University of Szczecin
Faculty of Physical Culture
and Health Promotion

4/2016

Central European Journal of Sport Sciences and Medicine

EDITORIAL OFFICE
University of Szczecin
Faculty of Physical Culture and Health Promotion
Al. Piastów 40B, building 6, 71-065 Szczecin, Poland

SECRETARIAT
Agata Baranowska
e-mail: agata.baranowska@usz.edu.pl

FUNDING BODY
Faculty of Physical Culture and Health Promotion
University of Szczecin, Poland

TEXT DESIGN AND TECHNICAL EDITORIAL | Wiesława Mazurkiewicz

COVER DESIGN | Agnieszka Nawrocka

Print edition is the original published version of the journal
Indexed in: AGRO, Index Copernicus, Google Scholar, PSJD, SafetyLit

The names of the reviewers are available on the journal's website: www.cejssm.usz.edu.pl

ISSN 2300-9705

PUBLISHER | Wydawnictwo Naukowe Uniwersytetu Szczecińskiego

Central European Journal of Sport Sciences and Medicine

a quarterly journal

University of Szczecin
Faculty of Physical Culture
and Health Promotion

Vol. 16, No. 4/2016

Contents

EFFECTS OF MODERATE-INTENSITY RESISTANCE EXERCISE ON BLOOD PRESSURE IN HYPERTENSIVE INDIVIDUALS

Marya Rahmani Ghobadi,[1, A, B] Rastegar Hoseini,[2, C, E] Zahra Hoseini[3, B, D]

[1] Department of Physical Education and Sport Sciences, Damavand Branch, Islamic Azad University, Tehran, Iran
[2] Department of Sport Science and Physical Education, Kermanshah Branch, Islamic Azad University, Kermanshah, Iran
[3] BSc Student of Physical education & sport sciences Student, Faculty of Physical Education and Sport Sciences, University of Guilan-Rasht, Iran
[A] Study Design; [B] Data Collection; [C] Statistical Analysis; [D] Manuscript Preparation; [E] Funds Collection

Address for correspondence:
Rastegar Hoseini
Department of Sport Science and Physical Education, Kermanshah Branch, Islamic Azad University, Kermanshah, Iran
P.O.Box.6791166148
Email: Rastegar.hoseini@gmail.com

Abstract The purpose of this study was to evaluate the effects of moderate-intensity resistance exercise on postexercise hypotension (PEH) in the hypertensive. The study was conducted with eighteen hypertensive elderly individuals (20–30 years). They were subjected to two experimental sessions: control session (SC) and 50% (S50%) of 1RM. For each session, subjects were evaluated pre-and postintervention. In the preintervention, the blood pressure (BP) and FVR were measured after 10 min of rest. Thereafter, they were taken to the gym to perform the exercise sessions or remained at rest in each of the equipment during the same time. In the S50% group was composed of a set of ten repetitions of ten exercises, with an interval of 90 s between exercises. Subsequently, the FVR and BP measurements were again performed at 15, 30, 45, 60 and 75 min of recovery (postintervention). The PEH was greater in S50% compared with SC, with the lower value of BP being found at 75 min of recovery for the two sessions (systolic BP: 125.21 ±0.98mmHg versus 145.45 ±1.72 mmHg; diastolic BP: 83.60 ±1.67 mmHg versus 95.14 ±0.74 mmHg respectively). Moderate-intensity resistance exercise was effective in promoting PEH, this phenomenon being accompanied by a reduction in FVR within the first minute of recovery in the hypertensive young.

Key words blood pressure, exercise, postexercise hypotension

Introduction

Hypertension is associated with increased risk of mortality from all causes and from cardiovascular disease (Godinas et al., 2016). It is related to metabolic, hormonal and trophic phenomena, being classified as a polygenic illness (Chobanian et al., 2003; Pimenta, Oparil, 2012). In Iran, this disease affects about 30–50% of the population, reaching levels higher than 55% in the elderly, one of the most affected groups (Rezazadehkermani, 2008; Farzadfar et al., 2012). Hypertensive individuals have an increased blood flow and vascular conductance at rest, which reduce its vasodilator reserve, with consequent alteration of vasodilator responses (Medeiros et al., 2011). Increased

age, associated with genetic and environmental factors, augment the likelihood of changes in vascular adaptive capabilities. Concomitantly, it is already evident in the literature that regular physical activity can prevent these undesired changes (Green et al., 2011). The ability of exercise to reduce blood pressure (BP) is well established. Although most studies show that aerobic exercise promotes greater pressure reductions compared with resistance exercise (RE). One of the possible mechanisms of this reduction would be an improvement in vasodilator function (Fernandes et al., 2011). But, recently, resistance exercise training (RT) has been recommended as part of a well-rounded exercise program by the American Heart Association and the American College of Sports Medicine to maintain or increase skeletal muscle strength and to prevent osteoporosis (Haskell et al., 2007), cardiovascular disease (Williams et al., 2007). Despite the research already carried out so far have investigated the effects of resistance exercise on BP, there are obvious gaps concerning the best prescription of RE, because of the diversity and variations in the protocols of research with respect to intensity, number of sets, interval, method of BP measurement and, principally, concerning to population and what mechanisms are involved in postexercise responses (Papathanasiou et al., 2015; Young et al., 2014). Once the RE is associated with metabolites production, these can promote muscle vasodilatation, reduced peripheral vascular resistance and BP. Thus, it is pertinent and relevant to investigate the hemodynamic effects of a session of moderate-intensity resistance exercise in elderly hypertensive patients. Therefore, the main aim of this study was to evaluate the moderate-intensity RE effects on blood pressure in hypertensive overweight patients.

