th and 25th Uhlan Regiments who obtained this title twice. From 1923 to 1939, when the Militari Competition was organized, only two officers managed to win the titles of individual army champion more than once. They were representatives of the 15th Poznań Uhlan Regiment – Lt. Władysław Zgorzelski in 1924 and 1929 and Lt. Jan Brodzki in 1930 and (already as Rittmeister) in 1937. Moreover, Lt. Zgorzelski also won the title of vice-champion in the Polish Army and thanks to this, he came first in the classification for the best participant in this competition. He was also the head of the equestrian team of the 15th Uhlan Regiment for many years and was responsible for preparing the representation of the regiment for the Militari (*Przegląd Kawalerii i Broni Pancernej*, 1971b).

The Polish Equestrian Championships

The Polish Equestrian Championships were held for the first time in 1931. It was a world-class event, as Poland proved to be the precursor in organizing championships in this discipline. Championships, popular in other sports, were not known at the time in equestrian sport. The initiator of the Polish Equestrian Championships was the president of the Polish Equestrian Association, Col. Zbigniew Brochwicz-Lewiński. The main goal of the championships was to motivate riders to maximum effort and work systematically on themselves and the horse, as well as to promote equestrian sport far and wide among the Polish society. The championships were also the preliminary qualification of competitors and horses to the national team who attended international competitions and the Olympic Games (*Jeździec i Hodowca*, 1932).

At the beginning, the Polish Equestrian Championships comprised two competitions: show jumping and horse championship, from 1933 called Eventing. The dressage competition was not included, as it was not popular among Polish riders. It was only the opinions and statements of Maj. Leon Kon, an expert on equestrian art (*Koń Polski*, 1978), that changed the situation. In 1932, the dressage competition was also introduced to the Polish Equestrian Championships programme, which from that year was held regularly until the end of the interwar period.

Initially, in the years 1931–1935, the Polish Equestrian Championships were organized only in Warsaw (*Konie i Rumaki*, 1996a). In 1936, the Polish Equestrian Championships were held outside the capital for the first time. Eventing was traditionally held in Warsaw during the Official International Equestrian Competitions (28.05–8.06), but the Championships in show jumping and dressage took place in Lublin from 28 September to 4 October. In 1937, the PZJ decided to conduct all three equestrian competitions in the country in one place and at the same time. The first organizer of the comprehensively planned Polish Equestrian Championships was Gniezno. Whereas in 1938, the championships were organized in Bydgoszcz on October 6–11. They were the last Equestrian Polish Championships before the outbreak of the Second World War (*Konie i Rumaki*, 1996b, c, d).

The Polish Equestrian Championships were an elite event and only top national champions could take part in it. The championship regulations for 1936 were supplemented with a new provision to establish the title of the Polish Equestrian Champion, which was awarded to a competitor who in one year won the 1st place in all three equestrian competitions during the organized Polish Equestrian Championships. The title of Polish Equestrian Champion belonged to the rider until another competitor won the triple championship. In the interwar period, no rider succeeded in doing.

In the interwar period, the Polish Equestrian Championships were organized 8 times (1931–1938). Among the holders of championship titles were 31 competitors, with fourteen of them winning titles several times. Maj. Wilhelm Lewicki won the most Polish Champion titles – 4 (3 in dressage and 1 in show jumping). 3 titles were won by Rittmeister Seweryn Kulesza (2 in eventing and 1 in dressage), Rittmeister Jan Mossakowski (2 in dressage and 1 in eventing) and Lt. Col. Karol Rómmel – 2 (both in show jumping). The title of vice-champion was won 6 times by Rittmeister Henryk Roycewicz (3× in dressage, 2× in eventing, 1× in show jumping). Twice was the title won by Capt. Wojciech Biliński (in show jumping) and Rittmeister Tadeusz Sokolowski (1× in show jumping and 1× in dressage). Whereas the titles of the second vice-champion went to Maj. Wilhelm Lewicki – three times (2× in show jumping, 1× in eventing) and twice to Rittmeisters: Seweryn Kulesza (1× in eventing, 1x in dressage), Henryk Roycewicz (1× in eventing and 1× in dressage) and Józef Trenkwald (1× in eventing and 1× in show jumping). The most versatile riders who won championships or vice-champion titles in all equestrian events were Rittmeister Henryk Roycewicz, who won a total of 9 titles and Maj. Wilhelm Lewicki – 7 titles (*Przegląd Kawalerii i Broni Pancernej*, 1971a).

Participation and successes of Polish officers in international equestrian competitions

The official debut of Polish riders took place in April 1923 during international equestrian competitions in Nice. From this year until the outbreak of the Second World War, Polish representatives regularly participated in the most important equestrian events in Europe and North America. At the beginning, they competed only in equestrian competitions, whereas in the second half of the 1930s (1936), they also took part in the Eventing Competition. Such a late participation of Poles in the eventing was due to the fact that no international contest (except for the Olympic Games) of championship or cup ranks were organized in this competition. However, Poles did not participate in international dressage competition at all. Although in Europe there were organized such competitions with the participation of foreign teams, Poles did not take part in them in the interwar period (*Jeździec i Hodowca*, 1938a, b).

During the competition organized by national equestrian organizations in individual cities, various types of equestrian competitions were held: ordinary, accuracy, speed, power of the jump, hunting and others. The most important international equestrian competition was the Nations Cup competition, organized as the climax of the competition programme. The name "Nations Cup" was in force until 1933, when the regulations of the International Federation for Equestrian Sports reserved it only for competitions held during the Olympic Games. In view of this situation, the individual cities which organized this competition named it the Cup of the State in which the competition took place. In Warsaw, it was a competition for the "Polish Award" of the President of the Republic of Poland, in Riga – "Latvian Cup", in Tallinn – "Estonia Cup", in Berlin – "German Award" for the Cup of the Reich Chancellor, in Nice – "France Award" for the Cup of the Minister of Foreign Affairs (*Prix du Ministre des Affaires Étrangères*), in Rome – "Mussolini Cup" (*Coppa Mussolini*), in London – "the Prince of Wales Award", in New York – "the International Military Trophy" (Pruski, 1980).

In the interwar period (1923–1939), the Polish national team participated 54 times in the Nations Cup. Most often the team fought for this trophy: in Nice – 14 times, Warsaw – 12, Riga – 7, Rome – 6, New York – 4, in Berlin, Bucharest and London – 2 times, and in Aachen, Brussels, Budapest, Lucerne and Spa – one time. Polish riders won the top awards in the Nations Cup competitions many times. Out of 54 competitions, they won medals 38 times, including: 17 times – 1st place, 13 times – 2nd place, 8 times – 3rd place and 18 times further places. In the classification of all countries (17) which in the years 1920–1939 participated in the Nations Cups, Poles with seventeen victories came in 5th place when taking into account the first places. Italians proved to be more effective – 41 wins, Germany – 39, French – 26 and Irish – 23. Given the fact that Poles joined the competition three years later than most countries and the difficult political situation as well as socio-economic problems of the first years after regaining independence after 123 years of partitions, taking 5th place in this classification was undoubtedly a great achievement (*Koń Polski*, 1982).

In the discussed period, a total of 36 officers represented Poland in the Nations Cup competitions, of which a dozen or so participated in the competition many times. The record holder was Kazimierz Szosland, who participated in this competition up to 28 times. Frequent participants of the Nations Cup were also: Janusz Komorowski – 19 times, Adam Królikiewicz – 17, Karol Rómmel – 13, Zygmunt Ruciński – 12, Roman Pohorecki – 11, Wilhelm Lewicki – 10, Stefan Starnawski, Stanisław Czerniawski and Bronisław Skulicz – 9 times each, Aleksander Rylke, Michał Gutowski and Henryk Roycewicz – 7 times each, Michał Toczek and Henryk Kulesza – 6 times each, Zdzisław Dziadulski, Kazimierz Gzowski and Władysław Zgorzelski – 5 times each. The Polish National Team also included also Antoniewicz and Jerzy Bilwin – 4 times each, Wojciech Biliński, Henryk Dobrzański, Jan Mossakowski and Józef Trenkwald – 3 times each, Włodzimierz Korytkowski, Franciszek Mrowec, Paweł Nerlich-Dąbski, Jan

Sałęga, J. Skupiński, Tadeusz Sokołowski, Stanisław Wołoszowski and Sergiusz Zahorski – 2 times each, as well as Leon Burniewicz, Janusz Kapuściński, Jan Strzałkowski and Antoni Żelewski – 1 time each (Urban, 2003).

In addition to participating in competitions for the Nations Cup, Polish riders also competed in many others, achieving very good results. Since Poles participated most often in equestrian events organized in Nice (within 17 years up to 14 times), naturally they were the most successful in this city. Nice provided perfect competition conditions not only in terms of sports level, but also in the variety of competitions held there. The Polish riders achieved very good results especially in the competition for the City of Nice Award (Grand Prix de la Ville de Nice) and for the Monaco Award (Prix de Monaco) by winning cups in each of these competitions six times (*Przegląd Kawalerii i Broni Pancernej*, 1974b).

Polish officers also participated four times in riding competitions overseas. The contests organized in Madison Square Garden in New York were an extraordinary event for Polish American community. The Polish riders in a uniform and impeccable riding style and the successes achieved in the parcours aroused widespread admiration and recognition, and the American audience with unflagging enthusiasm admired the sports achievements of Poles. "Poles' victory can only be explained by the extraordinary talent and efficiency of riders (...). Thousands of thoughts arise when you see our guests riding horses of a much lower category than those our enthusiasts used to admire at international competitions" (*Jeździec i Hodowca*, 1927) – commented American William Morris on the performance of the Polish riders in New York.

The national team won the Nations Cup three times out of four it participated in the New York competitions in 1926–1929, thus becoming the Cup's permanent holder in 1929. Furthermore, the team won awards in other competitions many times. In total, it stood on the podium 26 times: it took the 1st place 8 times, 10 times – the 2nd, and 8 times – the 3rd. The team won the greatest number of prizes in 1927, when the riders won 10 medals: 4 gold, 4 silver and 2 bronze. Poland was represented in New York by: Maj. Michał Toczek, Rittmeister Adam Królikiewicz and Lt. Kazimierz Szosland (in 1926), Lt. Col. Karol Römmel and Rittmeister Michał Antoniewicz (in 1927 and 1928), Lt. Stefan Starnawski (in 1927), Lt. Władysław Zgorzelski (in 1928 and 1929) and Lt. Kazimierz Gzowski and Lt. Stefan Starnawski (in 1929) (*Przegląd Kawalerii i Broni Pancernej*, 1974a).

In 1936, Polish riders participated for the first time in the International Eventing competition, held during the winter horse competition in Berlin. Due to weather conditions, dressage in a quadrangle test and two jumping shows were held, however cross-country riding was cancelled. The debut was not successful. Out of fourteen running horses, the only Polish representative, i.e. Maj. Wilhelm Lewicki riding Dunkan, took the 10th place (Central Military Archive (CAW), the Cavalry Training Center, ref. No. I 340.40/8). After a one-year break, the Poles took part in the eventing competition during the International Equestrian Contest in Insterburg in East Prussia, where Lt. Jerzy Bilwin riding Arlekin III won the final classification and took the 2nd place. The last International Equestrian Competition before the outbreak of the Second World War took place in June 1939 in Turin and was a preparation for the Olympic Games in Helsinki. Six national teams participated in the competition, including Poland under the leadership of Capt. Jan Mickunas. Only two teams were classified: on the 1st place – Germany, and on the 2nd – Switzerland, the remaining teams were rejected after the cross-country riding test (*Przegląd Kawalerii i Broni Pancernej*, 1978b).

Poles' Olympic achievements in equestrian sport

Polish riders performed for the first time at the 5th Olympic Games in Stockholm. However, unable to represent their own country, which was at that time under occupation, they competed in the Russian team. Two Polish officers appeared in a team of seven: Second Lieutenant Karol Rómmel and First Lieutenant Sergiusz Zahorski. The highest place in the national team in jumping show – 7th, was taken by Prince Pawłowicz. Second Lieutenant K. Rómmel riding the Cossack horse Ziablik, after an unfortunate fall, took the 9th place, and Lt. S. Zahorski on the Polish Bandura – the 11th. The injury deprived Lt. Rómmel of an opportunity to win a gold medal. However, in recognition of a very good performance, King Gustaf V personally gave the Polish athlete a copy of the Olympic gold medal (Urban, 1998).

In 1920, shortly after Poland regained independence, the 7th Olympic Games in Antwerp were held. The Olympic competition became an excellent opportunity to present the reborn state on the international stage. The Polish Olympic Committee, established in 1919, in response to the invitation of the International Olympic Committee, notified the Polish national team to participate in the Olympic Games. Pursuant to the order of the Inspector General of the Cavalry, 14 riders and Maj. Karol Rómmel, as the group's manager, were appointed to participate in the 7th Olympic Games. However, the Polish riders did not attend the Olympic competition, as in mid-June 1920, the officers were directed to the Eastern Front and took part in the Polish-Soviet war (Central Military Archive (CAW), the Inspector General of the Cavalry (GIJ), ref. no. I 300.25.9).

Immediately after the war, activities aimed at developing Polish equestrian sport began, in particular improving the skills of the equestrian leaders of that time. The Equestrian Preparation Group at the Central Riding School (later the Cavalry Training Center) in Grudziądz (*Przegląd Kawalerii i Broni Pancernej*, 1969), which was set up in 1922–1929, made an enormous contribution in training the competitors.

Polish riders made their debut at the Olympic Games in Paris. Equestrian competitions began on July 21, 1924, in which participants from 15 countries took part. The competition comprised three disciplines: individual dressage competition, eventing and show jumping for the Nations Cup. Poles did not take part in the dressage competition, but they represented Poland in the other two competitions (Central Military Archive (CAW), Department of Cavalry of the Ministry of Military Affairs, ref. no. I 300.30.192).

46 competitors from 13 countries competed in the Horse Championship (eventing), including 10 teams representing the national teams. It consisted of three tests: dressage in a quadrangle, cross-country riding and show jumping tests. The Poles, as a team debuting at the Olympic Games, failed to succeed. As a team, they were classified at the 7th place (the 1st place – the Netherlands, the 2nd place – Sweden, the 3rd place – Italy). Individually, the best of Poles turned out to be Lt. Col. K. Rómmel riding Krechowiak who won the 10th place and farther Lt. K. Szosland riding Helusia – the 23rd place, Rittmeister K. Rostwo-Suski riding Lady – the 24th place, Maj. T. Komorowski riding Amon – the 26th place (Łysakowska, 2000).

On July 27, the Nations Cup competition was held, which brought together 43 competitors from 15 countries. In the difficult international competition, the contestants took the 6th place as a team, whereas in the individual classification Prix des Nations, a success was achieved by the young lieutenant of the 1st Cavalry Regiment – Adam Królikiewicz, who finished 3rd and won the bronze Olympic medal, the first in the history of Polish equestrianism. Other competitors took lower places: Lt. Col. K. Rómmel – the 11th place, Rittmeister Z. Dziadulski – the 28th place and Lt. K. Szosland – the 32nd place (Królikiewicz, nd).

The equestrian sport in Poland had been developing systematically over the next four years and until the Olympic Games in Amsterdam. The riders gained increasing recognition in the country and abroad, and over time joined the group of the best not only in Europe, but also in the world. Medals and awards won by Poles at European and American hippodromes testified to their good instructor preparation and the chances for success during the Olympic Games in the Netherlands.

The 9th Olympic Games in Amsterdam were held July 28 – August 12, 1928. The event was attended by representatives of 17 countries and several individual contestants. Poland was represented in this competition by: Rittmeister M. Antoniewicz riding on Moja Mila, Lt. Col. K. Rómmel on Donneuse, Rittmeister J. Trenkwald on Lwi Pazur (substitute rider was Maj. H. Dobrzański on Fucase). On August 8–9, the first part of the championship was organized, i.e. dressage in a quadrangle. Poles did not do well in this test. The cross-country riding test was held on August 10. In this test, it was very important to keep the team together (three contestants). Incomplete team meant losing the right to team classification. On August 11, the last test was organized – a show jumping competition. The experience of the riders and the excellent preparation of animals resulted in the whole Polish team completing the test. Out of 17 teams that competed, only three finished the contest, and out of 46 horses, only 28 got to the finals. Poles won the bronze Olympic medal and took the 3rd place, right after the Netherlands and Norway (*Jeździec i Hodowca*, 1928).

A competition for the Nations Cup was organized on the last day of the event, i.e. August 12, in which 16 teams of 3 contestants and 6 individual participants took part. The following riders were prepared for the show jumping competition: Rittmeister M. Antoniewicz with Readgledt, Lt. K. Gzowski with Mylord, Lt. K. Szosland with Alli and as a substitute Rittmeister Z. Dziadulski with the Lad. The Poles won the silver Olympic medal as a team, second only to the Spanish. Individually, the best Polish rider turned out to be Lt. K. Gzowski, taking the 4th place together with a Spaniard; Lt. K. Szosland took the 13th place, and Rittmeister M. Antoniewicz the 20th (Central Military Archive (CAW), Department of Cavalry of the Ministry of Military Affairs, ref. no. I 300.30.192).

After the Olympic Games in Amsterdam, the Equestrian Sports Group at the Cavalry Training Center in Grudziądz was dissolved. The military authorities recognized that among the cavalry and horse artillery officers there is a sufficiently large number of competitors whose riding skills would allow Poland to be represented internationally. The lack of a full-time training unit negatively affected the performances of riders in sports competitions, where Poles began to suffer many defeats since 1929 (Urban, 1998).

In 1932, the Olympic Games were held in Los Angeles. The military authorities and the PZJ faced a dilemma regarding sending the Polish equestrian team to the United States, collecting appropriate funds and preparing it to participate in the competition. However, the financial issue was not the president's only problem, as many equestrian activists, as well as riders themselves doubted the possibility of achieving a success in America. Ultimately, in order "not to jeopardize the honour of Polish equestrianism at such a sports ceremony", the PZJ decided that Polish equestrianism would not be represented at the Los Angeles Olympic Games (Pruski, 1980).

In view of the upcoming 11th Berlin Olympic Games organized in the summer of 1936, the Department of Cavalry of the Ministry of Military Affairs decided to establish a special Olympic group in the Cavalry Training Center in Grudziądz (Urban, 2013). By order of the Department of Cavalry of the Ministry of Military Affairs no. 2422-99/36 of July 20, 1936, the Polish equestrian team was sent to the 11th Berlin Olympic Games. Traditionally, Poles had reported their participation in two equestrian competitions: Eventing and show jumping competition for the Nations Cup (Central Military Archive (CAW), Journal of Orders, ref. no. I 340.40/8).

Eventing started on August 13, with 53 contestants from 19 countries, including 17 teams of three, participating. On the first day, dressage in a quadrangle competition was held, in which the Poles took the 5th place. The riders considered the second test of the eventing the most exhausting and dangerous among the international field trials carried out thus far. The Poles won the 3rd place in this competition and were placed just behind Germans and Bulgarians. The last competition was a jumping show that also proved to be difficult. In the end, after the disqualification of a Bulgarian rider, the Polish team took the 2nd place and won a silver Olympic medal. In the individual contest, the Poles took the 15th place – Rittmeister H. Roycewicz, the 18th place – Rittmeister Z. Kawecki, and the 21st place – Rittmeister S. Kulesza (Wryk, 2015).

At the end of the Olympic equestrian competition, i.e. on August 16, the Nations Cup competition was held, with 18 teams taking part in it (3 competitors each). There were 20 obstacles on a small square, as a result of which they were extremely focused, and the rider was forced to overcome them from a very short take-off site. Poles did very poorly. Lt. M. Gutowski and Rittmeister T. Sokołowski did not finish the competition, and Lt. J. Komorowski individually took the distant 36th place (Gaj, 2002).

The medal achievements of the Polish equestrianism in the Olympic Games of the interwar period were 4 medals: 2 silver and 2 bronze, including 3 won in team competitions and 1 individually. Starting from the Olympic Games in Berlin, Polish equestrianism entered a new successful period of development, and the crisis of 1929–1934 had definitely passed. Furthermore, Polish riders had won many significant victories in top-ranking competitions abroad. In 1937, the organization of a full-time Equestrian Sports Group at the Cavalry Training Center in Grudziądz was completed, whose main task was continuous improvement in competitive riding and representing Poland at international competitions. The Polish Equestrian Association had taken successful activities that resulted in increased interest in horse riding among civil society. The outbreak of the Second World War overshadowed the considerable achievements of Polish equestrianism gained in the interwar years.

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EFFECT OF COMPRESSION MODALITIES FOR RECOVERY ON WRESTLERS' BIOMARKERS IN ONE DAY TOURNAMENT

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Abstract The aim of the study was to investigate the effect of different compression modalities as to recovery enhancement on some biomarkers in wrestlers.

Serum creatinine, lactic acid and glucose level were tested in elite wrestlers before a match-up, 3 minutes post-match up and 19 minutes after applying recovery compression model.

The results showed insignificant differences between pre-post 3-minutes tests among research groups due to sample equality, 3-minutes and 19-minutes post match up tests showed efficacy of compression technique in enhancing recovery in sake of 160/20 mmHg compression modality with enhancement percentage of 16.614% for serum creatinine, 43.214% for lactic acid and 22.505% for glucose level.

The compression band with 160/20 mmHg exceeds recovery after match-up.

Key words Compression modalities, recovery, wrestling, serum creatinine "SCR", lactic acid "LA", glucose level "GL"

Introduction

Fatigue has been investigated in different sports to theorize its classification. Mechanical fatigue can be realized as a decline in muscle strength or efficiency, while psychological fatigue states tiredness, perception and low cognitive function. The physiological fatigue occurs in insufficient blood flow to the working tissue and weakening muscle contraction. Fatigue also restrains nervous activation and metabolism; some fatigue may be controlled by passive recovery, but muscular fatigue is complicated because of its extended effect (Allen, Lamb, Westerblad, 2008; Gambetta, 2007; Green, 1997; Locke, Osborne, O'rouke, 2009), especially in the maximal power when measured immediately after the fatiguing performance (Hunter, Critchlow, Shin, Enoka, 2004; Lévénez, Kotzamanidis, Carpentier, Duchateau, 2005; McNeil, Murray, Rice, 2006). Scientists claim lactic acid production as prior factor of fatigue, resulting of severe exercise, but there is a growing interest of studying other metabolic

byproducts causing fatigue (Brooks, 2001; Kass, Carpenter, 2009). The impact of fatigue on athlete's achievement actuates scientists to monitor training loads, recovery duration and modality (Allen et al., 2008; Thorpe, Atkinson, Drust, Gregson, 2017).

Proper recovery aims at restoration of physiological and psychological excellence, so that the athlete can compete or continue training at optimal level depending on the exercise's nature.

Compression techniques of recovery vary in application and effect. Ischemic preconditioning (IPC) consists of repeated cycles of vascular occlusion with high pressure cuff applied on upper or lower limbs, followed by reperfusion in which pressure in the cuff is gradually released. IPC is known to improve vasodilation, oxygen utilization muscle function and to enhance exercise performance (Dalleck, 2018).

Compression garments are one of the recovery applications that use a graduated compression on the limbs from proximal to distal. Compression pressure of a garment reduces the intramuscular space prone to swelling and promotes stable alignment of muscle fibers (Bochmann et al., 2005; Kraemer et al., 2010).

IPC improves muscle blood flow, oxygen delivery and may contribute to an increased removal of lactate including the potential up regulation of intra- and extracellular lactate shuttles during exercise (Brooks, 2000; Hashimoto, Brooks, 2008; Riksen, Smits, Rongen, 2004).

Periodic cycles of ischemic compression followed by gradual reperfusion, enhance molecular, vascular adaptations and muscular blood flow (Berger, Macholz, Mairbaurl, Bartsch, 2015; Tapuria et al., 2008).

Compression for recovery of post-exercise fatigue may cease inflammatory responses, reduce v delayed onset muscle soreness and accelerates recovery process period (Duffield, Cannon, King, 2010; Pruscino, 2013).

High intensity exercise, especially eccentric muscle contraction, results in high circulating creatinine (Koch, Pereira, Machado, 2014), which is related to the athletes' muscle size, fiber type, and exercising duration (Gleeson, Maughan, 2013).

Whole blood or plasma creatinine and estimated glomerular filtration rate are particularly increased in strength sports, while creatinine kinase (CK) may be elevated during acute changes in training load. However, regarding the inter- and intraindividual variations within the same or different seasons, the effect of exercise on biomarker concentrations, and the lack of reference values, little progress has been made towards the integration of these tools in sports practice and the discrimination among health training, overtraining and fatigue (Banfi, Colombini, Lombardi, Lubkowska, 2012; Fragala, Bi, Chaump, Kaufman, Kroll, 2017; Meeusen et al., 2013).

Wrestling is a part of poly-structural acyclic sports. Wrestling matches occur in the zone of maximal and submaximal load. The energetics of wrestling is very complex, anaerobic glycolytic or lactic pathways prevail during a fight, in order to perform sudden, explosive throws or lifting (Karninčić, Gamulin, Nurkić, 2013).

Hematological biomarkers have been proven valid for quantifying and monitoring training load throughout a training period (Djaoui, Haddad, Chamari, Dellal, 2017).

From above reading one can state that varieties of compression modalities had been investigated in regard to their effect in enhancing recovery, eliminating biomarkers of fatigue as serum creatinine, lactic acid and restoring glucose level. However, there has never been a certain procedure in estimating pressure or location of the compression, so the researchers aimed to establish a new compression modality and investigate its effect on serum creatinine, lactic acid clearance, and glucose level.

Materials and Methods

Experimental method had been used to investigate the effect of three compression modalities on lactic acid clearance, serum creatinine and glucose level in blood using pre- and post-test.

Sample: Twenty four elite wrestlers (aged 18–23 and weighted 82–87) from registered Egyptian federation players participated in this study; the sample was divided into 4 groups (control; experimental – Exp1; experimental – Exp2; experimental – Exp3). Each group consisted of 6 players; 12 players intentionally played in each official weigh. The data in Table 1 describe homogeneity of the sample.