Method

The study was conducted with eighteen young patients with mild hypertension, according to the classification proposed by the ACSM (Pescatello et al., 2004). All were physically active and participated regularly for at least 3 months of the program of resistance exercise in the gym at the Damavand Islamic Azad University of Iran. To participate in the study, they should have had a minimum age of 20 and maximum of 30 years, assiduously practicing physical exercise three or more times per week, presenting only hypertension as cardio metabolic disease and use only the drug class of angiotensin-converting enzyme inhibitors and diuretics. The subjects' characteristics are shown in Table 1. All participants were informed about the procedures that would be made in data collection and, prior to their participation, signed consent pursuant to resolution 162/11 of National Health of Iran for human experiments. All of them agreed to participate in the methodological procedures proposed in the research, approved by the ethics committee of the Center for Health Sciences UFPI, under protocol number 112/15. Considering that classically resistance training protocols to promote postexercise hypotension (PEH) in hypertensive individuals were performed with mild to moderate intensity, The subjects were randomly divided into two groups (experimental and control) (www.randomizer.org).The sessions consisted of ten exercises, in which it was performed with one set ten reps, in loads of 50% of 1 RM and with an interval of 90 s between exercises (Pescatello et al., 2004). BP, heart rate (HR), forearm vascular resistance (FVR) and FBF were evaluated before and after each experimental session. Before the experimental sessions, the young underwent a familiarization session (a series of ten repetitions of each exercise with the minimum weight allowed by the machines). Three days later, they underwent a 1 RM test to leg extension, front pulley, leg 45, fly, knee flexion, low row, adductor, triceps, plantar flexion in the leg 45 and biceps following the protocol (Kraemer et al., 1995). Seven days later, we performed a retest to legitimize the validity of previous results. The maximum weight was considered to be the major load in either of 2 days. Hypertensive patients underwent two experimental sessions: control session (CS) and exercises with three sets at 50% 1 RM

(S50%), always performed between seven and nine o'clock in the morning and at an interval of at least 7 days. The order was determined individually and randomly using the website Research Randomizer (www.randomizer.org), so that each subject had their own order to carry out the three study sessions. Before the study, all were instructed to not perform physical activities 48 h before the experimental sessions. For each session, subjects were evaluated pre-and postintervention. In the preintervention, at rest in the supine position was recorded the BP. They were later taken to the gym, where they remained for about 20 min to perform the exercise sessions (S50%) or CS, which remained at rest in each of the equipment during the same time of the sessions exercise. The S50% group followed the protocol of Pescatello et al. (2004) for variables such as intensity, number of repetitions, time interval and number of exercises, differing only in exercise workload. Thus, the elderly performed one set of ten repetitions of ten exercises mentioned above, with a 90 s interval between exercises for loads of 50% of 1 RM. During the execution of the sessions, the Valsalva manoeuvre was constantly discouraged, without any stimulus to motivate the subjects. In sequence, they returned to the laboratory for the postintervention period where, positioned in the supine position, measurements for FBF and BP were performed at five times over 90 min of recovery. After a 5-min rest in the seated position, BP was measured three times during two different visits to the laboratory. On the occasion of each visit, BP was measured by the same experienced observer using a standard mercury sphygmomanometer (ALPK2, Japan), taking the first and the fifth phases of Korotkoff sounds as SBP and DBP values, respectively. Participants were excluded if the average of the last two values obtained during each visit for SBP and DBP was greater than 139 and 89 mmHg, respectively. To determine heart rate, an electrocardiogram (ECG) was used. Three electrodes were placed in the patient's chest, in D2 position. The acquisition and visualization of the ECG signal was obtained through WINDAQ Acquisition software (WinDaq DI-720; Dataq Instruments Inc). The final data analysis was carried out using SPSS-19 (version 19; SPSS Inc., Chicago Illinois, USA).After confirming of normal distribution of the variables using by the Kolmogorov-Smirnov (K-S) test. Data were statistically analyzed by dependent t-test, independent t-test and two-way ANOVA for repeated measures. Data are presented as mean ± SE. Significance for all analyses were set at $P < 0.05$.