Table 1. Means, standard deviation and variance of sample groups in research variables

Variables	Control			Exp1			Exp2			Exp3			Hartly test
	M	±SD	v										
SCR	1.080	1.175	0.044	1.130	1.115	0.015	1.093	1.095	0.021	1.092	1.100	0.032	2.976
LA	2.500	2.500	0.200	2.483	2.500	0.222	2.633	2.700	0.127	2.617	2.700	0.138	1.750
GL	128.500	128.500	19.500	127.333	128.000	11.467	127.167	126.500	47.367	128.833	129.000	25.367	4.131

Note: Homogeneity of research groups, where significance between 4.5 F (Freedom degrees) at 0.05 = 13.7. Variance differences were insignificant according to Hartly test.

Measurements: Venous blood samples were taken from players before participating in the customized match as in officially organized matches. The measurements were serum creatinine, lactic acid and glucose. Samples preserved in vacutainers till were sent to medical lab to be analyzed.

Serum creatinine “SCR”: Serum creatinine is one of health biomarkers which states the athlete's responses to physical performance, especially in exhaustive performance that produces high loss of hydro electrolytes. High training workload and psychophysical stress from competitions may modify their homoeostasis, inducing apparently pathological biochemical and hematological values. Therefore, the definition of the behavior of creatinine (Banfi, Del Fabbro, 2006; Banfi, Del Fabbro, 2006), where exercise will acutely change serum creatinine level depending on the severity and duration of the exercise, as well as on the age of athletes (Banfi, Del Fabbro, Lippi, 2009).

Serum creatinine concentrations were higher than those measured in age matched sedentary subjects. This finding may be linked to the average higher muscle mass of athletes, because total muscle mass is the most important determinant of the creatinine pool size and of creatinine production (Perrone, Madias, Levey, 1992). Exercise-induced changes in creatinine levels are transient and promptly normalize during the recovery (Banfi, Del Fabbro, Lippi, 2009).

Lactic acid “LA”: Lactic acid is an important marker of fatigue (Hübner-Woźniak, Kosmol, Lutoslawska, Bem, 2004; Hübner-Woźniak, Lutoslawska, Kosmol, Zuziak, 2006; Kraemer et al., 2001), blood lactate varies directly after exercise and following exercise depending on the time at which it was sampled. Depending on the mode of exercise and sample site, extracted blood borne parameters could be altered, yet recovery of lactate changes up to twenty-five minutes post exercise. Training has also proven to increase the rate at which lactate is removed after aerobic and anaerobic exercise (Karničić, Tocilj, Uljević, Erceg, 2009; Kass, Carpenter, 2009).

Glucose “GL”: Physical training enhances insulin-stimulated glucose disposal in proportion to the improvement in physical fitness (Mikines, Sonne, Farrel, Tronier, Galbo, 1988; Soman, Koivisto, Deibert, Felig, DeFronzo, 1997).

Physical training is known to improve insulin sensitivity, both immediately post-exercise and through multiple long-term adaptations in glucose transport and metabolism (Costill, Hargreaves, 1990).

However, in contrast, strenuous exercise is known to increase circulating concentrations of catecholamines, such as adrenalin and noradrenaline, to near pathological levels, resulting in hyperglycemia and hyperinsulinemia post-intense exercise (Marliiss, Vranic, 2002; Rehrer, Brouns, Beckers, 1992).

Lactic acid, serum creatinine and glucose level were investigated among several sports players, where little is known about their profile during a wrestling competition. Venues blood samples were collected, maintained in a vacutainer and handled in ice box till to medical lab of Tanta. Samples collected from arm vein where closer to active muscle in wrestling arm performances, referring to previous study (Comeau, Lawson, Graves, Church, Adams, 2011) that declared sampling blood lactate from sites that are not close to the working muscle could result in inaccurate blood lactate level due to the pooling of lactate in areas of inactive muscles.

Main protocol

Pilot study was carried out on 2 wrestlers to investigate the utility of the equipment and assistants needed, where the researchers decided to have two lab experts to ensure the blood collecting process speed.

The main experiment was carried out in two days. Customized match conditions were as following: morning breakfast was 1 hour before the experiment and consisted of 200 ml of orange juice, two bananas and a slice of cake. No further food was supplied till the end of the 19-minutes post-match test. 3 blood samples of 3 cm (first one in the morning before players warmed up, second one after 3-minutes post-match and third one 19 minutes post-match; with and without recovery modality). The blood samples collecting is presented in Figure 1.



Figure 1. Blood samples collecting

Players performed in wrestling matches of two rounds, 3 minutes each; intermittent rest of 30 seconds with confirmed condition manipulation (eliminating the shoulder touch down – OUTO touch), neglecting the score superiority (super URTY). Matching underwent the whole timing of 6 minutes with 30-second intermittent rest. United World Wrestling (UWW) organized the first-round matches (3–4 matches) with 20 minutes intermitted rest. Every two groups wrestled each other randomly according to weight (Figure 2) documentary of wrestling match.



Figure 2. Documentary of wrestling match

After 3-minutes post-match, players were classified into four groups. The players from the control group did not apply any recovery method (passive recovery).

Group Exp1 applied intermittent compression band (inflator cuff) for 14 minutes with interval 2-minute compression, then 2-minute release. The compression was 160 mm Hg (mercuric pressure), with gradual release up to 20 mm Hg. Figure 3 represents the athletes applying inflatable cuff with 160/20 mm Hg.



Figure 3. Athletes applying inflatable cuff

Previous studies varied in their compression pressure, compression sites, upper limb or lower limb, single or double site occlusion and compression tactics. I. San Millán et al. (2013) used MMC devise on feet with intervals of pressure and gradual release. A. Kraus et al. (2015) used an automated inflatable cuff (E20 Rapid Cuff Inflator) with four cycles of 5-minute occlusion, each followed by 5-minute reperfusion.

Group Exp2 applied intermittent compression band (inflator cuff) for 14 minutes with interval 2-minute compression, then 2-minute release. The compression was 120 mm Hg (mercuric pressure), with gradual release up to 20 mm Hg.

Group Exp3 applied IPC device, arm cuff for 15 minutes. Figure 4 represents an athlete applying IPC cuff.



Figure 4. An athlete applying IPC cuff

A previous study (Hanson, Stetter, Thomas, 2013) emphasized that using IPC for recovering was faster especially after a multitude of competition (Jones, 2016). There was used graduated low-pressure 20:15:10 mm Hg IPC use and graduated high-pressure 70:65:60 mm Hg IPC. T. Waller et al. (2006) utilized the IPC as a recovery modality with graduated low-pressure (20 mm Hg) IPC use, and graduated high-pressure (70 mm Hg) IPC. M. Winke and S.H. Williamson (2018) also demonstrated intermittent pressure release with 100 mm Hg.

Statistical procedures

Statistical analyses were performed using SPSS software. All data are reported as means; SD – “standard deviation”, ANOVA – “analysis of variance”, LSD – “least significant differences” and enhancement percentage Hartly test were assumed at $p < 0.05$. Experimental method was that of four groups using 1 pre-test and 2 post-test.

Results

Analytic treatment of research data resulted in differences among the four research groups. Tables 2 and 3 represent the means, LSD and enhancement percentage of the pre-tests of the research variables (Serum Creatinine – SCR, Lactic acid – LA and Glucose – GL) of the four research groups (Control – cont., Experimental 1 – Exp1, Experimental 2 – Exp2 and Experimental 3 – Exp3).

Table 2. Means, LSD and enhancement percentage of the pre-tests of the four research groups

No.	Variables	Cont.			Exp1			Exp2			Exp3		
		SCR	LA	GL	SCR	LA	GL	SCR	LA	GL	SCR	LA	GL
1	2	3	4	5	6	7	8	9	10	11	12	13	14
Means	pre	1.080	2.500	128.500	1.130	2.483	127.333	1.093	2.633	127.167	1.092	2.617	128.833
	post 3-minutes	1.232	20.200	72.000	1.298	20.433	74.500	1.292	20.017	72.500	1.307	20.400	73.833
	post 19-minutes	1.245	15.350	85.167	1.053	8.717	104.333	1.210	11.817	91.333	1.228	12.150	90.167
LSD		0.216	1.899	6.642	0.127	1.039	4.776	0.129	1.863	5.607	0.170	2.053	4.905
F		1.6329	210.573*	179.842*	8.8672*	697.951*	279.245*	5.193*	197.685*	222.698*	3.712*	170.592*	213.012*
P value		0.112	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Enhancement percentage		pre	Post	Post	pre	Post	Post	pre	Post	Post	pre	Post	Post
		3 min	19 min		3 min	19 min		3 min	19 min		3 min	19 min	

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	1	2	3	4	5	6	7	8	9	10	11	12	13	14
SCR	pre			14.043	15.278		14.897	6.814		18.140	10.671		19.695	12.519
	post 3-minutes				1.083			18.896			6.323			5.995
	post 19-minute													
Lactic	pre			708.000	514.000		722.819	251.007		660.127	348.734		679.618	364.331
	post 3-minute				24.010			57.341			40.966			40.441
	post 19-minute													
Glucose	pre			43.969	33.722		41.492	18.063		42.988	28.178		42.691	30.013
	post 3-minute				18.287			40.045			25.977			22.122
	post 19-minute													

* p value <0.05, F value at 2.15, significance 0.05 = 3.68.

Table 3. ANOVA, LSD and enhancement percentage of the post-tests among research four groups

Variables	Groups	Means	Enhancement perc.			MD			LSD	F	p value	
			Cont.	Exp1	Exp2	Exp3	Cont.	Exp1	Exp2	Exp3		
SCR	Cont.	1.245		15.395	2.811	1.339		0.192*↑	0.035	0.017	0.114	5.477*
	Exp1	1.053			14.873	16.614			0.157*→	0.175*→		
	Exp2	1.210				1.515				0.018		
	Exp3	1.228										
LA	Cont.	15.350		43.214	23.018	20.847		6.633	3.533*↑	3.200*↑	0.580	189.888*
	Exp1	8.717			35.564	39.388			3.100*→	3.433*→		
	Exp2	11.817				2.821				0.333		
	Exp3	12.150										
GL	Cont.	85.167		22.505	7.241	5.871		19.167	6.167*↑	5.000*↑	3.886	38.469*
	Exp1	104.333			12.460	13.578			13.000*→	14.167*→		
	Exp2	91.333				1.277				1.167		
	Exp3	90.167										

* p value < 0.05, F value at 3.20, significance 0.05 = 3.01. Horizontal arrows are indicators of significance, vertical arrows are the highest significance; → — highest significance.

Discussion

Recent research aimed at investigating different compression modalities on wrestlers' recovery after customized wrestling match. Different compression modalities showed significant differences towards enhancement of post-performance recovery, varied by the recovery procedure. Pre matching tests showed no differences owing to the homogeneity of the wrestlers' performance level and BMI. 3-minute post-match tests showed little differences with insignificance, due to reason. 19-minute post-match tests taken after application of different recovery modalities, showed varied readings with significant differences between experiment groups and control group.

Serum creatinine "SCR": The concentration of serum creatinine is a reliable indicator of renal function in medicine research (Perrone et al., 1992). Serum creatinine positively responses to physical exercise, and vary according to sample age, exercise intensity and duration (Banfi et al., 2009).

In recent study, serum creatinine resulted in dramatic increase in 3-minute post-match test, ranging 1.23–1.30 mg/dL. That may indicate subclinical muscle disease, where training loads may evidence through the onset of profound fatigue as in the study of P. Brancaccio et al. (2007).

Our findings matched the study of N. Gill, C. Beaven and C. Cook (2005) and I. Papassotiriou and A. Nifli (2018) who emphasized higher excretion of serum creatinine in 70% of the athletes according to athlete's body mass, especially in wrestlers, while athletes with lower creatinine concentrations presumed albumin abnormality.

M.S. Fragala et al. (2017) proved that strength exercise was associated with higher levels of creatinine, where physical performance compels athlete's muscles to process high amounts of creatine which produce higher levels of serum creatinine.

In the 19-minute post-match creatinine test, after applying 3 different recovery modality, the results among groups showed insignificant differences between cont. and Exp3 groups, which declares that compression modality of (IPC) was less influenced than passive recovery. Significant differences between Exp1, Exp2 and cont. groups differed according to the recovery modality, with recovery of creatinine clearance in favor of the Exp1 with mean 1.03 mg/dL, showing the superiority of compression modality (160/20 mm Hg). Exp2 with 140/20 mm Hg modality showed significant difference to cont. group and to Exp1 in sake of the latter, where enhancement percentages were as follows: 16.614%, 15.395% and 14.873% between Exp1, Exp2 and Exp3 respectively.

Creatinine clearance after match-up in wrestling is essential for wrestlers to continue the match-up in preparation phase or in finals, using recovery modality to shorten the recovery period.

Our findings matched the studies of P. Brancaccio et al. (2007), K.E. Fallon, G. Sivyer, K. Sivyer and A. Dare (1999), T. Hortobagyi and T. Denhan (1989) and I. Papassotiriou and A. Nifli (2018) that resting creatinine levels are higher in athletes, especially wrestlers.

Creatinine clearance induced by using compression modality, which was previously tested in studies of J. Chase (2017), A. Comerota and F. Aziz (2009), P. Deschênes, D. Joannis and F. Billaut (2017), T. Lopes et al. (2018) and R. Thorpe et al. (2017), emphasizing the validity of compression modalities in enhancing limb vasculature, blood circulation, oxidation and post exercise recovery.

Lactic acid "LA": Lactate is the product of the anaerobic breakdown of glucose in tissues. While earlier research demonstrated that lactate was a waste product and a cause of acidosis, new findings have shown that lactate not only does not cause acidosis (Robergs, Ghiasvand, Parker, 2004) but it is also a very useful carbohydrate in times of increased energy demand (Miller et al., 2002). Competitive fight particularly depends on the capacity of maximum mobilization of anaerobic lactic energy (Sybil, 2018). The anaerobic system provides the short, quick bursts of maximal power during the match while the aerobic system contributes to the wrestler's ability to sustain effort for the duration of the match (Callan et al., 2000).

Pre match-up lactic acid test was normal range for all research groups with range of "1.9–3.0" mmol·L. Recent results matched the studies of W.J. Kraemer et al. (2001) and K. Mahdi (2007), where resting lactate concentrations before warming up ranged 1.7 mmol·L – 1 to 2.6 mmol·L – 1.

3-minute post match-up lactate test was raised for all research groups, due to the anaerobic nature of wrestling match performance. Readings differences were insignificant among groups according to the likelihood of training experience, the readings ranged "20.017–20.433 mmol·L", matching the study of H. Karninčić et al. (2009), A.C. Utter, H.S. O'Bryant, G.G. Haff and G.A. Trone (2002), where post-match test ranged "17.1 to 20.0 mmol·L".

19-minute post match-up, lactic acid test, varied in the four research groups with minimal insignificant change in cont. group, where passive recovery did not record lactate clearance, which matches the study of M. Jemni, W. Sands, F. Friemel and P. Delamarche (2003).

Significant differences were found among the experimental groups. The compression modalities showed remarkable attitude in lactate recovery with enhancement percentage of (43.214, 39.388, 35.564) between Exp1, Exp2 and Exp3, respectively. The highest enhancement was in sake of Exp1 with mean of 8.717 mmol·L⁻¹, emphasizing on the role of intermittent compression pressure in lactate recovery. Our findings matched the studies of S. Baker and N. King (1991), I. Barbas et al. (2011), E. Hanson et al. (2013) and L. Sharma and S. Verma (2017).

Glucose level "GL": Glucose is a master nutrient of body organs, especially the organs of the nervous system. Insulin and glucagon hormones are the moderators of blood glucose "hyperglycemic and hypoglycemic actions" to normal range in order to keep the body systems out of danger (Marshall, 2012).

3-minute post match-up glucose test recorded high reduction in all research groups, due to the high anaerobic exertion of wrestling match performance. Readings differences were insignificant among groups as the likelihood of training experience, readings ranged "72–74.5mg/dl", where reductions in blood glucose levels have been associated with fatigue matching the studies of P. Abernethy and B. Eden (1992), L.B. Borghouts and H.A. Keizer (2000), D.L. Costill and M. Hargreaves (1990) and M. Goodwin (2010).

19-minute post match-up glucose test recorded high increase in glucose level, matching the study of L. Hermansen, E.D. Pruitt, J.B. Osnes and F.A. Giere (1970), which emphasized the great increase in glucose level responding to maximal exercise performance. That increase in blood glucose was deduced in the study of R.H. Coker and M. Kjaer (2005) to be an immediate release of glucose from the liver.

Glucose increase varied in the four research groups enhancement percentage (22.50, 13.578, 12.460) between Exp1, Exp2 and Exp3, respectively, with high significance in sake of Exp1 with mean 104.333 mg/dl, showing the efficacy of the compression modalities in increasing the muscle blood pooling, matching the studies of M. Goodwin (2010), Z.A. Khayat, N. Patel and A. Klip (2002) and E.A. Richter, W. Derave and J.F. Wojtaszewski (2001) which stated that exercise and hypoxia (resembled in occlusion the procedure in the recent study) induce glucose increase.

Exhaustive bout of wrestling performance represented in recent customized match and hyperemic effect of occlusion- perfusion; recovery modality coincided with the previous finding of J.D. Fluckey et al. (1994) and J. Henriksson (1995), where the reduction in muscle glycogen was an important factor of increasing insulin sensitivity in the post exercise. P. Adams (2015) declared that the high increase in blood glucose lasted up to 1 hour post exercise, leading to Plasma insulin levels rise, correcting the glucose level and restoring muscle glycogen.

The recovery modalities applied in recent study proved their effectiveness in recovery improvement, especially with the dietary restriction condition. The utilization of these different modalities differs by the compression pressure level and the technique of inflation-deflation sequence. The idea of these modalities depends on manipulating blood flow speed and volume, flushing out muscles fatigue products such as lactic acid, which enhance recovery, especially in wrestling matches where multiple performances were exerted. These kinds of compression modalities had been used in blood flow restriction "BFR" training technique, which involves manipulating blood flow, increasing anaerobic function of muscles and enhancing rehabilitation, as in the studies of M. Ghoraba, M. Ghazy and M. El Tomey (2017), L. Hughes, B. Paton, B. Rosenblatt, C. Gissane and S.D. Patterson (2017), A. Kraus et al.

(2015), C.J. McNeil, M.D. Allen, E. Olympico, J.K. Shoemaker and C.L. Rice (2015) and J. Slysz, J. Stultz and J.F. Burr (2016).

Conclusions

Compression modalities used in post exercise recovery with different pressure level and technique, as used in this study, showed superiority of high pressure with 160–20 mm Hg, which accelerated recovery time due to its hyperemic effect of the perfusion. This technique should be used in regard to the athletes' muscularity and blood pressure "systolic and diastolic numbers" with high concern to nerves safety. M.E. Tschakovsky et al. (2004) regarded that peripheral nervous system likely played a role in vasodilation along with compression effect of increasing oxygenation. However, N. Labropoulos, J. Cunningham, S.S. Kang, M.A. Mansour and W.H. Baker (2010) emphasized that higher pressure produced greater increase in blood flow as well as quicker acceleration of blood flow, there is not a fixed value for compression level so far and it is still a matter of research.

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READINESS TO CHANGE AND PRO-HEALTH BEHAVIOURS AMONG STUDENTS OF PHYSICAL EDUCATION AND OTHER TEACHING SPECIALISATIONS

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Abstract The aim of the study was to analyse the relationship between the profile of readiness to change and pro-health behaviours as well as physical activity among students of physical education and other teaching specialisation. The study was carried out among a randomly selected group of teaching specialisation students (464 females and 143 males). In the research, the following were applied: Inventory of Pro-health Behaviours by Z. Juczyński, the IPAQ and the Readiness to Change Questionnaire. Diversification in pro-health behaviours, level of physical activity and selected features of readiness to change among students of teaching specialisations was demonstrated. In the general population, along with the increase in self-confidence, passion and optimism, the level of health pro-behaviours also increased. Regardless of the type of studies, there were significant positive correlations between the level of physical activity and the degree of passion, optimism and boldness. Among students of other teaching specialisations (apart from physical education), a positive relationship was also noted between physical activity and creativity. Among the students of teaching specialisations, a correlation was demonstrated between the level of pro-health behaviours and physical activity as well as the degree of selected features constituting readiness to change.

Key words students of teaching specialisations, pro-health behaviours, physical activity, readiness to change

Introduction

A key determinant of holistically defined health is a lifestyle shaped as a result of the socio-cultural factors and personal resources of a subject. Preservation and improvement of health potential are fostered by pro-health behaviours, particularly related to a rational diet, recreational physical activity, effectively coping with psychological stress, undergoing regular preventative check-ups and avoiding psychoactive substances (Grey, 2017).

Despite the key role of a pro-health lifestyle in raising health potential and prevention of chronic diseases, numerous studies have demonstrated the prevalence of anti-health behaviours in the lifestyle of different population groups, including academic youth, even among those of teaching specialisations (Palacz, 2014; Deasy, Coughlan, Pironom, Jourdan, McNamara, 2015; Monhollen, Summers, Sabin, Rutherford, 2016; Kosiba, Gacek, Bogacz-Walancik, Wojtowicz, 2016) or teachers (Sharma et al., 2013; Laudańska-Krzemińska, 2014).

Pro-health behaviours, as behavioural determinants of health, are shaped in the process of socialisation. In this respect, a special role, apart from family, is played by schools, which have the obligation to create conditions for shaping the pro-health attitudes and behaviours of students, including the implementation of health education. An important condition for fulfilling the role of a health educator is a teacher's readiness to present his/her own attitude towards health via pro-health behaviours, making teachers role models for students (Schee, Gard, 2014). Referring to the subjectivity of health, active and conscious care for health among teachers is conducive to shaping positive attitudes towards health and factors conditioning them in children and adolescents. Being aware of the importance and value of health, a teacher becomes a more reliable health educator (Schee, Gard, 2014; Moynihan, Paakkari, Välimaa, Jourdan, Mannix-McNamara, 2015). In this context, the proper preparation of teaching specialisation students in the field of knowledge, skills and social competences is a prerequisite for the effective implementation of school health education among children and adolescents (Moynihan et al., 2015).

As is evident from contemporary concepts regarding professional development, developing and shaping teachers' qualifications is of processual nature, and in order to properly function in this profession, readiness to change, including modification and improvement of professional competences, is a key aspect (Leśniewska, 2016) also found in the area of health education (Talvio, Berg, Ketonen, Komulainen, Lonka, 2015).

The optimal level of readiness to change facilitates the enrichment of teachers' competences regarding the implementation of school health education. Readiness to change is defined as the subjective perception of requirements from the environment, related to specific emotional states, cognitive processes and behavioural elements, which is the result of interpreting objective reality. In the model by R. Kriegel and D. Brandt, which concerns readiness to change, seven indices are distinguished, namely: creativity, passion, self-confidence, optimism, boldness, adaptability and tolerance of uncertainty. A person of ready-to-change profile is able to generate ideas and effectively implement them, s/he positively responds to reality, is active and open to new challenges, aware of his/her competences and able to adapt to changing environmental conditions (Kriegel, Brandt, 1996).

Readiness to change fits into the essence of modern models of change in health behaviours, including the transtheoretical model, concerning graded introduction, continuation and maintenance of behaviours that are conducive to health. In this context, literature comprises works on changing health behaviours, including limiting the consumption of alcoholic beverages (Kazemi, Wagenfeld, Van Horn, Levine, Dmochowski, 2011) and increasing the level of physical activity among students (Dae-Jung, Ki-Jong, Myoung, 2014; Han, Gabriel, Kohl, 2017). Research on readiness to change in the context of tackling various challenges was undertaken among various professional groups, including teachers (Leśniewska, 2016; Yusuf, Gil, 2016; Winardi, Prianto, 2016; Kondakci, Beycioğlu, Sincar, Ugurlu, 2017).

Pro-health behaviours, including physical activity, are key determinants of health, and students of teaching specialisations taking up professional work will be involved in the implementation of school health education. Research on the lifestyle of teaching specialisation academic youth in the context of features constituting their

readiness to change, as one of the factors determining the development of professional competences, is also present in the dimension of health culture.

The aim of the study was to assess pro-health behaviour and level of physical activity, readiness to change, as well as to analyse the relationship between the examined variables (profile of readiness to change and health-related behaviours) among students of physical education (PE) and other teaching specialisations (OTS).

The specific objectives concerned analysis of: a) the degree of pro-health behaviours and the level of physical activity as well as readiness to change depending on sex and educational profile; b) the relationship between the degree of pro-health behaviours and the level of physical activity as well as the degree of features constituting readiness to change depending on sex and educational profile. The hypothesis was verified stating that female and male students demonstrating higher values of indices constituting readiness to change present, at the same time, a higher level of pro-health behaviours and physical activity.

Material and methods

The study was carried out among 607 subjects, including 464 females (76.44%) and 143 males (23.56%), aged 22–28 (M: 22) – teaching specialisation female and male students of 3rd year B.A. studies at four Krakow universities: the Pedagogical University (53.05%), the Jagiellonian University (20.26%), the Andrzej Frycz Modrzewski Krakow University (6.75%) and the University of Physical Education (19.93%).

On the basis of the Inventory of Pro-health Behaviours (IZZ) by Z. Juczyński (2012), four categories of health behaviours (proper eating habits, preventive behaviours, pro-health practices and positive mental attitude) and the overall pro-health behaviour index were assessed.

Based on the short version of the International Physical Activity Questionnaire (IPAQ), the level of physical activity was assessed, including four of its categories: vigorous activity (above 1,500 or 3,000 MET-min/week), moderate physical activity (600–1,500 or 600–3,000 MET-min/week), walking (less than 600 MET-min/week) and sitting (Biernat, Stupnicki, Lebiedzinski, Janczewska, 2008).