Results

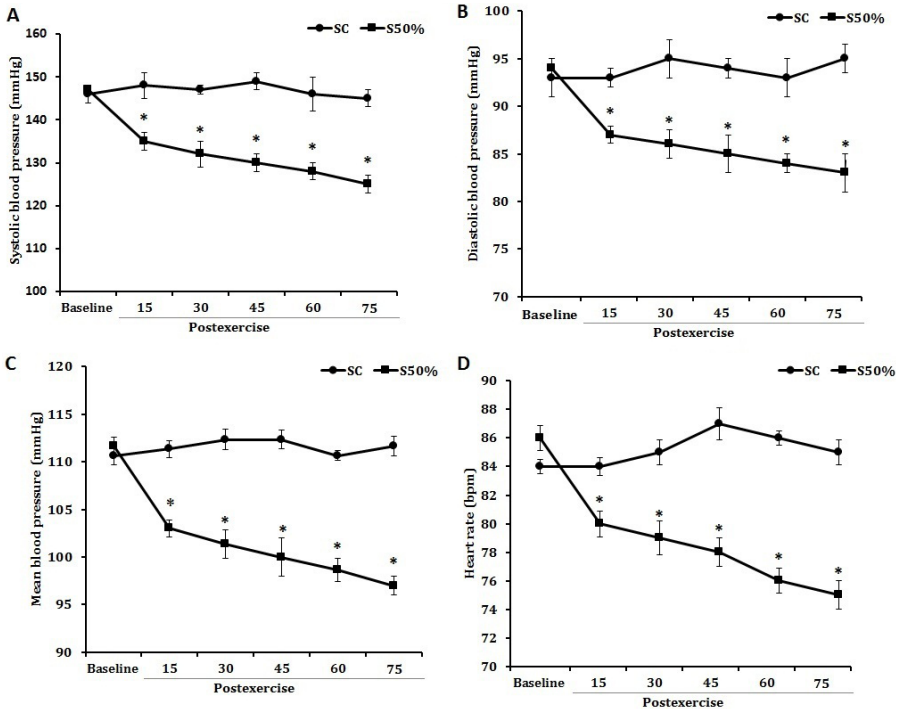
During the days of experimental procedures, subjects presented similar baseline values for BP and HR, being not identified any statistical difference between the sessions. Data summarized in Table 1.

Table 1. Hemodynamic characteristics of subjects

Variables	Groups		PV[a]
N	CS	S50%	
1	2	3	4
SBP(mmHg)			
Before	146.31 ±2.96	147.72 ±3.97	0.068
After	145.45 ±1.72	125.21 ±0.98	0.001†
PV[b]	0.201	0.002*	
DBP(mmHg)			
Before	93.45 ±0.86	94.69 ±0.96	0.065
After	95.14 ±0.74	83.60 ±1.67	0.001†
PV[b]	0.323	0.001*	
MBP(mmHg)			

1	2	3	4
Before	110.33 ±0.96	111.30 ±0.056	0.481
After	111.33 ±0.026	97.35 ±0.022	0.046†
PV[b]	0.749	0.154*	
HR (bpm)			
Before	84.03 ±0.91	85.12 ±1.033	0.928
After	85.04 ±1.021	75.11 ±0.88	0.002†
PV[b]	0.501	0.001*	

CS – control session; **S50%** – resistance exercise session with 50% RM; **SBP** – systolic blood pressure; **DBP** – diastolic blood pressure; **mmHg** – millimetres of mercury; **HR** – heart rate; **bpm** – beats per minute; **MBP** – mean blood pressure. Data are presented as mean ± standard deviation. * – significantly different in comparison pre and post-test within the groups; **†** – significantly different in comparison with pre and post-test between groups; **P** – statistical value; **a** – the values are calculated using independent t-test and **b** – the values are calculated using paired t-test.



CS – control session; **S50% –** resistance exercise session with 50% RM; * **–** significantly different in comparison with pre and post-test between groups. The values are calculated using two-way ANOVA for repeated measures test.

Figure 1 (A, B, C and D). Comparison of mean ± SD of variables between the groups

The systolic blood pressure, diastolic blood pressure, mean blood pressure and heart rate have been shown in the Figures 1 (A, B, C and D). Two-way ANOVA for repeated measures test showed a significant difference in systolic blood pressure, diastolic blood pressure, mean blood pressure and heart rate between CS and S50% groups. The resistance exercise session with 50% RM compared with control session significantly caused reduction in systolic blood pressure (125.21 ±0.98 mmHg versus 145.45 ±1.72 mmHg; Figure 1, A), diastolic blood pressure (83.60 ±1.67 mmHg versus 95.14 ±0.74 mmHg; Figure 1, B), mean blood pressure (97.35 ±0.022 mmHg versus

111.33 ±0.026 mmHg; Figure 1, c), and heart rate (75.11 ±0.88 mmHg versus 85.04 ±1.021 mmHg; Figure 1, D). However, the exercise protocols with intensities of 50% of 1RM were able to promote hypotension in the moment of postexercise recovery.