Based on the Readiness to Change Questionnaire (Kriegel, Brandt, 1996, Polish translation: Brzezińska, Paszkowska-Rogacz, 2002), the degree of readiness to change (creativity, passion, self-confidence, optimism, boldness, adaptability and tolerance of uncertainty) was assessed. The scale contains 35 items describing beliefs, attitudes and behaviours regarding various life situations.

Statistical analysis was performed using the SPSS 21 and Statistica PL 13 programmes with: a) the Student's *t*-test to determine gender-based differences related to educational profile (PE and OTS) – in the absence of homogeneity of variance, the *t*-test was carried out with a separate estimation of variance; b) analysis of variance for factor systems to determine differences in indices regarding the level of readiness to change depending on sex and specialisation of studies (PE and OTS); c) analysis of moderation to determine differences regarding the relationship between the level of indices of readiness to change, overall level of physical activity and the overall index of pro-health behaviours in the studied groups. Normality of distribution was determined using the Shapiro-Wilk test and distribution analysis. The significance level of $\alpha = 0.05$ was assumed.

Results

Intensity of pro-health behaviours (IZZ) among teaching specialisation students

Among the categories of pro-health behaviours included in the IZZ, students of physical education (PE) obtained the highest average scores in the category of positive mental attitude (21.01), while students of other teaching specialisations (OTS) obtained 19.48 points for everyday pro-health practices and 19.47 for positive mental attitude.

Statistically significant differences were found between physical education students and those of other teaching specialisations in the area of positive mental attitude and proper eating habits (in favour of PE students) and regarding daily pro-health practices (in favour of OTS students). In the category of preventive behaviours and the IZZ overall index of pro-health behaviours, there were no differences in the results depending on type of teaching specialisation (Table 1).

Table 1. Categories of pro-health behaviours (IZZ) among the academic youth depending on type of teaching specialisation (PE and OTS)

Pro-health behaviours	Total (n = 607)		PE (n = 121)		OTS (n = 486)		<i>t</i> (df = 605)	<i>p</i>
	\bar{x}	SD	\bar{x}	SD	\bar{x}	SD		
Positive mental attitude (PMA)	19.77	4.13	21.01	3.78	19.47	4.16	3.71	<0.001
Preventative behaviours (PB)	18.00	4.61	18.07	4.50	17.99	4.64	0.17	0.867
Proper eating habits (PEH)	19.22	4.93	20.31	4.85	18.95	4.92	2.73	0.007
Pro-health practices (PHP)	19.29	4.07	18.52	3.86	19.48	4.10	-2.32	0.021
IZZ overall index	76.28	12.75	77.90	12.33	75.88	12.83	1.57	0.118

N – number of observations; \bar{x} – mean; SD – standard deviation; *t* – Student's *t*-test; *p* – *p* value.

Analysis of IZZ results depending on sex showed that females obtained significantly higher average values than the males in terms of degree of the overall pro-health behaviour index (*p* < 0.001), preventive behaviours (*p* < 0.001) and proper eating habits (*p* < 0.001) (Table 2).

Table 2. Categories of pro-health behaviours (IZZ) among academic youth depending on sex

Pro-health behaviours	Total (n = 607)		Females (n = 464)		Males (n = 143)		<i>t</i> (df = 605)	<i>p</i>
	\bar{x}	SD	\bar{x}	SD	\bar{x}	SD		
Positive mental attitude (PMA)	19.77	4.13	19.86	4.09	19.50	4.25	0.90	0.370
Preventative behaviours (PB)	18.00	4.61	18.41	4.57	16.68	4.48	3.98	<0.001
Proper eating habits (PEH)	19.22	4.93	19.62	4.77	17.90	5.23	3.71	<0.001
Pro-health practices (PHP)	19.29	4.07	19.46	3.99	18.71	4.28	1.92	0.055
IZZ overall index	76.28	12.75	77.36	12.30	72.79	13.56	3.79	<0.001

N – number of observations; \bar{x} – mean; SD – standard deviation; *t* – Student's *t*-test; *p* – *p* value.

Physical activity level (IPAQ) among students of teaching specialisations

Among the physical activity categories included in the IPAQ questionnaire, physical education students obtained statistically significantly higher values for indices regarding vigorous and moderate efforts (IPAQ), and significantly lower values for the sitting index (IPAQ) than students of other teaching specialisations. It was also shown that the level of physical activity of physical education students expressed in the overall IPAQ index was statistically significantly higher than that for other teaching specialisations (Table 3).

Table 3. IPAQ physical activity categories (MET-min/week) of students according to teaching specialisation (PE and OTS)

IPAQ categories	Total			PE			OTS			<i>t</i>	df	<i>p</i>
	N	\bar{x}	SD	N	\bar{x}	SD	N	\bar{x}	SD			
IPAQ vigorous	587	1,794.28	2,728.55	119	4,153.95	3,662.84	468	1,194.27	2,042.66	-8.49	137.18	<0.001
IPAQ moderate	580	966.76	1,582.47	119	1,923.03	1,962.46	461	719.91	1,366.19	-6.30	148.77	<0.001
IPAQ walking	560	2,951.00	2,874.76	115	3,306.17	2,911.37	445	2,859.21	2,861.35	-1.49	558.00	0.137
IPAQ sitting	510	371.29	172.24	117	277.44	147.12	393	399.24	169.42	7.03	508.00	<0.001
IPAQ overall index	532	5,812.28	5,192.33	114	9,451.18	5,920.31	418	4,819.85	4,497.27	-7.76	150.36	<0.001

N – number of observations; \bar{x} – mean; SD – standard deviation; *t* – Student's *t*-test; df – degrees of freedom; *p* – *p* value.

Analysis of IPAQ results in relation to sex revealed that males obtained significantly higher values for indices concerning vigorous (*p* < 0.001), moderate (*p* = 0.001) and overall physical activity (*p* < 0.001) than females. At the same time, they spent significantly less time sitting per week (*p* < 0.001) (Table 4).

Table 4. IPAQ physical activity categories (MET-min/week) of students according to sex

IPAQ categories	Total			F			M			<i>T</i>	df	<i>p</i>
	N	\bar{x}	SD	N	\bar{x}	SD	N	\bar{x}	SD			
IPAQ vigorous	587	1,794.28	2,728.55	446	1,406.46	2,291.24	141	3,020.99	3,532.85	-5.10	178.71	<0.001
IPAQ moderate	580	966.76	1,582.47	440	818.14	1,377.38	140	1,433.86	2,037.08	-3.34	181.17	0.001
IPAQ walking	560	2,951.00	2,874.76	429	2,910.15	2,920.54	131	3,084.74	2,725.93	-0.61	558.00	0.543
IPAQ sitting	510	371.29	172.24	385	387.35	170.70	125	321.84	168.13	3.74	508.00	<0.001
IPAQ overall index	532	5,812.28	5,192.33	406	5,161.91	4,688.91	126	7,907.92	6,123.08	-4.63	172.87	<0.001

N – number of observations; \bar{x} – mean; SD – standard deviation; *t* – Student's *t*-test; df – degrees of freedom; *p* – *p* value.

Level of readiness to change among teaching specialisation students

Of the features in the Readiness to Change Questionnaire, the students of physical education and other teaching specialisations obtained the highest scores in terms of degree of passion and creativity, and the lowest regarding boldness and tolerance of uncertainty (Table 5).

Table 5. Categories of features determining readiness to change among PE students and other teaching specialisations (OTS) (descriptive statistics)

Type of school	Sex	N	Creativity		Passion		Self-confidence		Optimism		Boldness		Adaptation		Tolerance of uncertainty	
			\bar{x}	SD	\bar{x}	SD	\bar{x}	SD	\bar{x}	SD	\bar{x}	SD	\bar{x}	SD	\bar{x}	SD
OTS	M	70	21.53	4.43	18.64	4.88	18.67	4.24	18.41	5.53	16.63	4.34	17.23	4.24	13.41	3.91
	F	416	20.15	4.05	19.43	4.40	17.70	4.33	19.25	5.03	15.58	4.51	17.10	3.85	12.09	4.45
	total	486	20.35	4.13	19.32	4.48	17.84	4.33	19.13	5.11	15.73	4.50	17.12	3.91	12.28	4.40
PE	M	73	22.01	3.00	22.12	3.75	20.67	2.99	20.29	4.47	16.40	3.85	17.00	3.50	13.33	3.26
	F	48	21.56	3.19	22.56	4.21	19.15	4.18	20.77	4.22	16.69	3.87	18.00	3.29	12.52	3.61
	total	121	21.83	3.07	22.30	3.93	20.07	3.57	20.48	4.36	16.51	3.84	17.40	3.44	13.01	3.41
Total	M	143	21.78	3.76	20.42	4.66	19.69	3.78	19.37	5.08	16.51	4.08	17.11	3.87	13.37	3.58
	F	464	20.30	3.99	19.75	4.48	17.85	4.33	19.41	4.97	15.70	4.46	17.20	3.80	12.14	4.37
	total	607	20.65	3.98	19.91	4.53	18.29	4.28	19.40	4.99	15.89	4.38	17.18	3.82	12.43	4.23

N – number of observations; \bar{x} – mean; SD – standard deviation; df – degrees of freedom.

Analysis of the results depending on the type of teaching specialisation (PE and OTS) and sex showed that PE students (regardless of gender) were characterised by a higher level of creativity ($p < 0.05$), passion as well as self-confidence ($p < 0.001$) and optimism ($p < 0.01$) than students of other teaching specialisations (OTS), and men (regardless of the type of teaching specialisation) demonstrated greater creativity ($p < 0.05$), self-confidence ($p < 0.01$) and a higher level of tolerance of uncertainty ($p < 0.05$) than women. However, no statistically significant differences were found regarding the level of boldness, adaptability or tolerance of uncertainty depending on the analysed variables (Table 6).

Table 6. Level of features characterising readiness to change among females and males studying PE and other teaching specialisations (OTS)

		Creativity		Passion		Self-confidence		Optimism		Boldness		Adaptation		Tolerance of uncertainty	
Effect	df	F	P	F	P	F	p	F	p	F	p	F	p	F	p
Teaching specialisation	1	4.56	0.033	44.65	<0.001	13.31	<0.001	9.12	0.003	0.78	0.378	0.60	0.440	0.13	0.718
Sex	1	4.24	0.040	1.54	0.216	6.99	0.008	1.38	0.241	0.58	0.446	1.02	0.312	5.01	0.026
Teaching specialisation * sex	1	1.09	0.298	0.12	0.725	0.35	0.556	0.10	0.754	1.82	0.178	1.69	0.193	0.29	0.589
Error		603													
Total		607													

F – coefficient of analysis of variance; df – degrees of freedom; p – p value.

Relationships between the degree of features characteristic of readiness to change, pro-health behaviours (IZZ) and the level of physical activity (IPAQ) among teaching specialisation students

Analysis of the relationships between the degree of individual features comprising change and degree of pro-health behaviours showed differentiation depending on the type of teaching specialisation (as a moderator)

(Table 7). It was demonstrated that the type of teaching specialisation moderated the relationship of pro-health behaviours with creativity and tolerance of uncertainty ($p < 0.05$). Among PE students, the level of pro-health behaviours increased along with creativity ($p < 0.05$), while a decrease could be noted along with the increase in tolerance of uncertainty ($p = 0.001$). However, for students of other teaching specialisations, these two characteristics of readiness to change were not significantly correlated with pro-health behaviours (Figures 1 and 2). It was also found that regardless of the teaching specialisation, the level of students' pro-health behaviours increased with increasing self-confidence, passion and optimism. At the same time, in none of the subjects were there significant relationships between the level of pro-health behaviours, adaptability or boldness.

Table 7. Correlations between features of readiness to change and pro-health behaviours according to type of teaching specialisation (PE and OTS)

Dependent variable	Moderator	Independent variable	β	SE	<i>t</i>	<i>p</i>	Interaction
IZZ	Type of teaching specialisation	creativity	0.09	0.05	2.08	0.037	$\beta_O = 0.04 (p = 0.420)$ $\beta_P = 0.30 (p = 0.012)$
		passion	0.02	0.05	0.47	0.636	$\beta_O = 0.12 (p = 0.008)$ $\beta_P = 0.18 (p = 0.092)$
		self-confidence	0.03	0.05	0.66	0.508	$\beta_O = 0.18 (p < 0.001)$ $\beta_P = 0.26 (p = 0.017)$
		optimism	-0.04	0.04	-1.04	0.298	$\beta_O = 0.28 (p < 0.001)$ $\beta_P = 0.17 (p = 0.094)$
		boldness	-0.04	0.04	-0.82	0.415	$\beta_O = 0.05 (p = 0.291)$ $\beta_P = -0.05 (p = 0.661)$
		adaptability	-0.01	0.04	-0.17	0.865	$\beta_O = 0.01 (p = 0.751)$ $\beta_P < 0.01 (p = 0.963)$
		tolerance of uncertainty	-0.13	0.04	-3.03	0.003	$\beta_O = -0.01 (p = 0.824)$ $\beta_P = -0.37 (p = 0.001)$

Legend: β – Beta standardised coefficient; SE – standard error; *t*: Student's *t*-test; *p*: p value; O – other teaching specialisations; P – physical education (PE).

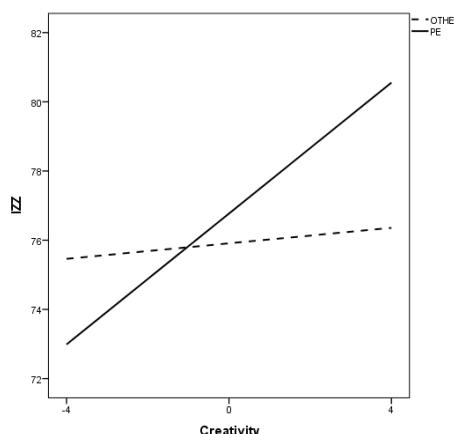


Figure 1. Relationship between the level of pro-health behaviours and creativity depending on the type of teaching specialisation (PE and OTS)

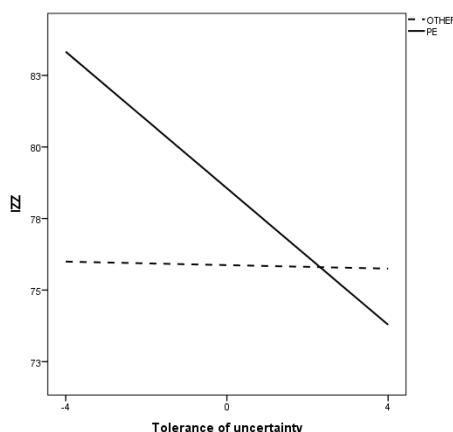


Figure 2. Relationship between the level of pro-health behaviours and tolerance of uncertainty depending on the type of teaching specialisation (PE and OTS)

Analysis of correlations between the degree of individual features comprising readiness to change and the level of physical activity did not show differentiation according to type of teaching specialisation (as a moderator). Regardless of the type of studies, there were significant, positive correlations between physical activity, passion, optimism and boldness. Among students of other teaching specialisations, there was a positive correlation between physical activity and creativity (Table 8).

Table 8. Correlations between features of readiness to change and the level of physical activity depending on type of teaching specialisation (PE and OTS)

Dependent variable	Independent variable	β	SE	t	p	Interaction
(IPAQ) overall index of physical activity	creativity	-0.01	0.04	-0.23	0.817	$\beta_O = 0.15 (p = 0.001)$ $\beta_P = 0.12 (p = 0.282)$
	passion	0.05	0.05	1.02	0.306	$\beta_O = 0.18 (p < 0.001)$ $\beta_P = 0.29 (p = 0.003)$
	self-confidence	-0.04	0.05	-0.87	0.386	$\beta_O = 0.08 (p = 0.061)$ $\beta_P = -0.02 (p = 0.877)$
	optimism	0.05	0.04	1.08	0.281	$\beta_O = 0.09 (p = 0.036)$ $\beta_P = 0.21 (p = 0.035)$
	boldness	0.07	0.04	1.67	0.096	$\beta_O = 0.09 (p = 0.033)$ $\beta_P = 0.27 (p = 0.005)$
	adaptability	0.05	0.04	1.22	0.222	$\beta_O = 0.03 (p = 0.529)$ $\beta_P = 0.16 (p = 0.101)$
	tolerance of uncertainty	0.03	0.04	0.70	0.486	$\beta_O = -0.01 (p = 0.863)$ $\beta_P = 0.07 (p = 0.495)$

Legend: β – Beta standardised coefficient; SE – standard error; t: Student's t-test; p: p value; O – other universities; P – PE.

Discussion

The presented research showed differentiation in pro-health behaviours and physical activity level as well as features of readiness to change among the group of teaching specialisation students (physical education and other teaching specialisations) and the existence of dependence between categories of pro-health behaviours, physical activity and the level of selected features constituting readiness to change.

Based on the obtained results, it was found that among the four categories of behaviours that are conducive to health (positive mental attitude, proper eating habits, preventive behaviours and pro-health practices), in the case of students other than those studying physical education, so-called pro-health practices (appropriate amount of sleep and rest, recreational physical activity, limitation of stimulants) and interactions beneficial for mental health (positive thinking, maintaining proper relationships with other people and avoiding strong emotions and tensions) dominated. Physical education students, alike those from other specialisations, obtained the highest results in the area of positive mental attitude. The greatest negligence in both groups was demonstrated in the category of preventive behaviours.

The results obtained in this study regarding individual categories of pro-health behaviours were comparable to the results obtained by R. Rasińska (2012), in which students of Poznań universities showed the highest degree of behaviours in the area of positive mental attitude, and the lowest in the area of preventive behaviours. Also, in a study by J. Palacz (2014), the students of Holy Cross University in Kielce achieved the highest values in the area of positive mental attitude and pro-health practices, and lower values regarding rational dietary habits. These results were similar as in the case of students from the Medical University of Lublin, who presented the highest degree in the area of pro-health practices, and the lowest in the category of preventive behaviours (Kropornicka et al., 2015). Between the students of physical education and other teaching specialisations, statistically significant differences were found regarding positive mental attitude and proper eating habits (more favourable in the case of PE students) and everyday pro-health practices (more favourable for students of other teaching specialisations).

It was also shown that the women obtained higher average scores than the males in terms of the degree of the overall pro-health behaviour index. Statistically significant differences between the male and female students were also demonstrated in the area of preventive behaviours and proper eating habits. The obtained results may indicate greater involvement of female than male students of teaching specialisations in the process of conscious and active achievement as well as improvement of health potential.

One of the key elements of a pro-health lifestyle is physical activity. It was found that the total level (overall IPAQ MET-min/week) of physical education students was significantly higher than for students of other teaching specialisations. In addition, among the four categories of physical activity included in the IPAQ questionnaire, physical education students obtained significantly higher values in terms of vigorous and moderate efforts, and significantly lower values in the area of sitting (IPAQ). The higher level of both overall, vigorous and moderate physical activity is obviously related to the specificity of the field of study. The total physical activity of the studied Krakow academic group was determined at the level of 5,812.28 MET-min/week (PE – 9,451.18 MET-min/week and OTS – 4,819.85 MET-min/week).

There were also gender-related differences in the level of physical activity in the overall group of studied students. The males obtained higher values for vigorous and moderate indices as well as overall physical activity compared to women, and they also spent less time during the week on activities related to sitting. Studies by other authors show a varied level of physical activity of academic youth, with an indication of higher physical

activity among men than women (Chung-Yan, 2014; Bergier, Bergier, Tsos, 2016; Ćosić Mulahasanović, Nožinović Mujanović, Mujanović, Atiković, 2018). Similar trends were described among students of the State Higher Vocational School in Biała Podlaska, who also most frequently undertook walking (959.2 MET-min/week) and vigorous efforts (901.5 MET-min/week), more often declared by men than women (Bergier, Stepień, Niżnikowska, Bergier, 2014). The research conducted by K. Suğuksu (2011) among students of different nationalities showed the level of physical activity was higher among Polish than Turkish female (3,720 vs. 1,690 MET-min/week) and male students (5,045 vs. 2,590 MET-min/week).

The level of readiness to change, which consists of the following features: creativity, passion, self-confidence, optimism, boldness, adaptability and tolerance of uncertainty, may affect the overall attitude of subjects towards various types of modifications of health-related behaviours. The discussed research shows that students in total (PE and OTS) obtained the highest average results in terms of the degree of passion and creativity, and the lowest in boldness and tolerance of uncertainty. At the same time, it was shown that regardless of gender, PE students were characterised by a higher level of creativity and self-confidence than students of other teaching specialisations. However, regardless of the type of specialisation, the men were more creative and confident, and showed a higher level of tolerance of uncertainty than women. At the same time, students of the University of Physical Education had a higher level of passion and optimism than students of other teaching specialisations.

The research by G. Leśniewska (2016) showed limited readiness to change among teachers, varied depending on age and professional experience, with an indication of greater openness to change among younger teachers. Also, Brazilian studies have shown low readiness of teachers to change behaviours related to health problems (Rossi-Barbosa, Gama, Caldeira, 2015). Research on teachers' readiness to change has also proven that teachers, although they generally declare their willingness to actively participate in on-going changes, limit their readiness in situations of top-down changes, in which their participation in making decisions important for school and education is limited (Inandi, Gilic, 2016). Other studies have shown that trust in school as an institution is an important predictor of teachers' readiness to change (Inandi, Gilic, 2016; Kondakci, et al., 2017). In this context, one should point to the supporting role of the school environment, cooperating in favour of school culture in which teachers' communication and mutual relations are particularly strengthened and appreciated, becoming a "vital" force during periods of change (Zayim, Kondakci, 2014). Research results have also shown that teachers working at smaller schools are more willing to accept and implement changes in which cooperation, mutual commitment and support imply greater willingness and readiness to participate in changes (Zayim, Kondakci, 2014). In the system of education, knowledge on the level of teachers' readiness to change may be an important instrument for the effective functioning of a school.

Analysis of the relationship between the degree of features constituting students' readiness to change and the degree of pro-health behaviours as well as the level of physical activity showed that regardless of the type of specialisation, the students in total, along with the increase in self-confidence, passion and optimism, there was also an increase in the level of pro-health behaviours. In addition, regardless of the type of study, significant positive correlations were observed between physical activity, passion, optimism and boldness. In students other than those studying PE, teachers have also described a positive relationship between physical activity and creativity.

The positive correlations between selected features constituting readiness to change, pro-health behaviours and the level of physical activity are justified by their characteristics and are confirmed by the research of other authors. With respect to the two primary variables analysed (health-related behaviours and physical activity),

important relationships in the case of all teaching specialisation students were described for the characteristics of passion and optimism. Associations of other features occurred in relation to areas of individual lifestyle (self-confidence – pro-health behaviours of the whole group, and creativity – physical activity of OTS students). The obtained dependencies confirm that pro-health behaviours are determined by a wide range of factors, including those related to individual resources (Juczyński, 2012). Sense of optimism, correlated with sense of satisfaction with life and effectiveness, expressing the expectations of positive events, increasing motivation and consistency, are important personal resources regulating pro-health behaviours (Carver, Scheier, Segerstrom, 2010). Passion seems to correlate with optimism as a feature that strengthens other dimensions building readiness to change. Trends described in this study also refer to the results of other research, conducted at both Polish and foreign centres, among various population groups, including students (Posadzki, Stockl, Musonda, Tsouroufli, 2010; Schnettler et al., 2015; Lesani, Mohammadpoorasl, Javadi, Esfeh, Fakhari, 2016), athletes (Lipowski, 2012; Gacek, 2015), women recreationally training fitness (Gacek, 2017). The study by P. Posadzki et al. (2010) showed the significant positive effect of positively correlated psychological traits, including sense of self-efficacy, optimism and sense of coherence on the pro-health behaviours of Polish students. The results indicating a larger scale of rational food choices along with the increase in the sense of self-efficacy, life satisfaction and features positively correlated with the level of optimism were also obtained among Polish players of American football (Gacek, 2015) and women recreationally practicing fitness (Gacek, 2017). Relationships of life satisfaction with selected health determinants, including nutrition, were also confirmed in Chilean (Schnettler et al., 2015) and Iranian studies (Lesani et al., 2016). The predictive significance of the sense of one's own generalised effectiveness for the level of physical activity was confirmed among Chinese nursing students (Chung-Yan, 2014) and Malaysian students of various specialisations (Ler, Wee, Ling, 2017).

Conclusions

1. Among the categories of health behaviours, students of physical education obtained the highest results in the category of positive mental attitude, and students of other teaching specialisations in the area of so-called health practices and positive mental attitude. However, students showed greatest negligence (regardless of their specialisations) in the category of preventive behaviours.
2. Among the physical activity categories included in the IPAQ questionnaire, students of physical education obtained statistically significantly higher values for intense (IPAQ vigorous) and moderate (IPAQ moderate) indicators, and significantly lower results for the sitting time indicator (IPAQ) compared to students of other teaching specialisations.
3. Students of physical education and other teaching specialisations, among the features constituting readiness to change, achieved the highest scores in terms of degree of passion and creativity, and the lowest in boldness and tolerance of uncertainty.
4. Along with the degree of some features regarding readiness to change (self-confidence, passion and optimism), the level of pro-health behaviours of all teaching specialisation students increased (regardless of the type of specialisation).
5. Regardless of study specialisation, significant positive relationships between the level of physical activity and selected features of readiness to change (passion, optimism and boldness) have been noted. In students

of teaching specialisations other than physical education, there was also a positive correlation between physical activity and creativity.

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PREVALENCE, ATTITUDES AND MOTIVATIONS CONCERNING DIETARY SUPPLEMENTS IN SPORT INTAKE AMONG MEDICAL STUDENTS

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Abstract Nowadays, because of irregular lifestyle, high level of stress dietary supplements (DS) are becoming more popular as a source of needful nutrients among millions of people all over the world. The main purpose of present study was to estimate prevalence of dietary supplement consumption in sport, motivation in DS usage and sources of information.

Anonymous self-administered questionnaire was spread among students of medical faculty in the end of their fourth year of study. There were 218 students of the fourth year of the Medical Faculty, of which 60.1% were females and 39.9% were males. Males more often used or had been using dietary supplements than females. The most popular dietary supplement was whey protein. The most common aim among men was to build up muscle mass.

It is possible to state conclusions that prevalence of using dietary supplement among students is similar to values reported previously in the literature. Males were definitely more often undertaking physical activity in the gym and that could be the reason why they were definitely more often using specific dietary supplements.

Key words dietary supplements, students, nutrition, sport

Introduction

In 1994 for the first time dietary supplements (DS) were legally defined by Dietary Supplement Health and Education Act, which constituted DS as products containing one or more nutritional ingredients such as vitamins, minerals, herbs, amino acids, or other botanicals (DSHEA, 1994). Then, in 2002, a similar directive, which contained juridical regulations of supplements in European Union countries, was extradited European Union Parliament (European Communities, 2002).

It is known that proper and balanced diet is responsible for providing different kinds of nutrients which are essential for our body to work efficiently, to maintain good health and to protect from diseases (Block et al., 2007). Nowadays – because of irregular, sedentary lifestyle, high level of stress and insufficient length of time to prepare appropriate meals – DS are becoming more and more popular as a source of needful nutrients among millions of people all over the world (Archer et al., 2005; Stojiljković, Radulović, Jović, 2012). College students are known as a distinctive group more predisposed to consume DS because of specific lifestyle including studying, sports activity, alcohol and tobacco usage (Paffenbarger, Kampert, Lee, 1997; Borsari, Carey, 2001). Moreover, medical students are a specific group, due to acquired knowledge about health and adequate nutrition (Borsari, Carey, 2001). Taking part in different mandatory medical courses during studies such as biochemistry, internal medicine and pharmacology, should have an effect on the level of knowledge about supplements among students; validity of their usage, potential benefits and side effects. Therefore, it is essential to find out if studying medicine has an impact on using DS in sport. According to data from German National Nutritional Survey II, the usage of DS is especially common among group aged 18–24 and is increasing with age (Federal Research Center for Nutrition and Food, 2008). Available research show that the most popular causes of using DS among students are to maintain/improve general health, strengthen immune system and provide adequate nutrition (Alhomoud, Basil, Bondarev, 2016; Stanojevic-Ristic et al., 2017; Sotoudeh et al., 2015; Žeželj et al., 2018). Even though the usage of DS can lead to improvement of general condition, endurance and appearance, help maintain good health and lower the level of stress, the specific influence of supplements to our organism is still not clarified (Froiland, Koszewski, Hingst, Kopecky, 2004; Erdman, Fung, Reimer, 2006; Lukaski, 2004).

Materials and methods

Anonymous self-administered questionnaire (Appendix A) was spread among students of Medical Faculty at the end of their fourth year on the Medical University of Lublin. The survey was composed of one choice questions (f.e. "Do you train in the gym?") as well as multiple choice questions (f.e. "Which from the most popular dietary supplements in sport mentioned below do you use /used?"), which were 19 in total. At the beginning we collected demographic data such as age, sex, place of residence, marital status. In the following questions, the respondents answered if they had been going to the gym and how often. Furthermore, we asked students if they had been using dietary supplements in sport, which type and what was the aim of using. The last part contained questions about the sources of information about supplements.

The results of the survey were statistically analyzed. The values of analyzed parameters were presented by numbers and percentage. Chi² test was used to detect dependence between analyzed variables. Moreover, Spearman's rank correlation was performed in order to examine dependency among some of the variables. The level of significance was $p < 0.05$, which signalized the existence of statistically significant differences and dependences. Database and statistical analysis were carried out using Statistica 9.1 (StatSoft, Poland).

Results

General characteristic of the study group is specified in Table 1.

Table 1. Characteristic of surveyed students of the fourth year of Medical Faculty

All	N = 218	%
Sex		
Females	131	60.10
Males	87	39.90
Place of residence		
Countryside	33	15.00
City (<150,000 inhabitants)	70	32.20
City (>150,000 inhabitants)	115	52.75
Age		
21–22 years old	40	17.88
23–24 years old	145	66.50
≥25 years old	34	15.60

The survey shows that there exists a difference between males and females in training in a gym (Table 2), while men definitely more often attend to the gym ($p = 0.02314$).

Table 2. Dependence between training in a gym among genders

		Do you train in a gym?		Chi ²	p	
		Yes	No			
Females	N	39	92	5.157959	$p = 0.02314$	
	%	29.77	70.23			
Males	N	39	48	55.17	–	
	%	44.83	55.17			
In total	N	78	140			
	%	35.78	64.22			

The present survey had in view to estimate dependency between dwelling place and attending to the gym. The number of students of both sexes, who confirmed training in the gym, is slightly larger among the respondents living in more populated cities ($>150,000$ inhabitants), although the differences are not statistically significant. Among the students, males used or had been using dietary supplements definitely more often than females (Table 3).

The most popular dietary supplement among both genders was whey protein. Moreover, definitely more males than females used creatinine ($p = 0.00022$). Distinctly more men than women used whey protein ($p = 0.02499$) (Table 4).

Table 3. Consumption of dietary supplements in sport among all the respondents

		Have you ever used dietary supplements in sport?			Chi ² p
		never used	had used before	currently using	
	N	109	9	13	
Females	%	83.21	6.87	9.92	23.98776 p = 0.00001
	N	46	21	20	
Males	%	52.87	24.14	22.99	
	N	155	30	33	
In total	%	71.1	13.76	15.14	-

Table 4. Consumption of specific dietary supplements among the respondents who confirmed consumption of dietary supplements currently or in the past

		Dietary supplement							
		BCAA	creatine	arginine	fatty acids	β-alanine	whey protein	gainer	carbohydrates
Females	N	7	2	1	4	1	9	1	2
	%	31.82	9.09	4.55	18.18	4.55	40.91	4.55	9.09
Males	N	21	25	4	7	5	30	11	7
	%	48.78	60.98	9.76	17.07	12.20	73.17	26.83	17.07
X ²		1.467614	13.69103	0.0578628	0.0564436	0.28771907	5.024963	3.278853	0.2357262
	p	0.22573	p = 0.00022	p = 0.80991	p = 0.81221	p = 0.59203	p = 0.02499	p = 0.07018	p = 0.62731
In all	N	28	27	5	11	6	39	12	9
	%	12.84	12.38	2.3	5.04	2.75	17.89	5.5	4.13

The most popular aim among men was to build up muscle mass and the difference between genders in case of that purpose was significant ($p = 0.00015$). Among females the most common aim of dietary supplement consumption was to reduce adipose tissue (Table 5).

Table 5. Purposes of dietary supplements consumption among the respondents who confirmed using dietary supplements

		Purpose				
		build up muscle mass	improvement of condition and endurance	reduction of adipose tissue	maintain health and strengthen immune system	improvement of appearance
Females	N	4	2	11	4	5
	%	18.18	9.09	50	18.18	22.73
Males	N	28	12	12	7	5
	%	68.29	29.27	29.27	17.07	12.20
X ²		14.38465	2.306125	1.835722	0.0564436	0.5313805
	p	0.00015	p = 0.12887	p = 0.17546	p = 0.81221	p = 0.46603
In all	N	32	14	23	11	10
	%	50.79	22.22	36.51	17.46	15.87

The most common way among both genders to obtain information was through the Internet. Significantly more men used newspapers as a source of knowledge than women, where $p = 0.01553$ (Table 6).

Table 6. Sources of knowledge about dietary supplements among the respondents

		Sources of knowledge				
		friends	the Internet	newspapers	physicians	others
Females	N	33	89	12	15	11
	%	25.19	67.94	9.16	11.45	8.40
Males	N	19	59	18	6	12
	%	21.84	67.82	20.69	6.90	13.79
χ^2		0.3233562	0.0003619	5.855683	0.7772275	1,091954
		$p = 0.56960$	$p = 0.98482$	$p = 0.01553$	$p = 0.37799$	$p = 0.29604$
In all	N	52	148	30	21	23
	%	23.85	67.89	13.76	9.58	10.55

Discussion

The present survey had in view to estimate consumption of DS in sport among medical students and the results of the research showed that 28.89% of students were currently using or had used supplements. Obtained results were similar to those in other research. According to available data the prevalence of DS consumption (mainly vitamins, herbs, microelements) was present among about 33% of Medical Faculty students (Alhomoud et al., 2016; Sotoudeh et al., 2015; Žeželj et al., 2018). In addition, the surveys detected that Medical Sciences students had used DS slightly more often than non-medical sciences students (Stojiljković et al., 2012; Alhomoud et al., 2016; Žeželj et al., 2018) and general population (Axon, Vanova, Edel, Slack, 2017). Higher educational status predisposes to more frequent DS consumption due to enrichment of nutrition (Alfawaz et al. 2017; Pouchieu et al., 2013). Moreover, the surveys showed that the knowledge of DS definition and its safety was statistically higher among Medical Science students, because of acquired knowledge during pharmacology and other medical courses (Žeželj et al., 2018; Al-Naggar, Chen, 2011; Azizi, Aghaee, Ebrahimi, Ranjabar, 2011).

In the present study, males used DS definitely more often than females, which was statistically significant. Therefore, the results in present scientific paper are not coherent with findings in other surveys. On the contrary, in some of the studies gender was not associated with DS intake (Žeželj et al., 2018), while in the others – females were using supplements more often (Sotoudeh et al., 2015). The variation in present study could be connected with the fact that the survey mainly concerns using DS in sport and males definitely more often attend to the gym. Some of the studies detected that the usage of DS is higher among more physically active respondents (Suleiman, Alboqai, Yasein, Al-Essa, El Masri, 2008). However, individual sport training may predispose to using supplements more than team sports (Sirico et al., 2018; Foote et al., 2003; Radimer et al., 2004; Ranelli, Dickerson, 1993; Gunther, Patterson, Kristal, Stratton, White, 2004; Dickinson et al., 2014).

The present research shows that the most common purpose of DS consumption in sport among males was to build up muscle mass (68.29%), while among females – to reduce adipose tissue (50%). Findings mentioned above are not consistent with the ones in other research. The most frequent reasons of taking DS (especially vitamins)

mentioned in available data was: maintain good health, strengthen immune system, provide adequate nutrition, enhance daily energy (Alhomoud et al., 2016; Stanojevic-Ristic et al., 2017; Sotoudeh et al., 2015; Žeželj et al., 2018). The difference between this scientific paper and others could be connected with the fact that the present survey was mainly concerned about using specific DS in sport and among physically active medical students. DS in sport have different effect; one of them is used to reduce adipose tissue, while the others – to build up muscle mass. Moreover, each DS should be used in specific dose or exact time of day (Kerksick et al., 2018). Therefore, the users of DS in sport have to have adequate knowledge about these substances. Other studies were centered upon using DS like minerals, herbs, vitamins. Scientific papers show that provision of nutritional status was the most common purpose among females, while enhancing stamina was the most frequent among males (Sotoudeh et al., 2015; Tsang, Pycz, Herbold, 2007; Saeedi, Mohd Nasir, Hazizi, Vafa, Rahimi Foroushani, 2013). Respondents who cared mainly about maintaining good health and exercise regularly, reported the lowest DS consumption (Vinnikov, Romanova, Dushpanova, Absatarova, Utepbergenova, 2018).

In the present survey the Internet was the most common source of knowledge of DS among the respondents (67.89%). The results were coherent with other studies. One of the researches presented that the Internet was the most popular source of knowledge among 66.1% of respondents (Žeželj et al., 2018), while in another study among 40% of students (Kobayashi, Sato, Umegaki, Chiba, 2017). On the contrary, another data reported that friends/family and a doctor were the most mainstream sources of information about DS (Al-Naggar et al., 2011; Dundas, Keller, 2003; Sharma et al., 2014). The comparison between medical and non-medical sciences students reported significant variations in sources of knowledge of DS among each group. Undergraduates of Medical Faculties read leaflets of products definitely more often, while non-medical undergraduates more frequent used friends or family advice (Žeželj et al., 2018).

Conclusions

This research mainly concerned specific dietary supplements used in sport. Based on obtained results, it is possible to state conclusions that: prevalence of using dietary supplement among students is similar to values reported previously in the literature. Males were definitely more often undertaking physical activity in the gym and that could be a reason why males were definitely more often using specific dietary supplements. The main purpose of using DS among men was to build up muscle mass, while among women – reduce adipose tissue. In both genders, the Internet was the most popular source of information about dietary supplements.

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THE INFLUENCE OF MODERN TECHNOLOGIES ON THE SELECTED DETERMINANTS OF TOURISM AND RECREATION DEVELOPMENT

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Abstract The 21st century, especially its second decade, is a period of very dynamically developing science and technology, which is particularly manifested in many discoveries and inventions. The development of medical sciences, biotechnology, cybernetics, and computer science are making important progress. Industrial robots and other machines carry out programmed work by specialists faster, more precisely and economically than workers. Currently, there is no problem with smartphones to book a plane ticket, accommodation in a hotel, order a taxi or set the shortest route to the holiday destination. Unfortunately, adverse effects of technological progress are also observed, e.g. loss of workplaces caused by the introduction of new production technologies, loosening of social bonds, loneliness and depression of the individual, etc. The aim of the conducted research was to get to know the respondents' opinions on selected problems related to modern technology in meeting the needs in the field of tourism and recreation and the impact of modern technology on the tourist labor market.

The research group was narrowed down to students studying at the Faculty of Physical Education and Health Promotion of the University. Its participants were first- and second-cycle students – a total of 211 people aged 18 to 25 (58 women and 153 men). According to our research, the 92.16% of the respondents use the services available via the Internet, for example for shopping. The 85.29% of the respondents are not afraid of the risk of losing their job to modern technologies. Our research presented in this article shows that the vast majority of the respondents perceive the negative impact of the development of modern technologies on the labor market related to tourism and recreation. In order to stay on such a labor market, employees should constantly acquire new qualifications and be ready for a change of their job at multiple times during their careers.

Key words physical activity, tourism, recreation, modern technologies, labor market

Introduction

The 21st century is a period of very dynamically developing science and technology, which can be observed especially in the field of medical sciences, biotechnology, cybernetics or in areas related to tourism and recreation. A large number of inventions finds application in all spheres of human activity and contributes to the faster development of civilization, which stimulates further progress in many spheres of life. The rapid growth of knowledge

makes it necessary to seek answers to the numerous questions that have troubled humanity. One of them is the problem of the practical use of such a huge and constantly growing knowledge base.

Industrial robots and automatons – especially in the automotive industry – have already performed work programmed by specialists in the production process of vehicles for a number of years, carrying out assigned tasks faster, more precisely and cheaper than human. Machines do not request for holidays, do not join trade unions nor do they require regenerative meals. The industry is therefore facing a technological revolution because parallel efforts are being made to improve autonomous vehicles. Self-driving vehicles will probably soon begin regular operation from the main airports to the big city centers. Technology makes new and previously unknown offers start to appear in the area of tourism and recreation, such as an orbital space trip which can be already available for reservation (Harari, 2018). Other examples demonstrating fast technical progress are computers, tablets, smartphones that are widely used in companies and also in the private life of every human being.

Modern technologies have undoubtedly had a profound impact on the life of an individual and, more broadly, civilizational changes, even global ones. Examples of the phenomena taking place include loosening of social bonds, loneliness, depression or loss of jobs caused by the introduction of new production methods. An incredible amount of information emerging at a rapid pace, which may cause some individuals to experience a kind of fatigue syndrome or, unfortunately often, have their brain overloaded with irrelevant information, may also be another social never-seen-before phenomenon until the times of the information revolution. There are millions of websites of companies and individuals on the Internet, and hundreds of thousands of messages appear on social media forums, and at the same time, countless emails are sent between network users. Huge information resources, therefore, force an individual to make choices and selectively absorb content.

The dynamic technological progress made it possible to manufacture equipment that also allows the development of new, previously undiscovered areas of the tourist and recreational services market. Previously unknown equipment capabilities, for example in the form of marking interesting objects with QR codes, virtual tours and trips to places of interest, or geotagging services are very popular and often used by tourists (Berbeka, Borodako, 2018).

Due to the drop in production prices and miniaturization, these devices become more accessible to the average user. For instance, smart watch type electronic equipment or fitness trackers etc. can be useful for people who care about their health and consciously implement planned activities related to their own recreation and a healthy lifestyle. Such technological solutions are designed for everyone who wishes to improve his/her physical condition, monitor his/her physical activity, the number of calories burned, or the length and quality of sleep (Bronikowski, Bronikowska, Glapal, 2016). More expensive and complex models are also equipped with a GPS module or virtual reality options that are compatible with applications installed in smartphones. Such trackers can be worn all day, because they are very light, often waterproof, not requiring frequent recharging, which extends their useful life. Fitness trackers and "smart" watches allow a user to maintain a good form or return to it, and improve his/her own well-being without the need to engage a personal trainer (Nadobnik, 2018). The great possibilities are also offered by the wireless Internet and satellite navigation technology. By using smartphones, a user can book an air ticket, check in a hotel, order a taxi or set the shortest route to his/her holiday destination. A mobile phone also often serves as the only camera carried by a modern tourist.

The dynamic development of modern technologies led to computers, tablets and smartphones enter new (sometimes surprising) areas of human activity. An example of using modern electronics are proposals for the use

of tablets in schools, including (which should no longer be surprising) during physical education lessons (Sinelnikov, 2012). High technological progress, miniaturization of devices, the decrease of prices of consumer electronics production, including so-called electronic haberdashery (fitness trackers, smart watches, etc.) makes it possible to talk about changes that take place in recreational and health behavior of children and adolescents. Numerous applications are created for the needs of consumers, including the needs of physical activity. At the same time, researchers postulate introducing such changes to curricula, so that PE lessons are also attractive for students and at the same time meet the needs of the 21st century in terms of content taught, in particular "Health Education", "Health Training" or "Whole Life Sports" (Bronikowski, 2015a).

The research carried out in the United States shows that 57% of smartphone users use their devices for holiday planning, some of them (32%) book air tickets and accommodation via mobile phones. 32% of tourists search for places worth visiting or attractions in their place of stay, while 27% of travelers store their airline boarding passes on mobile devices (Xi Yu, 2015), which is confirmed by a study of new technologies in sport and recreation that was conducted in Cracow (Berbeka, Lipecki, 2019).

In recent years, the tourist market has developed towards cheaper travel. This is due to the needs of tourists who prefer more frequent but shorter trips (Pettersson, Zillinger, 2011). These determinants cause geolocation devices (GPS) to become more popular or even indispensable. That is because they make it easier to reach the destination, replacing the classic maps, and in the place of stay, thanks to the Internet connection, there is no need to use local guides – all necessary information can be provided by the ICT network, allowing users to download and display information on their smartphones or tablets; additionally, users can specify the number of calories burned and post interesting travel photos on social media, etc.

There is also a growing need of enterprises for unrestricted access to information, which enables customer service at a convenient time for the consumer. Large global companies, hotel chains, airlines, fitness clubs, restaurants etc. serve customers through new and more efficient systems thanks to the enormous possibilities of modern technology. Not being able to allow themselves a short technical maintenance break, they enable customers to make purchases of products, services and reservations even 24 hours a day.

One of many practical and frequently used applications of information technology on the tourist market are "chatbots". These are computer programs with technologically advanced communication capabilities. They also work on tablets and smartphones on numerous platforms and operating systems. Thanks to them, there is the possibility of contacting a company that offers services of selling products using almost any language for the convenience of any potential client.

Owing to the technology, the popularity of virtual "smart" assistants, for example "Google" or "Alexa" is growing. These devices resemble small speakers that respond to voice commands and give users access to a range of useful services and extensive databases. The machine communicates with the user, for example helping in searching for holiday offers, flight connections, booking tickets, ordering a table at a selected restaurant, making an appointment or a visit to a fitness club, or even obtaining a recipe for a dish with a certain nutritional value and the desired number of calories. These devices are small in size, so they can be used at home or in the field. Electronic assistants use the database resources available on the Internet, thanks to which the user has access to a huge database of information, including up-to-date information, which in case of booking or setting up communication connections is necessary for their proper functioning. Applications available on almost all of the smartphones present on the market work similarly. Owing to modern software and technologically advanced equipment (hardware), every consumer with

a mobile phone, tablet or computer can start the personal virtual assistant service. Modern technology allows much more. In 2015, the first hotel of the "Henn na Hotel"¹ chain was opened in Japan, whose guests are served almost exclusively by machines. A humanoid robot welcomes guests at reception, assisting in check-in and then check-out, additionally it provides all necessary information in Japanese or English. The hotel bar serves drinks while the robot delivers luggage to the room. All these devices are able to execute commands given by a human voice.

The above phenomena are only selected examples that are becoming more and more visible in the world around us. They point to a certain trend in the impact of new technologies on tourism, recreation, physical activity and lifestyle of modern society in an environment where more frequently a person is supported or even sometimes replaced by machines. The purchase of air tickets, tickets for sporting events, booking trips, buying passes at ice rinks or swimming pools in most cases is possible without leaving home – via the Internet. The convenience of customers, no queues, multimedia and interactive presentations of offers, the opportunity to obtain other people's opinions on expert forums, etc. affects the decreasing number of employees hired in companies such as tourist offices, fitness clubs, recreational and other equipment rental centers, in which the owners have decided to implement modern sales and customer service systems.

The Aim of the Studies and Research Hypotheses

It is assumed that consumers of tourist services are very eager to use the opportunities provided by modern information technology. It is therefore appropriate to ask whether indeed and to what extent modern technologies determine the attitudes of customers, and whether it is possible to define potential threats resulting from phenomena accompanying the technical revolution. It is worth considering the issues of the perception of potential threats that may be associated with the ongoing processes of crowding out of people from the labor market and, thus, replacing people with the ubiquitous technique. Does technological development cause only positive changes in the area related to physical activity, tourism and recreation?

The views of people the vast majority of whom will be fulfilled professionally in the tourism and recreation industry and in other areas related to physical activity and culture or the promotion of a healthy lifestyle in the future may be particularly interesting.

Therefore, it has been suggested to test the following research hypotheses:

1. Universal access to information technology means that many consumers enjoy the opportunity to purchase goods and services online.
2. New technologies facilitate the implementation of professional responsibilities entrusted, so they are expected by employees.
3. Users of modern technical solutions use new technologies with elements of artificial intelligence to meet their own consumer needs in the field of tourism and recreation industry services.

Method

In order to provide answers to the author's questions in January 2018, a survey was conducted. The research method was carried out based on Babbie's survey research methods (Babbie, 2013). The research was anonymous, a questionnaire consisting of 25 questions closed with scaling (Yes/No/I do not know) and 5 additional questions

¹ See: <http://www.h-n-h.jp/en> (10.07.2019).

with the possibility of developing the statement was the tool for obtaining the data used for this purpose. Its participants were first- and second-cycle students – a total of 211 people aged 18 to 25 ($M = 22.65$), 58 women and 153 men. The research group was narrowed down to students studying at the Faculty of Physical Education and Health Promotion of the University of Szczecin in the following fields of studies: "Physical Education", "Tourism and Recreation", "Public Health" and "Sports Diagnostics". Graduates of these faculties could become trainers, PE teachers, healthy lifestyle advisers, fitness instructors, travel agents, tour leaders or tour guides for travel groups etc. The health of the population will largely depend on them in the future. Due to the imposed word limit for the article, it has been decided to present only a part of the results from the conducted research. Other results being part of wider inquiries regarding the impact of modern technologies on social, economic and cultural aspects of broadly understood physical education among children, adolescents and adults, will be presented by the author at a later stage in the scientific monograph.

The qualitative and quantitative analyses, as well as the collection of research results and the interpretation of results, were performed by using the Microsoft Excel Office 2013 program.

Results

Based on the questionnaires received – $n = 204$ people (96.6% return) – and after analyzing the data, it was possible to state that:

- a) 188 respondents (92.16%) made use of the possibility of making purchases via the Internet using access to the platforms of tourist, catering or transport companies at least once or more, and 16 of the surveyed students (7.84%) have never made use of the possibility of making purchases of tourist, catering or transport services through the computer network (Figure 1);

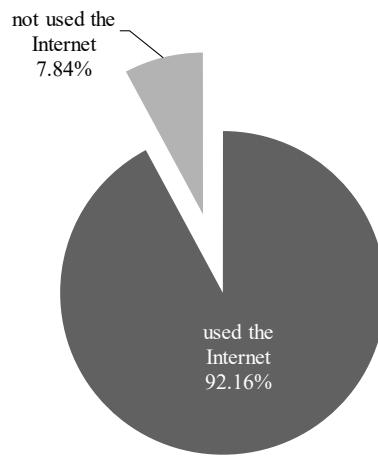


Figure 1. Percentage of respondents making purchases via the Internet using access to the platforms of tourist, catering or transport companies

- b) 119 respondents (58.33%) indicated preference for shopping in online stores, but the products other than those related to the tourist, recreational and catering sectors, while 85 respondents (41.67%) indicated preference for the traditional type of shopping in physical stores and their willingness to use the offers of "traditional" stores (Figure 2);

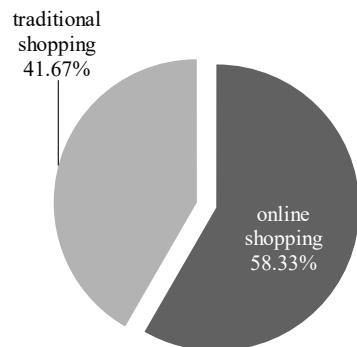


Figure 2. Percentage of the respondents' preference for the traditional or online type of shopping

- c) according to 85.29% of the respondents (174 people), modern technologies may have a negative impact on finding employment in the labor market related to tourist and recreational services, while 10.78% of the respondents (22 people) did not see the negative impact of modern technologies on finding future work in their acquired profession; the remaining 3.92% of the respondents (8 people) did not take an unequivocal position on the potentially negative or positive impact of modern technologies on the labor market (Figure 3);

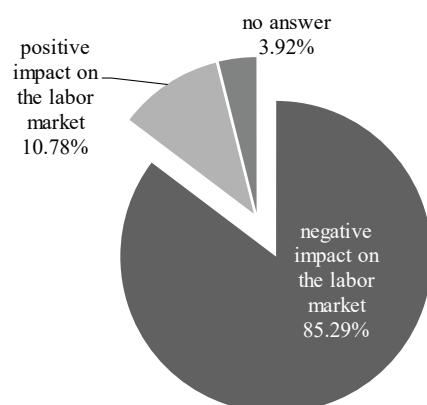


Figure 3. Percentage of the respondents indicating a potentially negative or positive impact of modern technologies on the labor market

- d) the analysis of received questionnaires shows that 141 people (69.12%) have not used the "smart" technical solutions available so far, while 63 people (30.88%) use elements of artificial intelligence, indicating examples of its presence in the form of, for example, online chatbots, virtual assistants, search engines, and booking systems, etc. (Figure 4).