Discussion

The main findings of this study are (i) moderate-intensity RE are able to promote PEH with significant magnitude in hypertensive young patients, (ii) this magnitude was significantly higher when compared to RE performed with SC. In spite of RE increasingly gaining notoriety for its ability to promote reduction of BP after exercise, making assertions about the best prescription for this type of exercise in promoting PEH is still something rash. This stems from the wide variety of experimental designs reported in the literature on differences in training models (conventional or circuit), time interval (30–120 s), intensity (medium to high), number of repetitions (8–20), number of exercises, analytical methods for measuring BP (clinic, ambulatory) and sample (young, middle-aged adults, elderly, healthy and/or hypertensive) (Anunciação, Polito, 2011; Cardoso Jr et al., 2010; Bruneau et al., 2015). Thus, generalizations are inappropriate. Although the existence of other studies using the young as the sample population, most of them were conducted with healthy subjects and in isometric or isokinetic resistance training (Maior et al., 2015; de Freitas Brito et al., 2014). Studies using resistance training in the young are scarce. In this way, our findings represent an important contribution to explain how RE may benefit the hypertensive young.

To date, studies investigating moderate-intensity exercises and its hemodynamic effects have only been performed in normotensive elderly individuals. Rezk et al. (2006) and Brown et al. (1994) observed similar PEH between moderate intensity exercises (Rezk et al., 2006; Brown et al., 1994). In contrast, O'Connor et al. (1993) and Focht, Koltyn (1999) did not observe this phenomenon (O'Connor et al., 1993; Focht, Koltyn 1999), while Simão et al. (2005) found differences in the hypotensive responses (Simão et al., 2005). To DBP observed in the present study, a significant reduction in all moments of post-exercise recovery, this behavior being not observed by other authors (Mediano et al., 2005; Rezk et al., 2006; Moraes et al., 2007). Only the study by Melo et al. (2006) observed similar behaviour as found in this study(Melo et al., 2006). As stated by Fisher (2001), these contrasting results can be attributed to different baseline BP in studies (Fisher, 2001), as different population groups (normotensive and hypertensive varying degrees) respond differently to exercise (Halliwill, 2001). Additionally, the intensity of exercise used varied from one study to other. Another interesting argument to elucidate this question is provided by Gotshall et al. (1994), affirming that the subject's position during the recovery period influences the pressure responses (Gotshall et al., 1994). The orthostatic stress imposed in the seated position, position used in various trials, could reduce venous return and cardiopulmonary reflex, resulting in increased peripheral vascular resistance and consequently the DBP. In subjects, hypertension is usually associated with reduced cardiac output (or even normal), and a combination of peripheral vascular resistance and decreased vascular compliance (Grobbee, Hofman, 1986). To our knowledge, this is the first study that aimed to investigate the mechanisms involved in post resistance exercise hypotension in the hypertensive young. The suggesting that the reduction in BP, but possibly by decreasing venous return; basically, two factors may explain these different results. First, the fact that the population of our study consisted of hypertensive young patients, which could allow a better response to exercise than normotensive subjects. Second, we use only one set of ten repetitions with moderate – intensity. Thus, we conjecture that, for moderate intensity, a resistance exercise session that takes a smaller number of sets may be more effective in promoting a minor component of sympathetic activity after exercise in hypertensive

elderly patients. Thus, although the cardiovascular repercussions prove beneficial, it is necessary to investigate whether hypertensives can keep a training protocol with moderate loads for several sessions without symptoms of chronic fatigue. These issues constitute a line of future research to provide effective and safe methodologies on the prescription of resistance training for the young. The present study has some limitations. First, only the clinical behaviour of BP was measured. Although BP measured in clinical laboratory is the classical form of diagnosis and assessment of BP, ambulatory BP (characterized by measurements throughout the day) has been shown to be a better predictor of target organ damage (Perloff et al., 1983). Second, subjects performed repetition maximum tests (RM) for homogenization of training intensity in the different exercises. The RM test for hypertensive patients should be discouraged due to the risk of stroke, a result of the sudden increase in BP during activity. Thus, the results obtained in this study cannot be played with different loads or repetitions. In this context, we can infer that a single session of moderate-intensity RE is able to promote PEH in hypertensive young patients, being this phenomenon accompanied by a reduction in forearm vascular resistance.

Acknowledgments

The authors would like to gratefully thank Mehry Hoseini for her kind help during test. This work has been done by grant from Research Council of Kermanshah University.

References

Anunciação, P.G., Polito, M.D. (2011). A review on post-exercise hypotension in hypertensive individuals. *Arquivos Brasileiros de Cardiologia*, *96* (5), 425–426.

Brown, S.P., Clemons, J.M., He, Q., Liu, S. (1994). Effects of resistance exercise and cycling on recovery blood pressure. *Journal of Sports Sciences*, *12* (5), 463–468.

Bruneau, M.L., Johnson, B.T., Huedo-Medina, T.B., Larson, K.A., Ash, G.I., Pescatello, L.S. (2015). The blood pressure response to acute and chronic aerobic exercise: A meta-analysis of candidate gene association studies. *Journal of Science and Medicine in Sport*.

Cardoso Jr, C.G., Gomides, R.S., Queiroz, A.C.C., Pinto, L.G., Lobo, F.d.S., Tinucci T., Mion Jr, D., C. Forjaz, L.d.M. (2010). Acute and chronic effects of aerobic and resistance exercise on ambulatory blood pressure. *Clinics*, *65* (3), 317–325.

Chobanian, A.V., Bakris, G.L., Black, H.R., Cushman, W.C., Green, L.A., Izzo Jr, J., Jones, D., Materson, B., Oparil, S., Wright Jr. J. (2003). National heart, lung, and blood institute joint national committee on prevention, detection, evaluation, and treatment of high blood pressure; national high blood pressure education program coordinating committee. *The seventh report of the joint national committee on prevention, detection, evaluation, and treatment of high blood pressure: The JNC, 7*, 2560–2572.

de Freitas Brito, A., de Oliveira, C.V.C., Brasileiro-Santos, M.d.S., and de Cruz S.A. (2014). Resistance exercise with different volumes: blood pressure response and forearm blood flow in the hypertensive elderly. *Clinical Interventions in Aging*, *9*.

Farzadfar, F., Murray, C.J., Gakidou, E., Bossert, T., Namdaritabar, H., Alikhani, S., Moradi, G., Delavari, A., Jamshidi, H., Ezzati, M. (2012). Effectiveness of diabetes and hypertension management by rural primary health-care workers (Behvarz workers) in Iran: a nationally representative observational study. *The Lancet*, *379* (9810), 47–54.

Fernandes, P.R.O.F., Lira, F.A.d S., Borba, V.V.L., Costa, M.J.C., Trombeta, I.C., Santos, M.d.S.B., Santos, A.d.C. (2011). Vitamin C restores blood pressure and vasodilator response during mental stress in obese children. *Arquivos Brasileiros de Cardiologia*, *96* (6), 490–497.

Fisher, M.M. (2001). The effect of resistance exercise on recovery blood pressure in normotensive and borderline hypertensive women. *The Journal of Strength & Conditioning Research*, *15* (2), 210–216.

Focht, B.C., Koltyn, K.F. (1999). Influence of resistance exercise of different intensities on state anxiety and blood pressure. *Medicine and Science in Sports and Exercise*, *31* (3), 456–463.

Godinas, L., Lau, E.M., Chemla, D., Lador, F., Savale, L., Montani, D., Jaïs, H., Sitbon, O., Simonneau, G., Humbert, M. (2016). Diagnostic concordance of different criteria for exercise pulmonary hypertension in subjects with normal resting pulmonary artery pressure. *European Respiratory Journal*: ERJ-01678-02015.

Gotshall, R.W., Aten, L.A., Yumikura, S. (1994). Difference in the cardiovascular response to prolonged sitting in men and women. *Canadian Journal of Applied Physiology*, *19* (2), 215–225.

Green, D.J., Spence, A., Halliwill, J.R., Cable, N.T., Thijssen, D.H. (2011). Exercise and vascular adaptation in asymptomatic humans. *Experimental Physiology*, *96* (2), 57–70.

Grobbee, D., Hofman. A. (1986). Effect of calcium supplementation on diastolic blood pressure in young people with mild hypertension. *The Lancet*, *328* (8509), 703–707.

Halliwill, J.R. (2001). Mechanisms and clinical implications of post-exercise hypotension in humans. *Exercise and Sport Sciences Reviews*, *29* (2), 65–70.

Haskell, W.L., Lee, I.M., Pate, R.R., Powell, K.E., Blair, S.N., Franklin, B.A., Macera, C.A., Heath, G.W., Thompson, P.D., Bauman, A. (2007). Physical activity and public health: updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. *Circulation*, *116* (9), 1081.

Kraemer, W.J., Fry, A., Ratamess, N., French, D. (1995). Strength testing: development and evaluation of methodology. *Physiological Assessment of Human Fitness*, *2*, 119–150.

Maior, A.S., Simão, R., Martins, M.S., de Salles, B.F., Willardson, J.M. (2015). Influence of Blood Flow Restriction During Low-Intensity Resistance Exercise on the Postexercise Hypotensive Response. *The Journal of Strength & Conditioning Research*, *29* (10), 2894–2899.

Medeiros, R.F., Silva, B.M., Neves, F.J., Rocha, N.G., Sales, A.R.K., Nobrega, A.C. (2011). Impaired hemodynamic response to mental stress in subjects with prehypertension is improved after a single bout of maximal dynamic exercise. *Clinics*, *66* (9), 1523–1529.

Mediano, M.F.F., Paravidino, V., Simão, R., Pontes, F.L., Polito, M.D. (2005). Subacute behavior of the blood pressure after power training in controlled hypertensive individuals. *Revista Brasileira de Medicina do Esporte*, *11* (6), 337–340.

Melo, C.M., Alencar Filho, A.C., Tinucci, T., Mion Jr, D., Forjaz, C.L. (2006). Postexercise hypotension induced by low-intensity resistance exercise in hypertensive women receiving captopril. *Blood Pressure Monitoring*, *11* (4), 183–189.

Moraes, M.R., Bacurau, R.F., Ramalho, J.D., Reis, F.C., Casarini, D.E., Chagas, J.R., Oliveira, V., Higa, E.M.S., Abdalla, D.S., Pesquero, J.L. (2007). Increase in kinins on post-exercise hypotension in normotensive and hypertensive volunteers. *Biological Chemistry*. *388* (5), 533–540.

O'Connor, P.J., Bryant, C.X., Veltri, J.P., Gebhardt, S.M. (1993). State anxiety and ambulatory blood pressure following resistance exercise in females. *Medicine & Science in Sports & Exercise*.