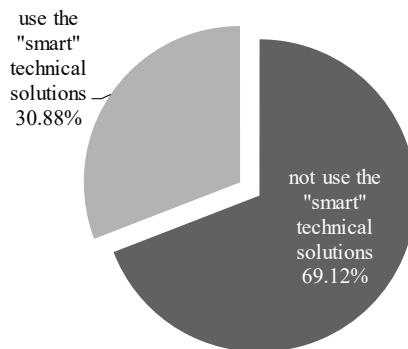


Figure 4. Percentage of the respondents using "smart" technical solutions

Discussion and Conclusions

Modern technologies, miniaturization of devices and their complexity, and in particular the Internet, currently play a significant role in all aspects of social and economic life of modern society (Mears, 2012). Changes also occur in such areas of professional activity as tourism, recreation and health promotion. Social media and a large number of applications available on smartphones and computers means that we automatically become consumers (participants) of new phenomena on the market that people have never experienced before. Examples of changes include sales channels for holiday trips, social marketing, thanks to which customers can exchange information, for instance, related to the quality of services, multimedia and attractive ads tailored to a specific recipient, quick hotel search engines or computer service and ticket booking systems etc. An interesting picture of the modern consumer emerges from the information received from the studies concerning the issues related to the purchase of services and products via the Internet. The vast majority of the respondents had the opportunity to purchase from tourist and recreational services provided remotely via the Internet, but considerably fewer people prefer shopping by the network for products and services other than those relating to tourism and recreation. It can, therefore, be assumed that the purchase of, for example, air tickets, holidays or other tourist services is more often carried out via a "virtual" channel than the purchase of, for example, food products, consumer electronics and household appliances, which are offered in physical stores – which is confirmed by the above results.

The vast majority of the respondents confirm the observation of the potentially negative impact of modern technologies on the labor market, which directly affects the financial situation of employees and their families. The tourist market also means services related to, among others, tourist information, tour-leading and tourist guiding the areas for which IT increasingly finds justification for the implementation of advanced technological solutions.

On the basis of the information obtained from the survey it can be concluded that the technological revolution we are experiencing, in particular digital technology, directly affects the labor market related to tourism and recreation, physical activity and promotion of a healthy lifestyle, which creates a real risk of job losses (Bronikowski, 2015b). Technology, on the one hand, facilitates the execution of official duties, but it can also be the cause of employment decline.

In technical development, we are currently witnessing the next step in the implementation of new technologies artificial intelligence, which is intended by scientists as a complex computer program simulating intelligent human behavior (Szymański, 2013). This technology has already been implemented in booking systems, virtual assistance, electronic translators, or chatbots, etc. The vast majority of the respondents declare that they have not used this technology so far. This result is surprising, given the fact that the significant majority of the respondents claimed that they made the purchase of tourist and recreational services via the Internet, and it is in this sector that the application of artificial intelligence is particularly widely used and thus visible.

Probably, a considerable number of the respondents did not know what technical solutions the operation of many on-line services is based on. Therefore, the elements of artificial intelligence were relatively little known to the respondents. The postulate of modifying curricula in selected fields of study and its subsequent implementation, which was mentioned at the beginning of this article, would be justified (Ludwiczak, Bronikowski, 2017).

Modern technology, together with automation and computerization, affects the efficiency of human resource management, increases sales and improves customer service, facilitates the management of deliveries (logistics) and the production process. Companies achieving global reach are subject to enormous competition, which has its source in the freedom of cross-border movement of people and goods (Kachniewska, Nawrocka, Pawlicz, 2012).

The Internet has blurred borders and space, and consumers with even minimal communication skills in foreign languages and the freedom to use information technologies are increasingly expecting high-quality products to meet their consumer needs relatively easily. The market of tourist and recreational services, health promotion and physical activity is no exception in this respect, therefore it is also subject to the rules and tendencies observed in other areas of human activity. The power of globalization alongside cultural, legal and political changes is the technological revolution, and in particular the commonly used computer information and booking systems, which are very good examples of the above. (Kędziorek, Różycza, 2016).

The distribution of offers and services by electronic means (online) is primarily due to the need for service providers, which are directed to providing the current product to the consumer as soon as possible in accordance with his/her specific needs. The choice of selling via virtual channels is currently becoming the most efficient way of delivering goods which significantly reduces distribution costs, but is also often expected by consumers themselves as a convenient and customer-friendly form (Oczachowska, 2015). Modern technology not only facilitates the implementation of tasks undertaken by a human, in some situations it substitutes or displaces a man from traditional work positions so far, for example, instead of a personal trainer in a fitness club "their" virtual character with any attractive avatar can be installed on the smartphone.

The rapidly changing human environment, including growing competition, forces the market to implement innovations. In the case of entities in tourism, recreation, fitness etc. sectors, it means continually customizing offerings to meet individual needs, learning about customer's "behaviors and habits, determining competitors" strategies and increasing competences and skills of employees in achieving customers' target wishes (Bednarczyk, 2006). Innovation also includes combining various types of services "into packages" (Krzyżanowska, 2013).

The observation of processes taking place in recent years allows to conclude that elements of modern technologies are particularly easily introduced into workplaces related to trade, transport, logistics and administrative service (BAS, 2016). Therefore, people working jobs with low education and qualifications requirements related to routine and repetitive simple tasks are inherently at risk of unemployment.

At the stage of the current technical advancement of the modern world, robots are becoming more and more of competition for people, although it seems to be a difficult task to automate workplaces where employees are expected to have social competence, for instance empathy, argumentation and negotiating skills. Machines still have problems with personal competences, including artistic and intellectual creativity.

The use of modern technologies on the tourist and recreational labor market in numerous aspects resembles other markets of economic activity, mainly related to services. The current generation of 20-year-olds will decide on the demand and supply in the perspective of the next few decades in the near future.

This new generation of employees should be equipped with the competences necessary to efficiently "find themselves" in the changing labor market. This applies to the efficiency in the use of information technology, the freedom to function in social networks, flexibility, mobility and commitment (Kachniewska, Para, 2014). Only employees who are aware of the necessity of constantly acquiring new qualifications and who agree to a change of position or even a place of work that is repeated during their professional career will find employment on such a labor market. Certainly, modern technology will have an impact on the directions of the development of the entire tourism and recreation industry, physical activity and health with similar determination that one observes the changes in other areas of a human activity.

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10 YEAR FOLLOW-UP STUDY OF GENDER IN SPORTS COVERAGE OF THE US AND SPANISH ONLINE NEWSPAPERS (2003–2004 VS. 2013–2014)

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Abstract The purpose of this paper was to assess the evolution of sports coverage regarding gender in online newspapers in two western societies Spain and the United States, in a period of ten years (2004 vs. 2014). A total of 2,951 articles with athletic content from the online newspapers usatoday.com and elmundo.es were analyzed. The variables registered were gender, placement in the newspaper, word count, inclusion of photographs, and the sports disciplines. The results show a significant reduction in sports articles in the two online newspapers for both genders. This reduction resulted in a decrease in the variability of sports articles. Further, there was a significant imbalance in sports news between the two genders. There was a significant reduction in the proportion of sports articles in both online newspapers for women, significantly reducing the accessibility of articles about women's sports. The gender imbalance was higher in the Spanish newspaper than in the U.S. newspaper. The gender imbalance was higher in the Spanish newspaper than in the U.S. newspaper. Both online newspapers showed an image of sport that is male-orientated, focused on elite-level sport and with an overall low number of sport disciplines.

Key words communication, mass media, online newspaper, gender, sport

Introduction

Sport, as part of our society, provides an image of how we develop on a physical level. Athletes' and teams' performances show how we improve, compete, overcome failure, and try to meet new challenges (e.g., faster, higher, and stronger). Sport has been predominantly male territory from its creation to current times. In the last few decades, however, there has been a significant increase in women's participation in sports (Garcia-Ferrando, Llopiz, 2010; NCAA, 2006; NFHS, 2006), although this increase has not been accompanied by changes in the presence of female athletes presented in the media (Cooky, Messner, Hextrum, 2013; Godoy-Pressland, 2014). Sport media provide an image of sport that is male, elite and selective (Chalabaev, Sarrazin, Fontayne, Boiché, Clément-Guillotin, 2013; Clarke, Ayres, 2014; Duncan, 1992; Lebel, Danylchuk, 2009; Trolan, 2013). Previous

research in politics, business, health, and marketing has demonstrated the media's influence over the public's perception of an issue or topic (Carroll, McCombs, 2003; McCombs, Shaw, 1972; Ogata, Denham, Springston, 2006). Greater accessibility of news about a topic involves more awareness and interest about this topic for the public. The image provided by sport media contributes toward maintaining the characteristics, traditions, interests, etc. of a society regarding sport, although the sport practice, with regard to gender and participation, has changed.

The imbalance in the way men's and women's sport is covered by the media is clear and well reported. Data from research and governmental reports show there is a significant imbalance regarding the number of news articles, their length, their importance, the orientation of the news, etc. (European Commission, 2014; United Nations, 2007). Though in recent decades there has been a slight improvement in the presence of female athletes in the media, women still appear in less than 10% of media coverage (Richards, 2015). Nevertheless, some improvements have been reported in the way women's sports are covered regarding the tone, language observations, content and more (Crolley, Teso, 2007; Lumby, Caple, Greenwood, 2014). Despite these improvements in the image of female athletes, it is still far from the role model, the professional model, or even the status of national heroes given to male athletes by media (Richards, 2015). Media are still providing a patriarchal image of sport and maintaining patriarchal traditions (Chalabaev et al., 2013; Duncan, 1992). The analysis of media content shows that articles about male athletes are more complex and elaborate than articles about female athletes. Only specific, occasional events, like the Olympic Games, slightly change these tendencies in the media (Packer et al., 2014).

In the last few decades, governments of various countries, as well as national and international institutions, have emphasized the importance of reducing this imbalance to allow both genders the same opportunities (European Commission, 2014; United Nations, 2007). However, not all countries have the same culture and level of professionalization of their sport. Therefore, the culture of each country and the sport structure must be considered in the study of this gap (Chalabaev et al., 2013; Frideres, Mottinger, Palao, 2008). For example, the profile of the United States is due to the importance of four competitive sports in the media: American football (professional and college), basketball, baseball, and hockey (Cooky, Messner, Musto, 2015). However, for many other countries in the world, the focus is on national and international soccer (BR, 2011). Spain, with club teams such as Real Madrid and FC Barcelona, has been a reference in this regard.

The current data show that the image of women's sport provided by the media around the world is far from equal to that of men's sport (Cooky et al., 2013; Godoy-Pressland, 2014). Traditional media has increased the possibility to reach a higher number of readers using online versions of their newspapers in the last decade. The evolution of online media makes it necessary to periodically monitor the image that media present to our societies. This could provide information about the current imbalance between male and female coverage (Chalabaev et al., 2013; Di Carlo, Cezar, 2014). The purpose of this study was to assess the evolution in sports coverage in relation to gender in online newspapers in two western societies, Spain and the United States, in a period of ten years (2004 vs. 2014).

Method

All articles with athletic content from the online newspapers usatoday.com and elmundo.es were analyzed during the two-week spans of October 13–26, 2003 (first register), February 16–29, 2004 (second register), October 13–26, 2013 (third register), and February 9–22, 2014 (fourth register). A total of 2,951 stories were analyzed, 1,816 from usatoday.com and 1,135 from elmundo.es (Table 1). In accordance with a study by the Amateur Athletic

Foundation of Los Angeles (Duncan, Messner, Williams, 1991), in general, articles were analyzed if they contained prose, though columns were not included. The following were not considered articles: free-standing statistics, surveys, and fantasy sports; however, when rankings contained prose descriptions of the team, they were included. Articles were analyzed daily at 11:00 p.m. local time (Pacific Summer Time for usatoday.com and Central European Summer Time for elmundo.es). Usatoday.com and elmundo.es were chosen because of their circulation at the beginning of the study. In 2001, USA Today was the United States' largest-selling newspaper, with an average daily circulation of 2.3 million, while the online version, usatoday.com, received over 25 million monthly visits (Commission Junction, 2001). Similarly, with over 25 million visits in September 2003, elmundo.es was the most-read online national newspaper in Spain (Oficina de Justificación de la Difusión, n.d.).

Table 1. Articles analyzed by online newspaper

	usatoday.com	elmundo.com	Total
1 st Register	610	422	1,032
2 nd Register	632	313	945
3 rd Register	337	169	506
4 th Register	237	231	468
Total	1,816	1,135	2,951

The variables included: gender (men-only, women-only, both genders, neutral), placement (front page of the newspaper, front page of the sports section, individual sports page), word count and inclusion of photographs. The gender basis of articles was analyzed to determine whether content was men-only, women-only, both or neutral. A minimum of 10% of the text had to be devoted to each gender for it to be considered in the "both genders" category. Neutral articles covered topics that were not focused on men's or women's athletics. Some examples include stories about the International Olympic Committee or articles about horse racing that focused on the horses.

Four trained observers carried out the analysis of the article (Anguera, 2003). Inter-observer and intra-observer reliabilities were calculated using a Kappa index and intraclass correlation coefficient (two observers demonstrated inter-observer reliabilities greater than 0.93, and there was an intra-observer reliability of 0.98). Descriptive and inferential analyses of the data were carried out (chi-square test, likelihood ratio, and Student's t-test). Statistical significance was set at $p < .05$. The statistical analysis was completed with the SPSS 21.0 software.

Results

Significant reductions in articles with athletic content were found between the years 2003–2004 and 2013–2014 (1st and 2nd register vs. 3rd and 4th register). Regarding gender (Table 2), a significant difference between men-only (88.4% of total articles) and women-only (5.9%) articles was found, when analyzed according to newspaper, register periods and total. Similar percentages of women-only articles were found in elmundo.es and usatoday.com in the 2003–2004 period. In the 2013–2014 period, a significantly lower percentage of women-only articles was found in elmundo.es than in usatoday.com (5.3% vs. 9.2%, respectively). In the 2013–2014 period, a significantly lower percentage of men-only articles was found in elmundo.es and in usatoday.com in comparison with the years 2003–2004. Further, in this period, the number of neutral articles increased significantly, while the men-only articles

decreased significantly in both newspapers. In contrast, in the 4th registration period (i.e. February of 2014), the number of women-only articles increased significantly in both newspapers. In this data collection period, the increase in women-only articles was significantly higher in usatoday.com than in elmundo.es.

Table 2. Number and percentage of sports articles in relation to gender

Newspaper	Register	Women		Men		Both		Neutral	
		n	%	n	%	n	%	n	%
2003–2004									
usatoday.com	1 st Register	35	5.7	522	85.8	27	4.5	24	3.9
	2 nd Register	38 ^{##}	6.0	552	87.3	23	3.6	19	3.0
	Total	73 ^{**}	5.9	1,075 ^{**}	86.6	50 ^{**}	4.0	43 ^{##}	3.5
elmundo.es	1 st Register	25	5.9	387	91.7	6	1.4	4 ^{##}	0.9
	2 nd Register	18	5.7	286	91.1	6	1.9	4 ^{##}	1.3
	Total	43 ^{**}	5.8	673 ^{**}	91.4	12 ^{**}	1.6	8 ^{##}	1.1
2013–2014									
usatoday.com	3 rd Register	18 ^{**}	5.3	286	84.9	11	3.3	22	6.5
	4 th Register	35 ^{##}	14.8	177	74.7	10	4.2	15	6.3
	Total	53 ^{**}	9.2	463	80.7	21	3.7	37 ^{##}	6.4
elmundo.es	3 rd Register	3 [*]	1.8	143	84.6	2	1.2	21 ^{##}	12.4
	4 th Register	18 [*]	7.8	185	80.1	6	2.6	22 ^{##}	9.5
	Total	21 ^{**}	5.3	328	82.0	8	2.0	43 ^{##}	10.8

Note: *Statistically significant between newspapers, p < 0.05 (chi-square test); **statistically significant between newspapers, p < 0.001 (chi-square test); #statistically significant between registration periods, p < 0.05 (chi-square test); ##statistically significant between registration periods, p < 0.001 (chi-square test).

The difference in word count between men-only articles and women-only articles reduced significantly through the different data collection periods (Table 3). Variations in the words per article in the different periods studied were found for women-only, men-only, both genders and neutral articles. A significant increase in word count in women-only articles was found between 2003–2004 and 2013–2014 in both newspapers.

Table 3. Average number of words per article in relation to gender

Newspaper	Register	Women		Men		Both		Neutral	
		M	SD	M	SD	M	SD	M	SD
1	2	3	4	5	6	7	8	9	10
2003–2004									
usatoday.com	1 st Register	278.1 ^{##}	201.7	579.9 ^{##}	421.6	555.1 [#]	194.0	516.3	307.2
	2 nd Register	568.6 ^{##}	426.3	568.9 ^{**}	441.5	618.1	329.4	640.5	567.2
	Total	429.3 ^{##}	366.0	574.2 ^{**}	431.8	584.1	264.0	571.2	439.8
elmundo.es	1 st Register	243.2 [#]	79.5	400.1 ^{**}	151.9	282.5	127.0	328.8	82.9
	2 nd Register	343.1 ^{##}	107.7	402.6 ^{**}	176.9	443.0	139.6	237.0	149.7
	Total	285.1 ^{##}	103.9	401.2 ^{**}	162.9	362.8	152.4	282.9	122.3

Gender in Sports Coverage of US and Spanish Online Newspapers

1	2	3	4	5	6	7	8	9	10
2013–2014									
usatoday.com	3 rd Register	564.2 [#]	309.2	465.7 [#]	288.3	448.6 [#]	272.9	460.6	230.1
	4 th Register	483.3 [#]	241.2	548.7 ^{**}	370.0	533.2	178.4	737.9	788.1
	Total	510.8 [#]	266.1	497.4	324.1	488.9	231.1	573.0	539.9
elmundo.es	3 rd Register	345.0 [#]	150.9	461.8	190.0	612.5	232.6	486.8	211.9
	4 th Register	428.2 [#]	233.7	451.9 ^{**}	190.2	416.7	168.8	559.3	214.9
	Total	416.3 [#]	222.7	456.2	189.9	465.6	190.5	523.9	214.0

Note: ^{*}Statistically significant between newspapers, p < 0.05 (Student's t-test for independent sample); ^{**}statistically significant between newspapers, p < 0.001 (Student's t-test for independent sample); [#]statistically significant between registration periods, p < 0.05 (Student's t-test for independent sample); ^{##}statistically significant between registration periods, p < 0.001 (Student's t-test for independent sample).

As for where these articles were placed (Table 4), in usatoday.com, a significant increase in the number of women-only articles on the front page of the newspaper and the front of the sports pages was found between 2003–2004 and 2013–2014. On the front of the sports pages, there was also a significant increase in the neutral articles and articles related to both genders between 2003–2004 and 2013–2014. No significant differences were found in elmundo.es.

Table 4. Number and Percentage of Sports Articles in Relation to Gender and Placement in the Newspaper

	Placement	Women		Men		Both		Neutral	
		n	%	n	%	n	%	n	%
2003–2004									
usatoday.com	Front Newspaper	1 ^{**}	1.5	60	89.6	3	4.5	3	4.5
	Front Sports Page	22 ^{##}	6.2	317 ^{##}	90.5	8 ^{##}	2.3	5 ^{##}	1.4
	Not Front Page	50	6.1	697	85.0	39	4.0	35	3.5
elmundo.es	Front Newspaper	1	6.7	14	93.3	0	0.0	0	0.0
	Front Sports Page	10	3.5	268	93.4	6	2.1	3	1.0
	Not Front Page	32	6.6	391	90.1	6	1.4	5	1.2
2013–2014									
usatoday.com	Front Newspaper	2 ^{**}	6.9	26 ^{**}	89.7	0	0.0	1	3.4
	Front Sports Page	27 ^{##}	13.9	131 ^{##}	67.5	16 ^{##}	8.2	20 ^{##}	10.3
	Not Front Page	24 ^{**}	6.8	306 ^{**}	87.2	5 ^{**}	1.4	16 ^{**}	4.6
elmundo.es	Front Newspaper	8	4.8	135	80.4	3	1.8	22	13.1
	Front Sports Page	3	4.3	60	87.0	3	4.3	3	4.3
	Not Front Page	10	6.6	133	81.6	2	1.2	18 ^{##}	11.0

Note: ^{*}Statistically significant between newspapers, p < 0.05 (chi-square test); ^{**}statistically significant between newspapers, p < 0.001 (chi-square test); [#]statistically significant between registration periods, p < 0.05 (chi-square test); ^{##}statistically significant between registration periods, p < 0.001 (chi-square test).

In usatoday.com, a significant increase in women-only articles with photographs of athletic content was found (Table 5). This increase was lower in proportion to those found in men-only articles. In elmundo.es, the same significant tendency was found in men-only, both genders, and neutral articles. In women-only articles, there was a significant reduction in the percentage of total photographs.

Table 5. Number of sports articles with photographs (n) and percentage with respect to sports articles by gender (%)

	Women		Men		Both		Neutral	
	n	%	n	%	n	%	n	%
2003-2004								
usatoday.com	24**	32.9	459**	42.6	13**	26.0	14**	32.6
elmundo.es	34**	79.1	576**	85.6	9**	75.0	4**	50.0
2013-2014								
usatoday.com	53***	100.0	462**	80.7	20**	95.2	36**	97.3
elmundo.es	21**	48.8	326	99.4	8**	100.0	41**	95.3

Note: The table represents frequency of data and percentages are of total articles in that category. *Statistically significant between newspapers, $p < 0.05$ (chi-square test); **statistically significant between newspapers, $p < 0.001$ (chi-square test); * statistically significant between registration periods, $p < 0.05$ (chi-square test); **statistically significant between registration periods, $p < 0.001$ (chi-square test).

Table 6. Number of sports articles by type of sports (n) and percentage with respect to sports articles by gender (%)

	usatoday.com				elmundo.es			
	2003-2004		2013-2014		2003-2004		2013-2014	
	n	%	n	%	n	%	n	%
Female								
Basketball	27**	37.0	0**	0.0	0*	0.0	0	0.0
Soccer	7**	9.6	0**	0.0	2*	4.7	0*	0.0
American Football	1*	1.4	0	0.0	0	0.0	0	0.0
Softball	1*	1.4	0*	0.0	0	0.0	0	0.0
Tennis	14*	19.2	12*	22.6	31**	72.1	2**	9.5
Motor	0	0.0	5	9.4	0	0.0	1	4.8
Golf	8	11.0	6*	11.3	2	4.7	0	0.0
Hockey	0	0.0	3	5.7	0	0.0	0	0.0
Cycling	0	0.0	0	0.0	0	0.0	0	0.0
Olympic Games	0**	0.0	24**	45.3	0**	0.0	13**	61.9
Other (n = 37)	15**	20.5	3**	5.7	8	18.6	5	23.8
Male								
Basketball	225**	20.9	58**	12.5	112**	14.5	48**	14.6
Soccer	31	2.9	15	3.2	243**	31.4	185**	56.4
American Football	270	25.1	149	32.2	0	0.0	2	0.6
Baseball	184*	17.1	75*	16.2	0	0.0	0	0.0
Tennis	15*	1.4	14*	3.0	86**	11.1	17**	5.2
Motor	73	6.8	18	3.9	63	8.1	40	12.2
Golf	65	6.0	22	4.8	48**	6.2	2**	0.6
Hockey	109	10.1	68	14.7	0	0.0	2	0.6
Cycling	6	0.6	0	0.0	66**	8.5	5**	1.5
Olympic Games	0**	0.0	31**	6.7	0**	0.0	17**	5.2
Other (n = 37)	97**	9.0	13**	2.8	156**	20.2	10**	3.0

Note: *Statistically significant between newspapers, $p < 0.05$ (chi-square test); **statistically significant between newspapers, $p < 0.001$ (chi-square test); * statistically significant between registration periods, $p < 0.05$ (chi-square test); **statistically significant between registration periods, $p < 0.001$ (chi-square test).

In usatoday.com, between 2003–2004 and 2013–2014, there was a significant reduction in women-only articles about basketball, soccer and other sports; a significant reduction in men-only articles about basketball and other sports; and a significant increase in men-only and women-only articles about the Olympic Games (Table 6). In elmundo.es, between 2003–2004 and 2013–2014, there was a significant reduction in women-only articles about tennis; a significant reduction in men-only articles about tennis, golf, cycling, and other sports; a significant increase in women-only articles about the Olympic Games; and a significant increase in men-only articles about soccer and the Olympic Games.

Discussion

The goal of this study was to assess the evolution of the accessibility of sports news regarding gender in the online media of two western countries, Spain and the United States. The data analysis is based on two assumptions. The first assumption is that it is well documented that there is a significant imbalance between coverage of men's and women's sport by the media (Chalabaev et al., 2013; Clarke, Ayres, 2014). The second assumption is that a topic's greater presence in the news affects the reader's perception of this topic (Carroll, McCombs, 2003; McCombs, Shaw, 1972). The media's current agenda-setting contributes to establishing what is seen by both the media themselves and their readers as normal (McCombs, 2004). The purpose is to try to better understand how the changes in online media newspapers of two countries with different sport cultures influence the accessibility of news about both genders. Theoretically, this may contribute to establishing a possible solution to reduce the gap.