Papathanasiou, G., Zerva, E., Zacharis, I., Papandreou, M., Papageorgiou, E., Tzima, C., Georgakopoulos, D., Evangelou, A. (2015). Association of high blood pressure with body mass index, smoking and physical activity in healthy young adults. *The Open Cardiovascular Medicine Journal*, *9*, 5.

Perloff, D., Sokolow, M., Cowan, R. (1983). The prognostic value of ambulatory blood pressures. *Jama*, *249* (20), 2792–2798.

Pescatello, L.S., Guidry M.A., Blanchard, B.E., Kerr, A., Taylor, A.L., Johnson, A.N., Maresh, C.M., Rodriguez, N., Thompson, P.D. (2004). Exercise intensity alters postexercise hypotension. *Journal of Hypertension*, *22* (10), 1881–1888.

Pimenta, E., Oparil, S. (2012). Management of hypertension in the elderly. *Nature Reviews Cardiology*, *9* (5), 286–296.

Rezazadehkermani, M. (2008). Epidemiology and heterogeneity of hypertension in Iran: a systematic review. *Archives of Iranian Medicine*, *11* (4), 444–452.

Rezk, C., Marrache, R., Tinucci, T., Mion Jr, D., Forjaz, C. (2006). Post-resistance exercise hypotension, hemodynamics, and heart rate variability: influence of exercise intensity. *European Journal of Applied Physiology*, *98* (1), 105–112.

Simão, R., Fleck, S.J., Polito, M., Monteiro, W., Farinatti, P. (2005). Effects of resistance training intensity, volume, and session format on the postexercise hypotensive response. *The Journal of Strength & Conditioning Research*, *19* (4), 853–858.

Williams, M.A., Haskell, W.L., Ades, P.A., Amsterdam, E.A., Bittner, V., Franklin, B.A., Gulanick, M., Laing, S.T., Stewart, K.J. (2007). Resistance exercise in individuals with and without cardiovascular disease: 2007 update a scientific statement from the American

Heart Association Council on Clinical Cardiology and Council on Nutrition, Physical Activity, and Metabolism. *Circulation*, *116* (5), 572–584.

Young, D.R., Reynolds, K., Sidell, M., Brar, S., Ghai, N.R., Sternfeld, B., Jacobsen, S.J., Slezak, M.J., Caan, B., Quinn, V.P. (2014). Effects of physical activity and sedentary time on the risk of heart failure. *Circulation: Heart Failure*, *7* (1), 21–27.

Cite this article as: Ghobadi, M.R., Hoseini, R., Hoseini, Z. (2016). Effects of Moderate-Intensity Resistance Exercise on Blood Pressure in Hypertensive Individuals. *Central European Journal of Sport Sciences and Medicine*, *16* (4), 5–12. DOI: 10.18276/cej.2016.4-01.

PHYSICAL ACTIVITY OF POLISH AND TURKISH UNIVERSITY STUDENTS AS ASSESSED BY IPAQ

Justyna Bednarek,[1, A, B, C, D, E] Sylwia Pomykała,[1, A, B, E] Monika Bigosińska,[2, C, D] Zbigniew Szyguła[3, D]

[1] University School of Physical Education, Kraków, Poland
[2] Department of Physical Education, Institute of Physical Education, State Higher Vocational School, Nowy Sącz, Poland
[3] Department of Sport Medicine and Human Nutrition, Institute of Human Physiology, University School of Physical Education, Kraków, Poland
[A] Study Design; [B] Data Collection; [C] Statistical Analysis; [D] Manuscript Preparation; [E] Funds Collection

Address for correspondence:
Justyna Bednarek
University School of Physical Education, Department of Sport Medicine and Human Nutrition
Jana Pawła II Ave 78, 31-571 Kraków, Poland
E-mail: bednarekjustyna1@gmail.com

Abstract Purpose: We examine physical activity levels of Polish and Turkish students to determine cross-cultural and gender differences in exercise habits.

Methods: Our study assessed 50 students from Adnan Menderes University in Aydin, Turkey and 50 students from the University of Physical Education in Krakow, Poland. Physical activity was measured using the International Physical Activity Questionnaire (IPAQ; short form). Results were expressed in MET-minutes/week (Metabolic Equivalent of Task).

Results: More than half of the students (52%) engaged in moderate physical activity in the week prior to the survey, while a quarter of the students (37%) engaged in vigorous physical activity. Low levels of physical activity were reported by 11% of the students. Total physical activity per week, expressed in MET-minutes/week, was significantly higher for Polish students (5,953.51 MET) than for Turkish students (3,095.45 MET). Moderate physical activity was higher among Turkish students while vigorous physical activity was higher among Polish students. Physical activity contrasts were further exemplified between genders. Polish women engaged in significantly more ($p < 0.05$) total physical activity than Turkish women. Total physical activity, high-level physical activity, and moderate-level physical activity differences were not significant ($p > 0.05$) between Polish and Turkish men.