The results show a significant reduction (i.e. 50–60%) of the sports news in the online newspapers of both countries. The information collected in the study does not allow us to assess the reasoning for this reduction. Possible causes include the evolution of online media and the financial crisis of 2008. With regard to the evolution of online media, Facebook, Twitter, and YouTube did not exist when this study began. However, in 2014, these sources were part of the way society obtained news and information, and they affected the way online newspapers evolved (Barthel, Shearer, Gottfried, Mitchell, 2015). Concerning the effect of the economic crisis, it impacted the overall funds that reached online newspapers (Michael, Barthel, 2015; Armentia, 2011). Regardless of the causes, in the ten-year period that was analyzed, these online newspapers significantly reduced the number of articles with athletic content, which dramatically affects the amount and type of information available for their audience. Therefore, due to the fact that the online newspapers' resources were reduced (e.g. space, number of journalists), the competition for visibility in the media between the different sport leagues, events, and organizations increased. This reduction in sports articles means that sports or events seen as most important will be the ones that are still visible in the news.

Traditionally, the study of the gap between genders has been analyzed as a zero-sum game. An increase in women's visibility in the news means a reduction in men's visibility, due to the fact that the number of journalists remains unchanged. However, the reduction of media resources involved a change in certain aspects of the zero-sum game. As an analogy, the pie to be shared is smaller. This change makes it more difficult for women's news to make the cut in these online newspapers, as well as men's news for nontraditional sports. In this new situation, traditional and professional sports will have the advantage due to being considered more important; additionally, they have more resources to get greater visibility (e.g. public relations and media structures). The United States and Spain have different sports structures, traditions, or levels of professionalism in the sports; thus, each online newspaper studied had different sports coverage. Another aspect that was found in the analysis of both newspapers

was that a significant difference was found between the registration periods in 2014. These differences show two different tendencies in online sport coverage: normal sport coverage and the particular impact of the Winter Olympic Games.

Regarding normal sport coverage, in usatoday.com, accessibility to women's sports news worsened from 2004 to 2014, affected by the reduction of total of articles published. The analysis of the proportions shows no change in the gender imbalance, as 5% of news was still about female athletes. The analysis of the number of articles about females shows a reduction in the available articles for the readers. In 2004, a reader could find approximately 2.5 articles about female athletes daily, but in 2014, a reader could find 1.25 articles about female athletes daily. This reduction in the number of articles affected the variability of sports that were reported on. Data show that it is easier for women's sports news to make the cut if only it does not compete directly with men's U.S. professional sports or if the news is related to outstanding athletes or performance, such as achievements reached by Serena Williams. In this context, no articles were found about women's basketball or women's soccer in the 2014 periods studied.

These findings may be the result of the increase in competitiveness caused by the reduction in the number of news articles. Previous studies found this reduction in women's sports coverage starting in 2009 for televised news and highlight shows (Cooky, Messner, Musto, 2015). The reduction in news also affected men's coverage. For example, men's basketball went from 225 articles in 2004 to 58 articles in 2014, which stands for three times fewer articles. In this context, usatoday.com did not report on any game or news from professional or college women's basketball in the period studied in 2014.

In elmundo.es, the situation was worse. The proportion of women's articles went from 5% in 2004 to 1.8% in 2014. In other words, in 2004, a reader could find approximately 1.5 articles about female athletes daily, while in 2014, a reader could find 0.21 articles about female athletes daily. The evolution of the online newspaper, due to the increase in competition in the online media as well as financial difficulties, has negatively impacted the already-low visibility of women's sport. The reduction of spots in the news affected all male sports, and it reduced the variability in the period studied. This tendency is similar to the one found in the U.S. online newspaper, although with differences in regard to their traditions. The professional and more traditional sports had a smaller reduction in the number of articles, and they increased or maintained their proportion of the news. In usatoday.com, around 75% of the articles in 2004 and 2014 were about American football, baseball, basketball, or ice hockey. In elmundo.es, soccer news went from 31.4% of the news in 2004 to 56.4% in 2014. Data confirm that media have a clear and set agenda about what is important in sport, and it is affected by the traditions of each country (e.g. Spain is all about male soccer).

Regarding the impact of the Winter Olympic Games on sport coverage, during the period of time that this competition occurred, there was an increase in the coverage of women's sports in the media, but it did not have a permanent effect (Packer et al., 2014). In both online newspapers there was a significant increase in women's articles (from 5.3% to 14.8% in usatoday.com and from 1.8% to 7.8% in elmundo.es). There were, however, different tendencies in the two newspapers.

In the Spanish online newspaper, there was an increase in women's sports articles during the Winter Olympic Games. This increase was facilitated by the increase in the total number of sports articles in this period of time, due to the tradition of providing information about this event. This was not associated with a change in the normal zero-sum game of the normal coverage. In the U.S. online newspaper there was no increase in sports articles during this period of the Olympic Games. The increase in women's articles was due to a reduction in men's articles

and neutral articles, changing the normal zero-sum game of regular coverage. These differences can be due to traditions related to winter sports and this international event. The higher number of sports articles related to the Winter Olympic Games found in usatoday.com than in elmundo.com can be related to the fact that in Spain, due to its geographical latitude, there is less tradition of winter sports. During the months leading up to and the period of celebration of the Olympic Games, there was an increase in the neutral news that contributed to reducing the spots in the sports articles and the accessibility to men's and women's articles. These articles were related to the facilities, institutions, countries, etc.

The reduction in women-only articles affected the content of articles in both online newspapers in the normal coverage of sport news and during the Olympic Games. In usatoday.com, between 2003–2004 and 2013–2014, there were changes in the placement of women-only articles, there was an increase in the use of photographs in articles, and there was a slight increase in the length of the articles. In 2014, all the articles about women had photographs although only 80% of articles about men's sport were accompanied by a photograph. These findings are similar to improvements previously reported regarding the way that women's sports are covered (Crolley, Teso, 2007; Lumby, Caple, Greenwood, 2014). These tendencies were not found in the Spanish online newspaper. There, the number of photographs for women's articles decreased significantly by 30%, while the number of photographs for men's articles increased significantly. These findings can show how the women's sport or the winter Olympics were covered in a different way by each newspaper.

The results confirm the data from previous studies (Godoy-Pressland, 2014; Sainz de Baranda, 2014). The imbalance is not improving, and it is affected by the traditions of the country, or sport structure. Changes in online media have reduced the accessibility of the readers to articles about women's sport (total available news). This reaffirms the difficulty female athletes have in obtaining visibility, sponsorship, etc., as well as the difficulty for the general population to obtain information about what happens in women's sport. Data show a reduction in articles outside of traditional professional sports: football, baseball, basketball, and ice hockey in the United States and soccer in Spain. The sport image put forth by these newspapers provides a reductionist image of the sport that is a partial and unfair perspective of the sport world.

Data show that when financial changes or competitive issues arise, online media maintain the traditions, or they use it as a strategy to increase their audience. Data confirm that from some online media, sport is still seen as something done by and for men. Online media are maintaining the traditional and stereotyped idea of sport (Chalabaev et al., 2013; Duncan, 1992). The problem is that younger generations are accepting this imbalance as normal, and they are not critical of it (Lebel, Danylchuk, 2009). These differences show the need for specific education and intervention approaches for each country and society. The media's presentation of just one perspective of sport (e.g. men's professional sport) as the reality of sport contributes to maintaining the beliefs and perceptions of society that there is no other perspective.

Data show that the visibility of the female athlete has deteriorated. The fact that this is caused by a reduction in the total men's and women's sport articles makes it a difficult problem to solve. The magnitude of the problem and the trend in recent decades show the need for specific multidisciplinary interventions, such as informational campaigns, education programs, awards to the media sources that promote equity, etc. It is necessary to inform our societies of the status of women's sport and the existence of the gap. Our young generations, both boys and girls, must be aware and critical of this situation. Society is the one that consumes the product offered by the media. Therefore, we have a role in the process. Monitoring and periodically informing about the gap is the first step in

correcting this imbalance. Changes involving the sport culture of a country or society require the involvement of all the stakeholders: governments, institutions, politicians, schools, teachers, coaches, audience, etc. The evolution of the way that society attains information about the world and specifically about sport is another possible way to break the cycle and reduce the gap. Traditional newspapers are utilized to obtain news, but this tradition can be changed or is changing through the use of online sources. Media companies are businesses that try to sell a product. However, if the image that they provide is not adequate, maybe other options that treat men's and women's sports in the same way need to be considered (Chalabaev et al, 2013; Di Carlo, Cezar, 2014). Media can contribute to reducing the obstacles that female athletes have to overcome and to placing importance on women's sport (Clarke, Ayres, 2014; Fink, 2014). Nothing can justify this imbalance. Sports practice changed decades ago, though the media do not yet show an image that reflects the reality and the diversity of current sport. One possible explanation is that media companies are businesses, and they are trying to sell a product. Publishers perceive that their market is the male population. The expectations and pressures of readership influence the type of news they generate. The goal of selling more and getting more revenue by paid commercials ends up altering the reality of sports news to which readers have access. Future studies are needed to test this hypothesis.

Conclusions

The online newspapers studied from Spain and the United States showed an imbalance in the image of sport between genders. The significant decrease in sports articles found in the online newspapers usatoday.com and elmundo.es has significantly reduced the possibility of their readers to access news about men and women's sports. The reduction has also decreased the variability of the sports articles. Due to the lower appearance of women's news, these reductions affected more the total available number of women's coverage. The imbalance is greater in the Spanish newspaper than in the US newspaper. The reduction of the sports articles has increased the competitiveness which has benefitted traditional and professional sports. Data show the image of sport provided by these online newspapers is male-orientated, focused on elite sport, and focused on a low number of sports. Online newspapers maintain and perpetuate the tradition that sport is done by and for men. The event of the Winter Olympic Games increased the visibility of female athletes and of different sports. This impact was higher in the online newspaper from the United States than in the online newspaper from Spain. The inclusion of the Winter Olympics Games, in the fourth registered timeframe, altered the normal women's coverage. Future studies are needed to confirm the findings of this paper.

Conflict of interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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THE MODULATORY EFFECT OF PHYSICAL ACTIVITY ON APE1-MEDIATED TELOMERE LENGTH AND STABILITY; A NARRATIVE REVIEW

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Abstract Physical activity is associated with enhanced generation of reactive oxygen species (ROS) that, in turn, can play a dual role in the human body. Upon physiological conditions, ROS act as secondary messengers in different cell signaling pathways. In contrast, ROS overexpression can lead to oxidative stress and oxidative stress-associated harmful consequences. This exercise-induced interplay among oxidants and antioxidants can modulate numerous physiological and molecular mechanisms, for example telomere length maintenance and stability. The latter is, in turn, under strict control of oxidative stress-activated base excision repair (BER) pathway, one of the DNA repair mechanisms; and growing evidence directs attention to apurinic/apyrimidinic endonuclease 1 (APE1), a multifunctional BER protein. Therefore, this review intends to address several issues concerning modulatory effect of exercise on APE1-mediated telomere length maintenance and redox activities.

Key words physical activity, telomeres, BER DNA repair, APE1, oxidative stress

Introduction

It is widely agreed upon that physical activity has a significant impact on human health. However, depending on a wide range of agents and mechanisms, physical effort may have beneficial or harmful effects (Radak, Chung, Goto, 2005). Among exercise-associated factors that mediate many physiological processes is oxidative stress. Although its role *per se* is relatively well-established and documented in numerous studies, several oxidative stress-driven mechanisms are still poorly recognized or remain unclear. One of such a phenomenon is exercise-dependent telomere length maintenance and stability. Although telomeres shortening is a natural phenomenon related with replication, there are some evidence suggesting that there is a link between physical activity and telomere length and stability (Ludlow, Ludlow, Roth, 2013). This relationship may be, in turn, mediated by oxidative stress-dependent activation of base excision repair (BER) mechanism at telomeric ends. Although, molecular-level details of this putative relationship are unclear, growing evidence suggest that protein-protein interactions between telomeric

shelterin and BER proteins might be the key mechanism (Miller, Balakrishnan, Buncher, Opresko, Bambara, 2012). Among BER proteins, apurinic/apirimidinic endonuclease 1 (APE1), a multifunctional protein, seems to play a crucial role in linking DNA repair, including telomeric sequences, gene expression and redox activities (Madlener, Ströbel, Vose, Saydam, Price, Demple, Saydam, 2013). Therefore, a modulatory effect of physical activity on telomere length and stability will be discussed here with emphasis on APE1.

Telomeres – structure and function

Telomeres (TL) are heterochromatic domains localized at the end of linear eukaryotic chromosomes. Telomeric DNA is constructed of tandem repeating nucleotide sequences (5'-TTAGGG-3'), connected to a series of specialized proteins that determine their stability and shape (de Lange, 2005; Blackburn, 2005). Telomeres shorten every round of replication due to the inability of DNA polymerases to fully replicate the end of the leading (G-rich) strand.

The shelterin is a multiprotein complex consists of 6 protein subunits: TRF1, TRF2 (telomere repeat factor -1, -2), POT1 (protection of telomere protein -1), TIN2 (TRF1-interacting protein 2), Rap1 (repressor/activator protein 1), and TPP1 (tripeptidyl pepti-90 dase 1). They protect telomeres by maintaining telomere structure, repress the DNA repair machinery at telomeres, and regulate telomere length (Palm, de Lange, 2008).

The shelterin complex interacts directly with the telomere and can modulate telomere length through allowing access to positive and negative regulators of telomere length in both telomerase-dependent and -independent mechanisms. TRF1 and TRF2 bind as homodimers to the double stranded telomeric DNA repeats. POT1 binds with high specificity to the single-stranded 5'-TTAGGG-3' repeat DNA (Baumann, Cech, 2001). TPP1, TIN2 and Rap1 associate with telomeres through interactions with protein-protein connections. TRF1 and TIN2 regulate telomere length, whilst TRF2 prevents end to end fusion and activation of DNA damage response. It has been reported that, additional proteins capable of interacting with telomeric proteins which are involved in DNA damage response and double-strand break repair also have implications for telomere length regulation and chromosome end protection (Denchi, de Lange, 2007).

Shelterin protein binds to telomeric DNA, forming the unique telomeric chromatin structure called t-loop. By creating t-loops, telomeres generate closed configuration that protects the chromosome ends from being recognized by the DNA damage repair machinery (de Lange, 2009). Another important functions of shelterin is blocking the ataxia telangiectasia mutated (ATM)/ataxia telangiectasia and rad3 related (ATR) damage response pathways and suppressing double-strand break repair activities at chromosome ends, thereby preventing linear chromosome ends from erroneously being recognized as damaged DNA. In addition, shelterin proteins control telomere length via regulating telomerase recruitment and/or modulating telomerase activity at chromosome ends (de Lange, 2009; Palm, de Lange 2008).

Telomere length can be controlled indirectly by shelterin protein complex and directly by the telomerase enzyme.

The end-replication problem is overcome by the enzyme telomerase that maintains telomere length homeostasis by adding 5'-TTAGGG-3' repeats to telomeres following DNA replication. Telomerase is a cellular reverse transcriptase that consists of two components, a reverse transcriptase subunit known as telomerase reverse transcriptase (hTERT) and a telomerase RNA component (hTERC) (Blasco, 2003). It seems that the hTERT

subunit is a factor limiting the functional telomerase activity, it can be used as an indicator of the telomerase function (Chilton et al., 2014).

What is more, single-stranded, guanine-rich polynucleotide sequences have the ability to form quadratic structures called G-quadruplexes (G4), stabilized by Hoogten hydrogen bonds and additionally by a metal cation (usually potassium or sodium). Telomeric DNA has also tendency to fold in to G4 structure. What is more, at least four repeats of the human telomeric motif TTAGGG fold into a variety of (G4) conformations *in vitro* (Bugaut, Alberti, 2015). This conformation prevents access of exonucleases to the terminal sections of telomeres and protects the single DNA strand from degradation, they become non-accessible for the replication machinery (Bochman, Paeschke, Zakian, 2012). Studies have reported that DNA damage, in particular oxidative damage, significantly affects G4 structures. Under oxidative stress conditions, oxidized products of DNA bases and abasic sites may be generated. Absence the purine decreases thermal stability of the structure G4 (Babinský et al., 2014). Furthermore, formation of telomeric G4 structure has been shown to inhibit the telomerase activity (Zahler, Williamson, Cech, Prescott, 1991).

Why telomeres shorten?

Telomeres shorten during DNA replication due to the „end-replication problem”, in which the DNA polymerase enzyme cannot fully copy the end of the DNA strand. This phenomenon was firstly described by A.M. Olovnikov and J.D. Watson independently and later confirmed by Harley (Olovnikov, 1971; Watson, 1972; Harley, Futcher, Greider, 1990).

What is more, telomere shortening, which is associated with each cell division, disrupts protective shelterin complex and leads to a DNA damage response (DDR) and activation of the senescence programme (Griffith et al., 1999).

Another reason why telomere shorten is damage accumulation that disturbs proper cell functioning. There are a lot of factors leading to DNA damage which all falls in one of two group: environmental factors (also called as external) or naturally occurring (called as internal factor). The most common for the first group is UV radiation, ionizing radiation and numerous genotoxic chemicals. The second group include errors during replication processes and reactive species i.e. oxygen, nitrogen, carbonyl, lipid peroxidation products and many more, which are able to hydrolysis cleaves chemical bonds in DNA (Jackson, Bartek, 2009). One of the most common DNA damage is lesion caused by increasing levels of ROS. Telomeres are particularly sensitive to base oxidation by ROS because of the large number of guanosine (G) nucleotides in their repeating sequence which will cause accelerate telomere attrition (Oikawa, Kawanishi, 1999). An imbalance between reactive oxygen species and antioxidants induce oxidative stress. To counteract excessive oxidative stress, and maintain a proper prooxidant/antioxidant balance, humans possess an extensive and efficient antioxidant defense system, containing endogenous antioxidant enzymes and non-enzymatic antioxidants (Powers, Jackson, 2008).

A role of ROS-driven DNA base excision repair (BER) in telomeric ends maintenance

Although under physiological conditions, ROS are important factors involved in cell signaling and immune system responses (Ścibior-Bentkowska, Czeczt, 2009), their increased level may lead to oxidative stress and oxidative stress-associated pathophysiological mechanisms, such as cardiovascular diseases (Dhalla et al., 2000),

metabolic syndrome (Bonomini, Rodella, Rezzani, 2015), neurodegenerative alterations (Sorce, Krause, 2009), as well as cancer (Reuter, Gupta, Chaturvedi, Aggarwal, 2010).

On the molecular level, increased ROS level can lead to significant cellular dysfunctions and oxidative damages to macromolecules, including proteins, lipids, and DNA (Zuo, Hallman, Yousif, Chien, 2012). The latter is thought to be the most deleterious, because – if unrepaired – might result in an increased rate of mutations and genome instability. One of the most common oxidative DNA lesions are several oxidized guanine products, including the well-documented biomarker of oxidative stress, that is 8-oxo-7,8-dihydroguanine (8-oxoG) (Wang et al., 2010; David, O'Shea, Kundu, 2007). 8-oxoG occurrence in DNA activates 8-oxoguanine DNA glycosylase (OGG1) and OGG1-mediated DNA base excision repair (BER) pathway (Wang et al., 2010; David et al., 2007).

Although there are many DNA repair mechanisms that are activated in response to a wide range of DNA lesions, BER pathway is the most common one at telomeric sequences, because triple guanine repeats, that are one of the features of telomeres, make them particularly susceptible to ROS-driven oxidation and, consequently, 8-oxoG generation (Wang et al., 2010). Moreover, some mechanisms – in particular, both standard and alternative nonhomologous end joining (NHEJ) (Webb et al., 2013) as well as canonical recombination repair (HR) that cope mainly with double strand DNA breaks (DSBs) – are generally inhibited at telomeres (Webb et al., 2013; Marcand, 2014; Claussin, Chang, 2015) to prevent telomeric ends from being recognized and repaired as DSBs (Webb, Wu, Zakiyan, 2013).

As mentioned above, OGG1-initiated BER pathway plays a crucial role in repairing and maintaining telomeric sequences. OGG1 recognizes and removes damaged bases and this action results in generation of apurinic/apyrimidinic (AP) site. Next, apurinic/apyrimidinic endonuclease 1 (APE1) cleaves phosphodiester bonds in DNA in the 5' direction from the AP site. APE1 action leaves a nucleotide gap, which is then repaired by short-patch (in the case of a single nucleotide gap) or long-patch repair (if break consists of more than one nucleotide). Missing nucleotide/s are synthesized by DNA polymerase β (Pol β) and a single strand DNA break is sealed due to the orchestrated action of the DNA repair enzyme DNA ligase III and XRCC1 or by the replicative DNA ligase I (Jia, Her, Chai, 2015; Krokan, Bjørås, 2013).

To date, a majority of research has focused on the role of OGG1 in BER-based response to oxidative stress at telomeric sequences, while several of them concern on relations between OGG1 level and/or activity and physical effort (Radak et al., 2011). However, even less is known about the potential modulatory effect of APE1 activity on response to physical activity-induced oxidative stress. Such a role seems to be consequential to the multifunctional characteristics of APE 1 that combines DNA repair (including telomeric ends), gene expression regulation and redox activities (Xanthoudakis, Smeyne, Wallace, Curran, 1996; Poletto et al., 2013; Burra et al., 2019).

The human APE1 protein is encoded by the *APE1* gene located on chromosome 14. The gene consists of 5 exons and 4 introns, and the encoded protein has 318 amino acids (Robson et al., 1992). Homologues of human APE1 protein have been identified in many organisms. It has been shown that the C-terminus is highly evolutionarily conserved. In contrast, the N-domain, although is characteristic for many species, is absent in some of them (for example in *Escherichia coli*) (Li, Wilson, 2014) (Figure 1).

These two abovementioned domains of APE1 exhibit two different activities. The N-terminal one, which contains the nuclear localization signal (NLS) sequence, acts as a redox co-activator that promotes DNA-binding activity of several transcription factors, e.g. nuclear factor- κ B (NF- κ B), p53, hypoxia inducible factor-1 α (HIF-1 α), early growth response protein-1 (Egr-1). Therefore, APE1 is also known as redox effector factor 1 (Ref-1)

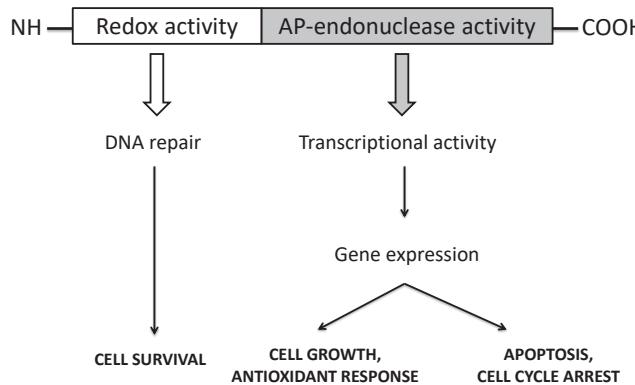


Figure 1. Schematic structure of APE1 protein and its role in different molecular pathways and cellular processes

(Xanthoudakis et al., 1996; Tell, Quadrifoglio, Tiribelli, Kelley, 2009; Poletto et al., 2013; Burra et al., 2019). In turn, C-terminus (61–318 aa) is responsible for AP-endoribonuclease activity and plays a key role in DNA damage repair pathways, including BER (Wang et al., 2010; David et al., 2007). Both functions are independent from each other (Xanthoudakis, Miao, Curran, 1994).

Physical activity and telomeres biology

It is well known that regular physical activity is associated with healthy aging and reduced risk for a number of chronic conditions (Bauman, Cech, 2001). Correlation between physical activity, sedentary behavior, telomere length and DNA repair has been extensively studied, but the relationship between those factors remains unclear.

Many scientific reports demonstrated that during physical activity ROS level increase. The production of those molecules during exercise is associated primarily with the functioning of mitochondria, NADPH oxidase and xanthine oxidase and have dual functions. On the one hand, with extremely strong activity, there is an excessive ROS outburst, which, by oxidizing biomolecules, destroy cellular components, causing a reduction in the physical capacity of the body. However, when the training is properly balanced, suited to the athlete's trained and endurance conditions, ROS become a positive modulator leading to rearrangement of skeletal muscles, stimulate the immune system or activate adaptive antioxidant systems (Radak et al., 2005).

Regular physical activity is associated with longer telomeres and could attenuate telomere attrition. The relationship between physical activity and telomere biology is becoming the subject of research for an increasing number of researchers but still remain elusive. As cross-sectional studies show, the relationship between physical activity and the length of telomeres, mainly in immune cells, can have different effects: a positive relationship with telomere length, no correlation or an inverted "U" correlation were observed. In inverse "U" correlation, sedentary individuals and extremely active athletes have shorter telomeres than moderately active subjects (Ludlow et al., 2013). But it is true that most of available research indicates that higher physical activity exhibits a positive relationship with longer leukocyte or skeletal muscle telomere length in comparison to a sedentary lifestyle.

Recent work indicates that endurance training can provide a protective effect on the telomeres length and alleviate the biological aging process (Mundstock et al., 2015). As T.J. LaRocca and colleagues' studies show,

older (55–72 years), athletic men have comparable telomere lengths to their young physically active colleagues (La Rocca, Seals, Pierce, 2010). In addition, young athletes have longer telomeres than their inactive colleagues (Muniesa et al., 2017). Recent studies conducted at master athletes showed that they have longer telomere, better oxidative profile, and lower body fat than untrained individuals. What is more, body fat was inversely correlated with both telomere length and markers of oxidative balance (Aquiar et al., 2019). J. Denham and coworkers showed that endurance athletes had longer telomeres than compared to non-trained group (Denham et al., 2013). Also, long-term endurance or interval training intervention increase telomeres length and telomerase activity in previously sedentary individuals (Werner et al., 2019). Other study performed both on the mouse model and on human leukocytes demonstrated that physical activity regulates telomere-stabilizing proteins and thereby protects from stress-induced vascular apoptosis. Peripheral blood leukocytes isolated from endurance athletes showed increased telomerase activity, expression of telomere-stabilizing proteins, and downregulation of cell-cycle inhibitors compared with untrained individuals. Long-term endurance training was associated with reduced leukocyte telomere shortening compared with untrained controls (Werner et al., 2009). It has also been reported that the higher the level of physical activity and the amount of physical activity per week could translate in longer telomeres (Latifovic, Peacock, Massey, King, 2016; Edwards, Loprinzi, 2017; Du et al., 2012). In opposite to study performed by H.G. Simoes et al. (2017), where master sprinters had longer TL, lower body fat and BMI, and a better lipid profile than age-matched controls, study performed by C. Mason et al. (2013) showed that leukocyte telomere length is positively associated with baseline VO₂ max (the maximum volume of oxygen that can be utilize during exercise which is a universal indicator of physical fitness) and inversely associated with age, while unassociated with BMI and percent body fat. Interestingly, Y. Shin et al. (2008) determine the changes of antioxidant levels after exercise training, and these enzyme activities were increased following long-term exercise training; but the lengths of telomere were not changed by both mid-intensity and high intensity of exercise stress. A. Borghini's group also showed that chronic endurance training can provide a protective effect related to shortening telomeres, thereby mitigating the effects of biological age. However, acute exposure to a long-distance race may contribute to the shortening of telomeres, which may be related to oxidative DNA damage (Borghini et al., 2015). It seems that regular and moderate intensity of physical activity has beneficial effect on telomere length.

APE1 is also involved in ensuring genome stability and integrity through telomeres protection

As it was mentioned earlier, during oxidative stress, the accumulation of 8-oxoG in telomeres is increased significant within the telomeric DNA sequences, and telomeres are less efficiently repaired than the rest of the genome. When 8-oxoG is not properly repaired, it induces a GC-TA mutation, which can lead to genomic instability. Previous studies have demonstrated that oxidative stress causes SSBs in telomeric DNA (Zglinicki, Pilger, Sitte, 2000). In addition, the presence of 8-oxoG inhibits telomerase activity and reduces binding of telomeric proteins, mainly TRF1 and TRF2, to the telomere sequence, which leads to the destabilization of the telomeric structure (Opresko, Fan, Danzy, Wilson, Bohr, 2005).

G4 is a specific structure that may trigger DNA damage and genome instability. This conformation prevents access of exonucleases to chromosomes ends, nevertheless, access to repair proteins is also hampered. However, it was demonstrated that APE1 is able to bind to quadruplex structure and promote lesions repair (Broxson, Hayner, Beckett, Bloom, Tornaletti, 2014). Further studies indicated that APE1 N-terminal sequence is required and essential for regulating APE1 enzymatic activity on G4- telomeric structure (Burra et al., 2019). Interestingly,

BER is a key DNA repair pathway promoted in telomeres which is stimulated through proteins included in telomere shelterin complex, such as TRF1, TRF2 or POT1 (Miller et al., 2012). Moreover, there are protein-protein interactions between those proteins and APE1. It has been found that APE1 is able to bind to telomeres (Li et al., 2018) and an enrichment of AP endonuclease at telomeres is promoted by TRF1, TRF2 or POT1. It was also shown that proteins included in telomere shelterin complex enhance APE1 ability to cleavage on telomeric substrate (Miller et al., 2012). Furthermore, APE1 is required for proper binding of TRF2 to chromosomes ends.

S. Madlener and co-workers (2013) analyzed what happened with telomeres in APE1-depleted human cell lines. Their results showed that APE1 deficiency leads to segregation defects and mitotic failure. FISH analysis revealed a number of telomeres dysfunction such as: chromosome end fragmentation, telomere signal loss and chromosome end-to-end fusions. Further studies confirmed that depletion of APE1 disrupts the association of TRF2. Moreover, terminal telomere fragments in APE1-depleted cells shortened during just 3 days of siRNA treatment in the investigated cell lines.

Although it has been shown that physical activity may be involved in modulation of DNA repair mechanisms (Schmidt, Nickerson, Boatright, 2016; Yang, Yu-Lin, Chuang, Bohr, Mattson, 2014; Laye et al., 2012; Radak et al., 2011), much less is known about the modulatory effect of physical activity on APE1 activity. Moreover, these data are often in contrary with each other. On the one hand, Z. Radak and coworkers (2011) demonstrated that neither APE1 nor its acetylated isoform, Ac-APE1, showed significant changes with aging and/or physical activity in human skeletal muscles. Such a modulatory effect exhibited, in turn, acetylated isoform of OGG1 and thereby, it has been considered as a rate-limiting factor in the BER pathway. Moreover, Z. Radak et al. concluded that, in general, repair of 8-oxoG indeed depends on physical state of muscles. Consequently, oxidative stress induced by physical effort mediates the adaptive response for effective repair of DNA lesion, especially through BER mechanism (Radak et al., 2011).

In contrary to findings obtained by Z. Radak et al. (2011), there is a report showing significant increases in APE1 levels in cerebral cortex and hippocampus of mice in response to 10-day period of voluntary running wheel exercise compared to the sedentary control mice (Yang et al., 2014).

Nevertheless, none of these studies have focused on APE1-mediated control of telomere length and stability in response to exercise. Perhaps, correlation between physical activity and DNA repair mechanisms may be a key for genomic stability promotion by telomeres structure stabilization and higher effectiveness of DNA lesions repair.

Conclusions

Significant progress has been made in understanding how ROS effects on telomere length maintaining. Telomeres integrity is a key feature of linear chromosomes, responsible for genome stability, however, the tandem repeats found in telomeres affect the increased sensitivity to oxidative stress, which can lead to genomic instability. Growing evidence indicate connection between telomere length and lifestyle factors. It is well established that during physical exercise ROS production increases. Therefore, experimental data demonstrating the link between physical activity and telomeres length are still unclear. Physical activity may be beneficial for telomere maintenance and protect telomeric DNA from damage. Mechanisms of telomeric DNA repair and mechanisms regulating telomeres activity may constitute a new approach in therapies, regeneration and increase of endurance in active people.

It seems that the special involvement of APE-1 in telomeres biology, especially shelterin proteins, can favorably modulate telomere maintenance, improve well-being and inhibit aging processes. However, more studies

are needed, especially those with type of exercise intervention, duration, intensity of exercise on telomere length and telomeric DNA repair. This is especially important in the context of aging and the occurrence of diseases where inflammation and oxidative stress may occur.

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SALSA DANCE AND PERCEIVED MENTAL HEALTH BENEFITS: A SERVANT LEADERSHIP THEORY-DRIVEN STUDY

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Abstract The purpose of the current study was to assess servant leadership dimensions, perceived mental health benefits, and correlations between the two following an eight-week servant leadership theory-driven salsa dance programme taught to novice learners at a West Midlands, UK university. Upon completion of the salsa dance programme (frequency – once per week, intensity – moderate-to-vigorous physical activity, time – 90 minutes, type – group-based Cuban style salsa dance), a paper questionnaire was administered to the participants to complete in person. The questionnaire contained 18 items related to servant leadership dimensions (authenticity, empowerment, humility, standing back, and stewardship) in terms of the teaching and learning of salsa dance and four items related to perceived mental health benefits (mood enhancement, self-confidence, skill mastery, and social well-being). Authenticity and stewardship were rated higher in females when compared to males. Differences were found between perceived mental health benefits in both females and males with mood enhancement rated highest in both genders. This is the first study we are aware of to have applied principles of servant leadership in the teaching of salsa dance as a leisure-time physical activity. Servant leadership may have facilitated the high perceived mental health benefits observed.

Key words health promotion, Latin dancing, Robert K. Greenleaf, university students

Introduction

Mental health in UK university students

Common mental disorders, such as anxiety and depression, are increasing in prevalence in UK young adults (Stansfeld et al., 2016). In this population group, common mental disorders can markedly disrupt daily functioning and cause severe emotional distress. In turn, lowered mood, lack of self-confidence, and feelings of social isolation often manifest (Royal College of Psychiatrists, 2011). A mental health and well-being survey of the English population in 2014 showed the prevalence of symptoms of common mental disorders in 16–24 year olds to be 26% and 9% for females and males, respectively (Stansfeld et al., 2016). The same survey taken two decades earlier in England, Scotland, and Wales indicated the prevalence used to be moderately lower, at 19% and 8% for females

and males, respectively, for symptoms of common mental disorders in the same age range (Stansfeld et al., 2016). Of note, the majority (89%) of current full-time undergraduates in the UK are of this age (≤ 24 years), according to recent data published by the Higher Education Statistics Agency (2019). Although it was reported that the number of undergraduates experiencing mental illness in UK universities is approximately equal to that found in the general population (Macaskill, 2013), minimal recent empirical work has been published in the peer-reviewed literature confirming this. One survey of 6,504 UK undergraduates of both genders reported that 13% of students consider themselves to have a mental health condition, with anxiety and depression being the most common (Unite Students, 2016).

Physical activity and mental health

Evidence suggests a likely association between engagement in physical activity and enhanced mental health outcomes in adults. Using cross-sectional methods, in a very large sample of 1.2 million adults, S.R. Chekroud et al. (2018) demonstrated that mental health burden was lower in individuals who took part in team- or group-based exercise in comparison to other physical activity types. Moreover, and specifically in students aged 16–24, similar findings were presented where better mental health and social connectedness were observed in those engaging in team- and group-based physical activity when compared with physical activity performed alone (Dore, O'Loughlin, Schnitzer, Datta, Fournier, 2018). Additionally, in a recent meta-analysis, in adults, physical activity was purported to improve mental health most effectively when undertaken as a leisure-time pursuit, as opposed to physical activity taken part in in any other domain (White et al., 2017). In university students specifically, leisure-time physical activity has also been demonstrated to be beneficial for well-being (Molina-Garcia, Castillo, Queralt, 2011). Intriguingly, although increasing levels of physical activity were associated with reduced anxiety and depression in UK undergraduates (Tyson, Wilson, Crone, Brailsford, Laws, 2010), recently, a systematic review of physical activity and mental health research in university students indicated inconsistent evidence of a beneficial effect when considering only low and moderate risk of bias studies (Dogra et al., 2018).

Servant leadership

As a multi-dimensional leadership theory, servant leadership advocates for personal interaction between leader and follower, an emphasis on nurturing and serving follower needs, and fundamentally, positioning the follower first so that essentially the leader becomes the servant of the follower (Greenleaf, 1977). Practicing servant leaders place the interests, motivations, and needs of others before their own (Greenleaf, 1977). Although reported to be a personal, complex, difficult to describe, and sometimes paradoxical leadership style (Westre, 2008), servant leadership has been steadily gaining momentum in the peer-reviewed literature since the original works of R.K. Greenleaf (1977) and L.C. Spears (1995) were published. Servant leadership application has been investigated widely within the context of organisational psychology, and to a lesser degree, in educational psychology, health psychology (Eva, Robin, Sendjaya, van Dierendonck, Liden, 2018), and sport psychology (Hammermeister et al., 2008; Rieke, Hammermeister, Chase, 2008; Westre, 2008). We are unaware, however, of empirical work that has applied principles of servant leadership to facilitate the teaching of physical activity for mental health-enhancing purposes. As servant leadership is focussed on the creation of opportunities for followers to grow and flourish (Greenleaf, 1977), we posit that this particular leadership style may lend itself well to the teaching of physical activity

to young adults in a university setting. N. Eva et al. (2019) provide the following contemporary definition of servant leadership theory:

Servant leadership is an (1) other-oriented approach to leadership (2) manifested through one-on-one prioritizing of follower individual needs and interests, (3) and outward reorienting of their concern for self towards concern for others within the organization and the larger community (p. 114).

In the current study, we considered each student in the salsa dance programme to be a follower, everyone involved with or attending the classes to be the organisation, and the university itself to be the larger community.

Purpose of the study

Salsa dance is an enjoyable (Domene, Moir, Pummell, Easton, 2014) group-based leisure-time physical activity that is not only popular with adults in the UK (National Health Service, 2016), but also potentially efficacious in terms of the enhancement of mental health outcomes (Birks, 2007; Coruh, 2014; Domene, Moir, Pummell, Easton, 2016). Currently, no empirical work has been published in the peer-reviewed literature to assess whether R.K. Greenleaf's (1977) servant leadership theory can facilitate the teaching of mental health-enhancing physical activity to novice learners in a university setting. It remains unclear whether a salsa dance programme taught to UK university students of both genders using principles of servant leadership would result in perceived mental health benefits. Furthermore, it is unclear whether the responses to servant leadership and any perceived mental health benefits would be different between females and males. It is also unknown whether servant leadership and any perceived mental health benefits would correlate and whether these correlations would be different between genders. Therefore, the purpose of the current study was to assess servant leadership dimensions (authenticity, empowerment, humility, standing back, and stewardship) using the Servant Leadership Survey short version (van Dierendonck et al., 2017), perceived mental health benefits (mood enhancement, self-confidence, skill mastery, and social well-being) (Maraz, Kiraly, Urban, Griffiths, Demetrovics, 2015), and correlations between the two following an eight-week servant leadership theory-driven salsa dance programme taught to novice learners at a West Midlands, UK university.

Methods

Ethical approval and study design

Ethical approval for the study was granted by the Faculty of Health and Life Sciences Ethics Committee at the lead author's university. A pre-experimental one group posttest-only design was used (Thyer, 2012).

Participants

Recruitment of participants was undertaken using online advertisements placed on the university virtual learning environment Moodle Version 3.4 (West Perth, Western Australia, Australia). As students access the virtual learning environment regularly, this method of recruitment ensured all students had equal opportunity to take part. Inclusion criteria stated participants must be enrolled as full-time students (either as undergraduates or postgraduates) and be novice learners of salsa dance. Exclusion criteria stated the study would not be suitable for those unable to take part in leisure-time physical activity at a moderate-to-vigorous intensity. No mental

health-related inclusion or exclusion criteria were set. Participants gave their informed consent in writing prior to commencement of the study.

Procedure

Salsa dance programme

An eight-week salsa dance programme was taught at an appropriate level for novice learners with instruction delivered by an experienced salsa dance teacher. The classes were held on a weekday evening with consistent start and end times in a 22 × 11 m laboratory research space at the lead author's university. No financial or academic incentives were given for attendance. Frequency of the classes was once per week. Intensity of the classes was set to a moderate-to-vigorous physical activity level (approximately 5.4–6.6 metabolic equivalents) based on the study by P.A. Domene and C. Easton (2014). Time of the classes was 90 minutes. Type of the classes was group-based Cuban style salsa dance commencing with the basic steps taught in a non-partner fashion and progressing through to more complex steps including partner work. Eight classes in total were delivered by the salsa dance teacher and attendance was on a strictly voluntary basis.

Incorporation of servant leadership theory

Principles of servant leadership theory were incorporated into the teaching of the salsa dance programme. The salsa dance teacher had previously completed a four-year undergraduate degree in human kinetics at a servant leadership-based university and had previous experience delivering leisure-time physical activity sessions (including salsa dance) to adults using principles of servant leadership theory. These principles are in alignment with the contemporary definition of servant leadership theory provided by N. Eva et al. (2019). The classes were structured in a manner that emphasised motive, mode, and mindset (Eva et al., 2019) in the teaching of a servant leadership theory-driven salsa dance programme.

Measures

Participant characteristics

Upon completion of the salsa dance programme, a three-page (A4 size) paper questionnaire was administered to the participants to complete in person. Participants self-reported age and gender. Participants also confirmed their enrolment as full-time students and that they were novice learners of salsa dance prior to commencement of the study.

Servant leadership dimensions

The questionnaire contained 18 items related to servant leadership dimensions in terms of the teaching and learning of salsa dance. An adapted version of the Servant Leadership Survey short version by D. van Dierendonck et al. (2017) was used. This questionnaire has been reported to be a valid and reliable measure of servant leadership dimensions in adults (van Dierendonck et al., 2017). The questionnaire's five dimensions comprised authenticity, empowerment, humility, standing back, and stewardship. Ratings were measured using a six-point Likert-type scale ranging from "Fully disagree" to "Fully agree". Item wordings were altered slightly from the original version to reflect the teaching and learning of salsa dance. Example items include: "My salsa teacher is open about his/her

limitations and weaknesses" (authenticity); "My salsa teacher gives me the information I need to learn salsa well" (empowerment); "My salsa teacher learns from criticism" (humility); "My salsa teacher keeps himself/herself at the background and gives credit to others" (standing back); and "My salsa teacher emphasises the importance of paying attention to the good of the whole" (stewardship).

Perceived mental health benefits

The questionnaire contained four items related to perceived mental health benefits. Based on the Dance Motivation Inventory by A. Maraz et al. (2015), mood enhancement, self-confidence, skill mastery, and social well-being were selected for investigation in the current study as these were the highest rated mental health-related reasons that account for why adults take part in Latin dance as a leisure-time physical activity. The reliability of the Dance Motivation Inventory has been demonstrated (Maraz et al., 2015). In the current study, ratings of perceived mental health benefits were measured using a 100 mm visual analogue scale. The validity of this method has been reported by E.P. Ahearn (1997). Anchor statements of "Fully disagree" and "Fully agree" were used to rate the following four items: "I feel the salsa classes improve my mood" (mood enhancement); "I feel the salsa classes improve my self-confidence" (self-confidence); "I feel I improve in my ability to dance by attending the salsa classes" (skill mastery); and "I feel I make friends by attending the salsa classes" (social well-being).

Statistical analyses

IBM SPSS Statistics Version 25 (Armonk, New York, USA) was used to conduct all statistical analyses. Differences between females and males were analysed using Mann-Whitney *U* tests. Differences within servant leadership dimensions and perceived mental health benefits were analysed using Friedman tests. Post hoc analyses were performed using Wilcoxon signed-rank tests with a Bonferroni adjustment applied. Correlations between servant leadership dimensions and perceived mental health benefits were analysed using Spearman rank correlations. Central tendency and dispersion are presented as *Mdn* ($Q_1 - Q_3$). Effect sizes were calculated using Cohen's *r* and interpreted as .10, .30, and .50 for small, medium, and large effects, respectively. All analyses were performed as two-tailed tests. Statistical significance was set at $p < 0.05$. Figures are shown as Tukey boxplots.

Results

Data screening, response rate, and participant characteristics

One hundred twenty-three students completed the salsa dance programme (with an attendance of ≥ 6 classes) and were invited to take part in the study. Of these, 106 volunteered to complete the questionnaire. Six were excluded from the statistical analyses due to either not meeting the inclusion criteria or for having excessive missing data (>2 items unanswered). Where missing data were ≤ 2 items unanswered, imputation was performed using within-participant *Mdn* values. There were no missing data for perceived mental health benefits. The response rate for the study, therefore, was 81% ($100/123 = 0.81$; $0.81 \times 100 = 81$). The final sample ($N = 100$) comprised 70 females and 30 males. No difference ($p > 0.05$) was found in age between females (21 (20–26) years) and males (23 (20–27) years).

Servant leadership dimensions

In females, a difference ($p < 0.001$) was found between servant leadership dimensions; however, in males, no difference ($p > 0.05$) was found. Ratings across servant leadership dimensions for both females and males are shown in full in Figure 1. Post hoc analysis for females indicated that stewardship was higher than authenticity ($p < 0.001$; effect size – .43), empowerment ($p = 0.001$; effect size – 0.35), humility ($p < 0.001$; effect size – 0.48), and standing back ($p < 0.001$; effect size – 0.39). No other differences (all $p > 0.05$) were found in the pairwise comparisons. When comparing between females and males, authenticity ($p = 0.040$; effect size – 0.21) and stewardship ($p = 0.010$; effect size – 0.26) were higher in females. No other differences (all $p > 0.05$) were found between females and males.

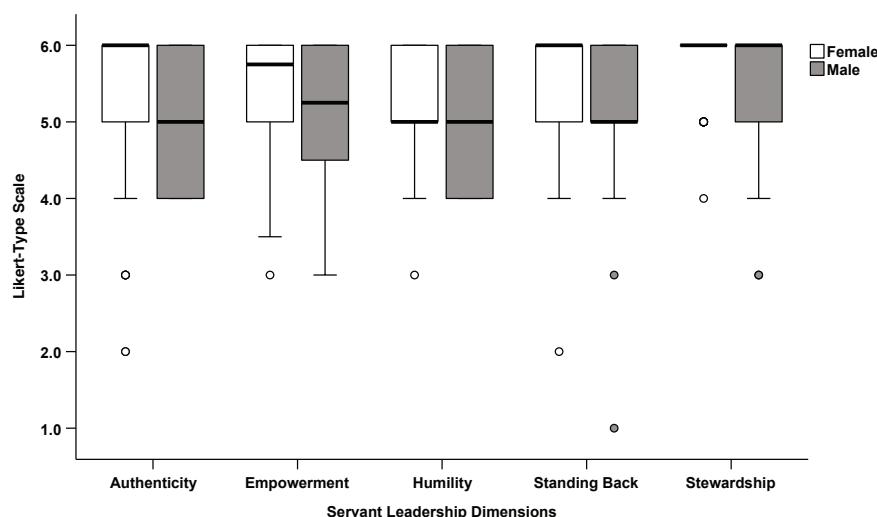


Figure 1. Servant leadership dimensions in female ($n = 70$) and male ($n = 30$) West Midlands, UK university students following completion of an eight-week servant leadership theory-driven salsa dance programme for novice learners

Perceived mental health benefits

Differences were found between perceived mental health benefits in both females ($p < 0.001$) and males ($p = 0.035$). The ratings are shown in full in Figure 2. Post hoc analysis for females indicated that mood enhancement was higher than self-confidence ($p < 0.001$; effect size – 0.40) and social well-being ($p < 0.001$; effect size – 0.52). Self-confidence ($p = 0.006$; effect size – 0.28) and skill mastery ($p < 0.001$; effect size – .41) were also higher than social well-being. Post hoc analysis for males indicated that mood enhancement was higher ($p = 0.002$; effect size – 0.32) than social well-being. No other differences (all $p > 0.05$) were found in the pairwise comparisons for either females or males. When comparing between females and males, no differences (all $p > 0.05$) were found in any of the perceived mental health benefits.

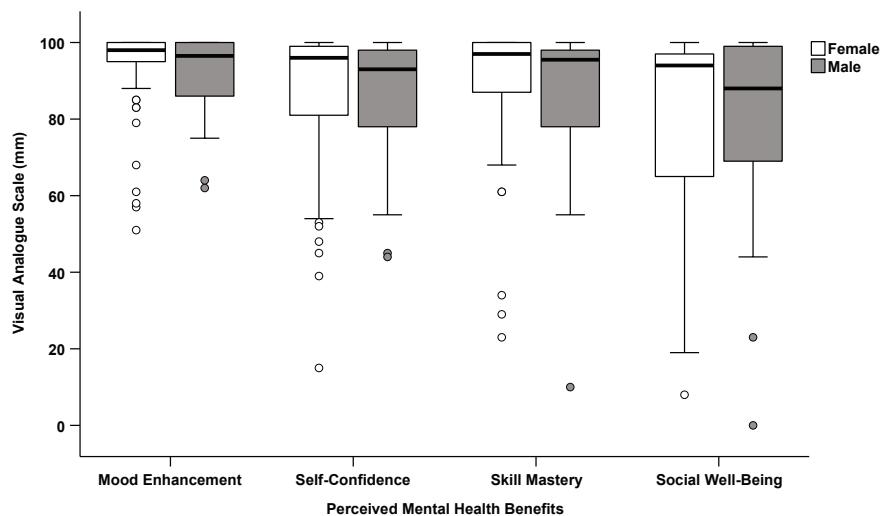


Figure 2. Perceived mental health benefits in female ($n = 70$) and male ($n = 30$) West Midlands, UK university students following completion of an eight-week servant leadership theory-driven salsa dance programme for novice learners

Correlation analyses

In females, low and moderate positive correlations were found between servant leadership dimensions and perceived mental health benefits. The correlations are shown in full in Table 1. No correlation, however, was found between humility and social well-being, stewardship and mood enhancement, and stewardship and self-confidence (all $p > 0.05$). In contrast, in males, only stewardship was found to be moderately positively correlated with mood enhancement ($r_s = 0.46$; $p = 0.011$). No other correlations were found between servant leadership dimensions and perceived mental health benefits (all $p > 0.05$) in males.

Table 1. Correlations between servant leadership dimensions and perceived mental health benefits in female West Midlands, UK university students following completion of an eight-week servant leadership theory-driven salsa dance programme for novice learners ($n = 70$)

	Perceived Mental Health Benefits			
	mood enhancement	self-confidence	skill mastery	social well-being
	Servant Leadership Dimensions			
Authenticity	$r_s = 0.33$; $p = 0.006$	$r_s = 0.29$; $p = 0.015$	$r_s = 0.33$; $p = 0.005$	$r_s = 0.27$; $p = 0.026$
Empowerment	$r_s = 0.27$; $p = 0.027$	$r_s = 0.29$; $p = 0.013$	$r_s = 0.31$; $p = 0.009$	$r_s = 0.28$; $p = 0.018$
Humility	$r_s = 0.28$; $p = 0.018$	$r_s = 0.27$; $p = 0.022$	$r_s = 0.35$; $p = 0.003$	
Standing Back	$r_s = 0.24$; $p = 0.046$	$r_s = 0.33$; $p = 0.006$	$r_s = 0.37$; $p = 0.002$	$r_s = 0.30$; $p = 0.013$
Stewardship			$r_s = 0.28$; $p = 0.019$	$r_s = 0.28$; $p = 0.018$

Note: Data are presented as Spearman rank correlations where statistically significant.

Discussion

Summary

This is the first study we are aware of to have applied principles of R.K. Greenleaf's (1977) servant leadership theory in the teaching and learning of salsa dance as a leisure-time physical activity for the enhancement of mental health outcomes. It was found that in novice learners, stewardship was the most highly rated servant leadership dimension and mood enhancement was the most highly rated perceived mental health benefit. Positive correlations between servant leadership and perceived mental health benefits were found in both genders and were of low to moderate magnitudes. Although a pre-experimental study design was chosen, our results suggest that servant leadership may have facilitated the high perceived mental health benefits observed following engagement in the salsa dance programme.

Servant leadership dimensions

The Servant Leadership Survey short version focusses on the personal relationship that develops between leader and follower and is evaluated from the follower's perspective (van Dierendonck, Nijiten, 2011; van Dierendonck et al., 2017). Servant leaders go beyond their self-interests and create opportunities for followers to become the best version of themselves that they can be (Greenleaf, 1977). In the current study, an eight-week servant leadership theory-driven salsa dance programme was taught to novice learners in a university setting with followers (the students) rating the dimension of stewardship highest in the leader (the salsa dance teacher). In this context, stewardship can be thought of as willingness to take responsibility for the promotion of leisure-time physical activity to students in the larger community (the university itself) through emphasis of service instead of control (Aij, Rapsaniotis, 2017; van Dierendonck, Nijiten, 2011). The high stewardship rating is likely due to the salsa dance teacher having facilitated others to focus on the common interests of the organisation (everyone involved with or attending the classes), for example building an environment that promotes both physical activity and mental health, while remaining socially responsible and with a sense of obligation to the common good (Aij, Rapsaniotis, 2017; van Dierendonck, Nijiten, 2011). Moreover, the salsa dance teacher considered the students as individuals entrusted under his/her care (Greenleaf, 1977). Hence, as a trustee, this meant ensuring the responsible running of the salsa dance programme with an overarching concern for the well-being of the followers, organisation, and larger community (Block, 1993).

Perceived mental health benefits

In the current study, both female and male university students rated mood enhancement as the highest perceived mental health benefit following completion of the salsa dance programme. This is in line with the study of A. Maraz et al. (2015) who reported the same finding in recreational Latin dancers. Similarly, according to P.A. Domene et al. (2014), psychological outlook ("a state of improved mental health and well-being, experiencing a sense of enjoyment or accomplishment, or being relaxed and without feelings of stress or tension"; p. 35) was found to be the dance-related perceived benefit of greatest importance in non-professional salsa dancers. Although the two aforementioned studies were undertaken using adults of both genders, neither was conducted in a university setting nor sought to recruit specifically university students per se. Additionally, it was reported that students are challenged not only with having to learn important new skills at university, such as living independently, creating

new relationships, managing finances, and handling academic pressures (Parker, Summerfeldt, Hogan, Majeski, 2004), but experience higher levels of poor mental health than pre-university (Bewick, Koutsopoulou, Miles, Slaa, Barkham, 2010). Much of this goes undetected and unsupported in the current university system (Macaskill, 2013; Royal College of Psychiatrists, 2011). Hence, it may be exactly these types of stressors that cause university students to seek out leisure-time pursuits that they perceive to be mood enhancing. Weekly salsa dance classes, therefore, may benefit mental health through mood enhancement as participation has been shown to foster interest and enjoyment (Domene et al., 2014), both of which are central to autonomously motivated behaviour (Ryan, Deci, 2000), and reduce feelings of distress acutely (Domene et al., 2016).

Correlation analyses

Servant leadership was found to be positively related to perceived mental health benefits in the current study. This may be explained through the fulfilment of follower needs satisfaction as servant leadership has been shown to influence feelings of autonomy, competence, and relatedness (Ryan, Deci, 2000) within organisational contexts (Chiniara, Bentein, 2016; Mayer, Bardes, Piccolo, 2008). Servant leaders are invested in the growth, development, and well-being of their followers, and as such, work hard to ensure these basic psychological needs are satisfied in those they are leading. It is plausible that as the servant leadership dimensions and perceived mental health benefits were both highly rated, that participation in the salsa dance programme did indeed satisfy follower needs, thereby contributing to the associations found. Recently, in a sport context, G.S. Sullivan (2019) provided theoretical support for how needs satisfaction can facilitate servant leaders in meeting the basic psychological needs of their followers. Moreover, those who experience fulfilment of their autonomy, competence, and relatedness needs are more likely to continue with task engagement due to increased intrinsic motivation (Ryan, Deci, 2000). There is some evidence of servant leadership theory applied in a sport context that supports this in university students (Hammermeister et al., 2008).

Limitations and future research recommendations

Despite the current study being novel in terms of servant leadership application to facilitate the teaching of mental health-enhancing physical activity, there are certain research limitations that we must acknowledge. First, no data were collected on the academic subject enrolled in by the participants. Having this data may have influenced the perceived mental health benefits as W. Larcombe, S. Finch and R. Sore (2015) reported that differences were found in depression, anxiety, and stress between university students enrolled in different academic subjects. Second, data were not collected on the academic year of study of the participants. This too may have influenced the perceived mental health benefits. It was reported by Macaskill (2013) that differences existed in psychiatric morbidity between academic year of study in (specifically UK-based) university students. Third, as the study design chosen was pre-experimental, cause and effect cannot be determined from our results. In the future, servant leadership theory-driven physical activity research should move from efficacy to effectiveness study designs (Thyer, 2012) in order to more comprehensively assess mental health outcomes in university students.

Conclusions

Following an eight-week servant leadership theory-driven salsa dance programme taught to novice learners at a West Midlands, UK university, high perceived mental health benefits were observed with mood enhancement

being the most highly rated in both genders. Low to moderate positive correlations were found between servant leadership dimensions and perceived mental health benefits. The current pilot study suggests possible feasibility of procedures for future implementation in a randomised controlled trial of salsa dance-based mental health-enhancing physical activity for university students. Using an appropriate study design that addresses the true effectiveness of this particular form of leisure-time physical activity could be actioned through funding from already established university-based mental health support services. In a similar fashion to the work of A. Macaskill (2013), this research was carried out at a post 92 university that has engaged with the UK government's widening participation agenda in relation to higher education access. We feel greater consideration ought to be given to mental health-enhancing physical activities targeting students specifically at universities such as these (Macaskill, 2013; Royal College of Psychiatrists, 2011).

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SEXUAL DIMORPHISM IN SIGNIFICANT CORRELATIONS FREQUENCY BETWEEN THE CHARACTERISTICS OF BODY TRUNK AND FEET IN CHILDREN AGED 4 TO 6 YEARS

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Abstract Relatively few publications have concerned characteristics of body trunk and feet. It is generally suggested that correlations exist between the characteristics of the developing foot and the spinal column. The purpose of the study was to show sexual dimorphism in frequency of incidence, as well as significant correlations concerning selected body trunk and feet parameters in the group of 4–6-year-old children.

The examinations conducted in a group of children aged 4 to 6 allowed for recording 2,988 observations, including 1,482 girls and 1,506 boys, and values of 87 characteristics that described body trunk and feet. The test stands for the measurement of the selected parameters using the photogrammetric method consisted of a personal computer, software, screen and printer, and a projection-reception device with a camera.

The general number of body trunk characteristics having significant correlations with feet parameters in females was slightly higher. The number of relationships in sagittal and frontal planes was the same in both sexes. The characteristics that differentiated males from females were found mainly in transverse and frontal planes. The number of feet characteristics that most often showed significant correlations with body trunk parameters was higher in girls than in boys. These were mainly characteristics concerning width and length, longitudinal arch and disorders in the position of the feet. The characteristics that differentiated boys described only the longitudinal arch of the feet.

Key words relationships, dimorphism, characteristics of body posture, feet, sex

Introduction

The issue of sexual dimorphism in the field of somatic traits has occurred in numerous publications and seems to be obvious, well-described and undisputed (Górniak, 2000; Webster-Gandy, Warren, Henry, 2003; Wolański, 2005, Gosh, Choudhary, Chowdhury, Ghosh, 2009; Perenc, Radochońska, 2012; Koudelová, Brůžek, Cagáňová,

Krajíček, Velemínská, 2015; Wojciechowska-Maszkowska, Wieloch, 2015). However, there have been very few publications regarding the impact and correlations of body trunk and foot parameters. M. Steinmetz (1984) assumes there is interdependence between the type of the forming foot and the shape of the spine. The suggestion that if the spinal traits can be corrected by modifying the foot parameters, the foot parameters can be influenced by changing the spinal characteristics, raises a number of objections. However, the results of the studies presented below, at least theoretically, allow such a possibility. M. Steinmetz (1984) also emphasizes legitimacy of wearing corrective footwear since a correctly positioned foot in a special footwear can cause spinal deformation which is consistent with the views expressed by the authors of this paper. The pilot studies by J. Drzał-Grabiec and S. Snela (2012) in the population of 7–9-year-old girls and boys allowed to find relationships between the longitudinal arch of the right and left foot, measured with Clarke's angle, and length parameters describing body posture. According to the research, there was a significant correlation between the longitudinal arch of both feet, measured using Clarke's angle and the spine height between points C7 and S1. This dependence was confirmed when considering the division into subgroups of boys and girls as well as age subgroups. As far as age groups are concerned, a significant correlation was observed only in the group of 9-year-olds.

The purpose of the study was to show sexual dimorphism in frequency of incidence, as well as significant correlations concerning selected body trunk and feet parameters in the group of 4–6-year-old children.

Material and method

The studies conducted in the Warmińsko-Mazurskie Voivodeship enabled to record 2,988 observations including 1,482 girls and 1,506 boys. Body posture was assessed by means of the photogrammetric method with regard to generally adopted principles (Mrozkowiak, 2015). The statistical analysis covered 87 angular and linear parameters of the spine, pelvis, trunk and feet in the sagittal, frontal and transverse planes, in particular age and environment categories (Table 1, Table 2). The empirical data were the quantitative and qualitative characteristics (gender, domicile, etc.). The conducted calculations covering the values of position statistics (arithmetic mean, quartiles), the dispersion parameter (standard deviation) and symmetry indicators (asymmetry and concentration indicators) provided a full view of the distribution of the studied features considering gender, environment and age ranges. The correlations and their significance were assessed using p-value and frequency expressed in percentage. Due to editorial requirements related to article volume, the authors deliberately did not include the detailed description and a full statistical analysis of the findings, citing only partial results ensuing from the subject of the paper.

Table 1. Body trunk parameters

No.	Symbol	Parameters		
		unit	name	description
1	2	3	4	5
Sagittal plane				
1.	Alfa	degree	Inclination of lumbo-sacral region	
2.	Beta	degree	Inclination of thoracolumbar region	
3.	Gamma	degree	Inclination of upper thoracic region	
4.	DCK	mm	Total length of the spine	Distance between C7 and S1, measured in vertical axis
5.	KPT	degree	Angle of extension	Defined as a deviation of the C7-S1 line from vertical position (backwards)

Sexual Dimorphism of Correlations Between Body Trunk and Feet in Children

1	2	3	4	5
6.	KPT-	degree	Angle of body bent	Defined as a deviation of the C7-S1 line from vertical position (forwards)
7.	DKP	mm	Thoracic kyphosis length	Distance between LL and C7
8.	KKP	degree	Thoracic kyphosis angle	$KKP = 180 - (\text{Beta} + \text{Gamma})$
9.	RKP	mm	Thoracic kyphosis height	Distance between points C7 and PL
10.	GKP	mm	Thoracic kyphosis depth	Distance measured horizontally between the vertical lines passing through points PL and KP
11.	DLL	mm	Lumbar lordosis length	Distance measured between points S1 and KP
12.	KLL	degree	Angle of lumbar lordosis	$KLL = 180 - (\text{Alfa} + \text{Beta})$
13.	RLL	mm	Lumbar lordosis height	Distance between points S1 and PL
14.	GLL-	mm	Lumbar lordosis depth	Distance measured horizontally between the vertical lines passing through points PL and LL
Frontal plane				
15.	KNT-	degree	Angle of body bent to the side	Defined as deviation of the C7-S1 line from the vertical axis to the left
16.	KNT	degree		Defined as deviation of the C7-S1 line from the vertical axis to the right
17.	LBW-	mm	Right shoulder up	Distance measured vertically between horizontal lines passing through points B ₂ and B ₄
18.	LBW	mm	Left shoulder higher	
19.	KLB	degree	Shoulder line angle, right shoulder up	Angle between the horizontal line and the straight line passing through points B ₂ and B ₄
20.	KLB-	degree	Shoulder line angle, left shoulder up	
21.	LLW	mm	Left scapula up	Distance measured vertically between horizontal lines passing through points L ₁ and L _p
22.	LLW-	mm	Right scapula up	
23.	UL	degree	Angle of scapula line, right scapula up	Angle between the horizontal line and the straight line passing through points L ₁ and L _p
24.	UL-	degree	Angle of scapula line, left scapula up	
25.	OL	mm	Lower angle of left scapula more distant	Difference of the distance of lower angles of the scapula from the line of spinous processes measured horizontally along the lines passing through points L ₁ and L _p
26.	OL-	mm	Lower angle of right scapula more distant	
27.	TT	mm	Left waist triangle up	Difference of the distance measured vertically between points T ₁ and T ₂ , T ₃ and T ₄ .
28.	TT-	mm	Right waist triangle up	
29.	TS	mm	Left waist triangle wider	Difference of the distance measured horizontally between straight lines passing through points T ₁ and T ₂ , T ₃ and T ₄
30.	TS-	mm	Right waist triangle wider	
31.	KNM	degree	Pelvis tilt, right ilium up	Angle between the horizontal line and the straight line passing through points M1 and Mp
32.	KNM-	degree	Pelvis tilt, left ilium up	
33.	UK	mm	Maximum inclination of the spinous process to the right	Maximal deviation of the spinous process from the line from S1. The distance is measured in horizontal line.
34.	UK-	mm	Maximum inclination of the spinous process to the left	
35.	NK	-	Number of the vertebra maximally distanced to the left or to the right	Number of the vertebra most distanced to the left or to the right in the asymmetric line of the spinous process, counting as 1 the first cervical vertebra (C ₁). If the arithmetic mean takes the value e.g. from 12.0 to 12.5, it is Th ₅ , if from 12.6 to 12.9 it is Th ₆
Transverse plane				
36.	LB-	mm	Lower angle of the right scapula more convex	Difference of the distance of lower scapula angles from the surface of the back
37.	LB	mm	Lower angle of the scapula more convex	
38.	UB-	degree	Angle of projection line of lower scapula angles, the left one more convex	Difference in the angles UB ₁ – UB ₂ . Angle UB ₂ between: the line passing through point L ₁ and at the same time perpendicular to the camera axis and the straight line passing through points L ₁ and L _p . Angle UB ₁ between the line passing through point L _p and perpendicular to the camera axis and the straight line passing through points L _p and L ₁
39.	UB	degree	Angle of projection line of lower scapula angles, the right one more convex	

1	2	3	4	5
40.	KSM	degree	Pelvis rotated to the right	Angle between the line passing through point M1 and perpendicular to the camera axis and the straight line passing through points M1 and MP
41.	KSM-	degree	Pelvis rotated to the left	Angle between the line passing through point Mp and perpendicular to the camera axis and the straight line passing through points Ml and MP

Source: author's own research.

Table 2. Foot parameters

No.	Symbol	Parameters		
		unit	name	description
1	2	mm	3	4
1.	DL p		Length of the right foot (P), left foot (L)	Distance between points akropodium and pterion in a plantogram
2.	DL l			Distance between points metatarsale fibulare and metatarsale tibiale in a plantogram
3.	Sz p		Valgus angle of the hallux of the right foot: AlfaPp, of the left foot: AlfaLp. Angle of varus deformity in the right foot: AlfaPm, left foot: AlfaLm	Angle between the straight line passing through points metatarsale tibiale and the most inner one on the medial edge of the heel and the straight line passing through points metatarsale fibulare and the most inner one on the medial edge of the great toe
4.	Sz l			Angle between the straight line passing through points metatarsale fibulare and the most outer one on the lateral edge of the heel and the straight line passing through points metatarsale fibulare and the most outer one on the lateral edge of the fifth toe in a plantogram
5.	Alfa p m			Angle between the straight line passing through points metatarsale fibulare and the most inner one on the medial edge of the heel and the straight line passing through points metatarsale fibulare and the most outer one on the lateral edge of the heel in a plantogram
6.	Alfa p p			Heel angle of right foot (P), of left foot (L)
7.	Alfa l m			
8.	Alfa l p			
9.	Beta p m			
10.	Beta p p			
11.	Beta l m	mm ²	Plantar surface of right foot (P), left foot (L)	
12.	Beta l p			
13.	Gamma p (Gam.P)			
14.	Gamma l (Gam.L)			
15.	PS p			Plantar surface of the foot
16.	PS l			
17.	DP 1			
18.	DP 2			
19.	DP 3			
20.	DP 4			
21.	DP 5	mm	Length of longitudinal arch 1, 2, 3, 4, and 5 of right foot (P), left foot (L)	Length of the arch from 1, 2, 3, 4 and 5 metatarsale foot to point pterion
22.	DL 1			
23.	DL 2			
24.	DL 3			
25.	DL 4			
26.	DL 5			
27.	WP 1			
28.	WP 2			
29.	WP 3			
30.	WP 4			
31.	WP 5		Height of the arch 1, 2, 3, 4 and 5 of right foot (P), left foot (L)	Distance from the bottom to the highest point of arch 1, 2, 3, 4 and 5
32.	WL 1			
33.	WL 2			
34.	WL 3			
35.	WL 4			
36.	WL 5			

1	2	3	4	5
37.	SP 1			
38.	SP 2			
39.	SP 3			
40.	SP 4			
41.	SP 5			
42.	SL 1			
43.	SL 2			
44.	SL 3			
45.	SL 4			
46.	SL 5			

mm Width of the arch 1, 2, 3, 4 and 5 of right foot (P), left foot (L) Bowstring of the distance of the arch 1, 2, 3, 4 and 5

The fundamental assumption of the study was to always assess the habitual posture as a relatively constant individual characteristic of a human being. This posture reflected an individual emotional, psychical and social condition of the subject. Moreover, the posture provided the most reliable description of the subject's silhouette at a given time and in a place. The conducted diagnostics did not determine whether an individual's posture was correct or not, it only identified the condition of its ontogenetic development. Objectified and comparable test results were able to ensure that the postural parameters adopted for the analysis were recorded with possible to determine compensations. The combined assessment of the trunk and feet allowed to objectively determine the quality of the postural model applied in a given environment, gender and age category. The measuring instrument used in the study determined several tens of parameters describing body posture (Table 1, Table 2). Obtaining the spatial picture was possible thanks to displaying the line of strictly defined parameters on back and feet. The lines falling on the skin of a child got distorted depending on the configuration of the surface screen. The applied lens ensured that the imaging of a subject could be received with the use of the MORA 4G HD diagnostics set, the picture can be received and transmitted onto a computer by a special optical system with a camera. The distortions of the line imaging recorded in the computer memory were processed through a numerical algorithm on the topographic map of the investigated surface. When conducting the study, one should be aware of the fact that the taken photo records an image of the silhouette displayed on a child's skin (Mrozkowiak, 2015). The acceptance of the Research Ethics Committee at the Kazimierz Wielki University in Bydgoszcz had been obtained before the research were conducted¹.

Results

The analysis of the findings headed in two directions. The first one was to determine how often and which body trunk parameters most frequently revealed a significant correlation with feet parameters within sexual dimorphism. The second, to explain which feet parameters most often significantly correlated with the body trunk parameters, also within sexual dimorphism.

The analysis of the study results with regard to sexual dimorphism, concerning feet parameters with which body trunk parameters correlated most frequently, showed the following parameters in girls: width of both feet (SZP,

¹ A written consent of parents or guardians was received, for their children to participate in a scientific project, as well acceptance of preschool principals and the Research Ethics Committee at the Kazimierz Wielki University in Bydgoszcz – KEBN 2/2018.

SZL), length of the left foot (DLL), valgus angle of the fifth toe in the right foot (BetaPp), and of the Plantar surface of left foot (PSL), height and length of the first arch in the right foot (WP1, DP1), width of the first and fifth longitudinal arch of the left foot (SL1, SL5). As regards boys, these were the values of such parameters as height of the second and third longitudinal arch in the right foot (WP2, WP3), width of the third and fourth arch in the right foot (SP3, SP4), height of the fourth and length of the fifth arch (WL4, DL5) and width of the third arch in the left foot (SL3) (Table 3).

Table 3. Sexual dimorphism of the characteristics of feet with the most frequent significant correlation with the characteristics of body trunk; (n) = 1,482 girls and 1,506 boys

Parameter	Gender		Parameter	Gender	
	girls	boys		girls	boys
SZP	13.4	0.0	SP1	6.5	17.3
SZL	13.4	0.0	SP3	0.0	8.6
DLP	17.3	17.3	SP4	0.0	6.5
DLL	17.3	0.0	WL4	0.0	10.8
BetaP	6.5	0.0	WL5	6.5	8.6
GamP	8.6	6.5	DL2	21.7	6.5
GamL	17.3	15.2	DL5	0.0	6.5
PSL	8.6	0.0	SL1	22.6	0.0
WP1	6.5	0.0	SL2	17.3	6.5
WP2	0.0	13.4	SL3	0.0	8.6
WP3	0.0	8.6	SL4	6.5	6.5
DP1	10.8	0.0	SL5	6.5	0.0

The analysis of the study results in terms of sexual dimorphism of body trunk parameters that most frequently differentiated the relationships with feet parameters revealed that among girls these were the values of the following parameters: the angle, height and depth of lumbar lordosis (KLL, RLL, GLL), angle of body trunk bent to the left side in the frontal plane (KNT-), angle of body bent to side in the sagittal plane (KPT-), asymmetry of waist triangles height with the right triangle up (TT-), asymmetry of the distance of lower angles from the spinous process with the angle of the left scapula being more distanced (OL), maximum inclination of one spinous process to the left (UK-). Among boys, these characteristics included: height of thoracic kyphosis (RKP), angle of body trunk bent to the right side in the frontal plane (KNT), asymmetry of the projection line of lower scapula angles with the left one more convex (UB), angle of pelvis rotated to the right (KSM), number of the vertebrae maximally distanced to the left from the spinous process (NK-) (Table 4).

No research similar to those presented in this study had been found in source literature. Statistical analysis revealed a number of dependencies significant for posture equilibrium disorders. Despite evident results of statistical analysis, the above presented relations should not be approached uncritically, for what logical connection can there occur between depth and height of thoracic kyphosis and varus or valgus angle of the fifth toe? While planning a correction procedure, one should take into consideration the above presented correlations not only between values of feet parameters and spine-pelvis system, but also between spine-pelvis system and feet, as well as weight and height, as presented in other research of the authors. The analysed relations between spine-pelvis and feet characteristics at boys and girls aged 4–18 demonstrate that the most often a significant correlation occurs in spinal sagittal longitudinal features, less often in frontal or transverse ones. These features most often

Table 4. Sexual dimorphism of the frequency of significant correlations between the characteristics of body trunk and feet; (n) = 1,482 girls and 1,506 boys

Parameter	Gender		Parameter	Gender	
	girls	boys		girls	boys
DCK	13.72	5.88	KPT-	19.6	0.0
Alfa	9.8	5.88	TT-	7.84	0.0
Beta	7.84	3.92	TS	3.92	7.84
Gamma	3.92	7.84	ŁB	3.92	11.76
KKP	3.92	7.84	UB	0.0	7.84
RKP	0.0	23.52	UB-	3.92	13.72
DKP	5.88	15.68	UL	5.88	7.84
GKP	5.88	13.72	LŁW	11.76	5.88
KLL	21.56	0.0	KLB	7.64	11.76
DLL	13.72	3.92	KLB-	7.84	11.76
RLL	15.68	0.0	OL	5.88	0.0
GLL	3.92	0.0	KNM	3.92	13.72
KNT	0.0	3.92	KSM	0.0	3.92
KNT-	5.88	0.0	UK-	13.72	0.0
			NK	0.0	9.8

showed dependency between right and left foot width, and valgus angle of the right foot's fifth toe. A significant correlation between feet parameters and spine-pelvis characteristics most often occurred with reference to width of both feet. Another correlation was repeatedly revealed between the height and length of lumbar lordosis and thoracic kyphosis, in the angle of upper thoracic part bent (Mrozkowiak, Jazdończyk, 2015). Among the analysed correlations between selected feet characteristics and trunk features in children and youth aged 4–18 years, those most popular and frequent occurred, as expected, at the age of 7–13 years, less frequent – at the age of 14–18 years, and the least frequent – at the age of 4–6 years. It should also be noted that, though in the first age group no meaningful relations with morphological features of feet (length and width) appear, in the remaining two – they do. Within sexual dimorphism at the age of 4–6 years, more numerous and frequent correlations occur among boys than girls. At the age of 7–13 years this disparity levels out, yet still boys maintain a slight dominance. In the last age group, 14–18-year-olds, girls display more numerous and frequent correlations than boys, which was also expected. No quantitative disparity of features occurred within environmental dimorphism in age group 4–6-year-olds, while frequency of significant correlations is slightly higher among boys. However, in the age group of 7–13-year-olds, individuals from urban environment display greater dominance in both, quantity and frequency of correlations with trunk features. In the last analysed age group, of 14–18-year-olds, mutual quantitative and frequency-related disparities disappear, approaching levels of the age group of 4–6-year-olds (Sokołowski, Mrozkowiak, 2017). The frequency analysis of essential correlations between feet and trunk features in youth aged 14–18 years revealed that values of left foot display more frequent correlation with trunk features than right foot. Feet characteristics display more frequent correlations with trunk features in sagittal plane, less in frontal one, and sporadic in transverse one. The features which feet characteristics most often correlate with are: angle of trunk bent to the left in frontal plane and height of lumbar lordosis, angle of upper thoracic bent, length of lumbar lordosis, height of thoracic kyphosis, scapulas height asymmetry, with the right one placed higher (Mrozkowiak et al., 2018).

Conclusions

1. The general number of body trunk parameters that significantly correlated with feet parameters was slightly higher in females. The number of dependencies regarding sagittal and frontal parameters was the same in both female and male subjects. The traits that differentiated males from females mainly concerned sagittal and frontal planes.
2. The number of feet characteristics that most often showed significant correlations with body trunk parameters was higher in girls than in boys. These were mainly characteristics concerning width and length, longitudinal arch and disorders in the position of toes. The characteristics that differentiated boys described only the longitudinal arch of the feet.

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