Conclusion: Polish university students engage in more physical activity than students from Turkey. Men were more physically active in both countries. More than half of Turkish students do not meet minimum weekly physical activity the World Health Organization recommends for preserving health.

Key words students, physical activity, IPAQ

Introduction

Physical activity is both an important component of social health (Booth, 2001; Bruunsgaard, 2005; Drygas, Jegier, Bednarek-Gejo, Kostka, 2005). Though physical activity is linked to general health and well-being, and is frequently associated with morbidity and mortality prevalence and severity, its role remains underestimated

(Janssen, Leblanc, 2010). Regular physical activity provides many health benefits, such as positive impact on quality of life and reduction in the risk of cardiovascular and metabolic diseases, including atherosclerosis, stroke, arthritis, diabetes, osteoporosis and some forms of cancer (Haskell et al., 2007; Nelson et al., 2007; Malina, Katzmarzyk, 2006). Physical activity can also reduce stress and anxiety, and can improve sleep quality (Penedo, Dahn, 2005). Moreover, physical activity, when regimented properly, positively affects physiological parameters that characterize health, such as physical fitness, body composition and lipid profiles (Drygas, Jegier, Bednarek-Gejo, Kostka, 2005; Zoeller, 2007). A sedentary lifestyle facilitates slowing of the body's metabolism and deterioration of metabolic function, as well as decline in both specific and nonspecific immune systems, physical fitness and mental health (Katzmarzyk, Church, Craig, Bouchard, 2009; Touvier et al., 2010).

However, recent trends show that regular physical activity is lacking among many populations around the world (Zatoński, 2011). Thus, it is imperative that we better understand the underlying patterns and drivers of physical activity to improve human well-being at both individual and societal levels. This can be best achieved by employing physical activity assessments at myriad demographic scales across both cultures and countries. Yet currently there exists a paucity of such comparative analyses due to inconsistencies in measurement methods that confound potential elucidations regarding physical activity and its effect on health (van Bottenburg, Rijnen, van Sterkenburg, 2005). Without a universal, systematic approach, conceptual and terminological pitfalls may be introduced as well (Narring, Cauderay, Cavadini, Michaud, 1999). Therefore, studies should aim to harmonize methodological procedures through the use of recognized, proven and standardized testing instruments (Mussino, 1999).

In recent years, international health communities, such as the European Health Interview Survey (EUROHIS), the European Physical Activity Surveillance System (EUPASS) and the European Social Survey 2002 ("www.ess.nsd.uib.no"; "www.healthcanada.ca/paguide Handbook for Canada's physical activity guide to healthy active living, Health Canada, Canadian Society for Exercise Physiology"), have galvanized their efforts by recommending the International Physical Activity Questionnaire (International Physical Activity Questionnaire, IPAQ) as the universal assessment for measuring physical activity ("www.ipaq.ki.se"). IPAQ was developed according to strict methodological rules that allow for country-to-country physical activity comparisons. The questionnaire is adapted to the relative conditions of each included country, accounting for lifestyle and cultural disparities (Craig et al., 2003). IPAQ is particularly preferred due to its strictly uniform terms and concepts, which are translated into multiple languages for use on a global scale.

Here, we compare physical activity habits of university students in Krakow, Poland with those in Aydin, Turkey to increase comprehension related physical activity patterns on international scales. The questions addressed in this work are: (1) Are there significant physical activity differences between students from Poland and Turkey? and (2) Are there significant physical activity differences between genders in both Poland and Turkey?

Materials and methods

We surveyed 50 undergraduate university students from both Adnan Menderes University in Aydin, Turkey (36 females and 14 males) and the University of Physical Education in Krakow, Poland (25 females and 25 males). Participants from both universities were enrolled in their respective Tourism and Recreation programs and were of similar ages (18–21 years old). A detailed characterization of the groups is shown in Table 1.

Table 1. Characteristics of participants

Nationality	Women		Men		Total	
	n	%	n	%	N	%
Poland	25	25	25	25	50	50
Turkey	36	36	14	14	50	50
Total	61	61	39	39		

Each participant's level of physical activity (PA) was measured using the International Physical Activity Questionnaire (IPAQ – short form). Participants reported the frequency (days per week) and duration (hours) of walking, moderate and vigorous physical activity that they engaged in during the week prior to survey. Vigorous physical activity, defined by the questionnaire, referred to intense exercise that resulted in very rapid breathing and an elevated heart rate (e.g. intense weight lifting, aerobics, running, and cycling). Moderate physical activity was defined as less intense exercise that slightly heightened breathing and heart rate (e.g. less exertive cycling, fast walking, and light weight lifting). Participants were asked only to report physical activity that exceeded ten minutes in duration. Physical activity data were converted to Metabolic Equivalent of Task units (MET-minutes/week) by multiplying the number of exercise minutes per day by the number of exercise days per week by the MET coefficient of exercise intensity (vigorous PA = 8 MET, moderate PA = 4 MET, walking PA = 3.3 MET). The MET coefficient of exercise intensity corresponds to an individual's oxygen consumption during physical activity relative to oxygen consumption at rest (3.5 ml O_2 per kg of body weight per minute). Questionnaires were scored using established methods posted on the IPAQ website (www.ipaq.ki.se). Respondents were then classified into groups (high, moderate, and low physical activity) based on the following criteria:

1. **High physical activity** – three or more days of vigorous physical exercise, including at least 1,500 MET--minutes/week, or seven or more days of any combination of vigorous exercise, moderate exercise, and walking that exceeded 3,000 MET-minutes/week.
2. **Moderate physical activity** – three or more days of vigorous physical exercise (at least 20 minutes per day), or five or more days of moderate exercise or walking (at least 30 minutes per day), or five or more days of a combination of vigorous exercise, moderate exercise, and walking that exceeded 600 MET-minutes/week.
3. **Low physical activity** – Little physical activity that resulted in a failure to comply with the conditions of moderate or high physical activity classifications (less than 600 MET-minutes/week).

Statistics

All statistical analyses were performed using STATISTICA software, v. 10.0 (StatSoft Poland). Frequency counts, means and standard deviations (SDs) were calculated for each university's participants as a whole (Turkey and Poland) and between genders (Turkish males, Turkish females, Polish males, and Polish females). Significant differences between groups ($p \leq 0.05$) were assessed using Mann-Whitney U tests. In addition, correlation coefficients between variables were calculated using the Spearman test.

Results

Our findings show that 52% of all participants exhibited high physical activity levels, 37% exhibited moderate physical activity levels, and 11% exhibited low physical activity levels.

In general, Polish students were more physically active than Turkish students. More than half (78%) of Polish students exhibited a "high" level of physical activity, the most prevalent among all of the subgroups, while only 2% of Polish students exhibited a "low" level of physical activity. In comparison, 26% of Turkish students showed a "high" level of physical activity while 20% of the Turkish students showed a "low" level of physical activity. "Moderate" levels of physical activity were higher amongst Turkish students (54%) than Polish students (20%) (Figure 1).

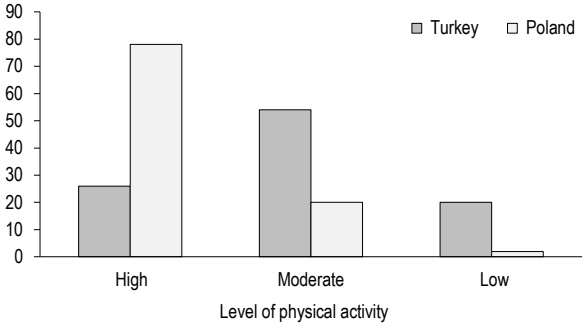


Figure 1. Physical activity levels of Polish and Turkish university students, expressed in Metabolic Equivalent of Task units (MET-minutes/week) using IPAQ (short-form) questionnaire data (%)

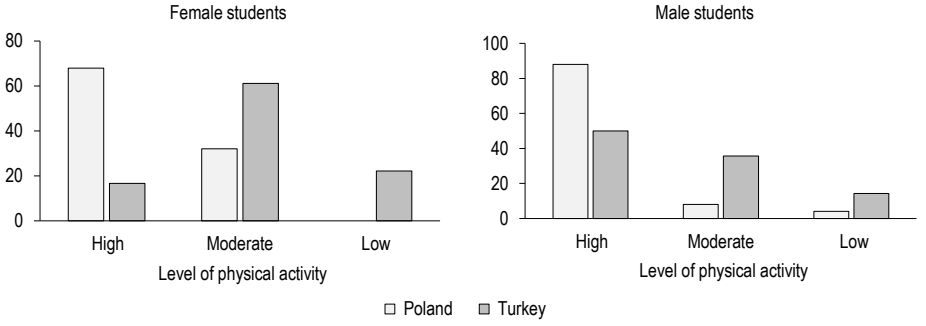


Figure 2. Physical activity levels of Turkish and Polish university students, grouped by gender, expressed in Metabolic Equivalent of Task units (MET-minutes/week) using IPAQ (short-form) questionnaire data (%)

Physical activity data, classified by gender, also differed between nationalities (Figure 2). Polish females (68%) and Polish males (88%) were more engaged in "high-level" physical activity compared to Turkish females (17%) and Turkish males (50%). However, Turkish females (61%) and Turkish males (38%) were more engaged in

"moderate-level" physical activity than Polish females (32%) and Polish males (8%). Polish students (0% female; 4% male) were less likely to exhibit "low" levels of physical activity than Turkish students (22% female; 14% male).

Overall, Polish students exercised significantly more ($p < 0.05$) in total than Turkish students (Table 2). The mean sum of exercise for Polish students was 5,953.51 MET-minutes/week compared to 3,095.45 MET-minutes/week for Turkish students. Both "moderate" and "high" levels of physical activity as measured in MET-minutes/week were significantly different ($p < 0.05$) between nationalities. "Low" levels of physical activity (i.e. walking) were not significantly different between nationalities.

Table 2. The level of physical activity of university students in Poland and Turkey expressed in MET-minutes/week. Bolded p-values denote statistical significance ($p < 0.05$)

Physical activity	Vigorous – intensity		Moderate – intensity		Walking		Total	
	Poland	Turkey	Poland	Turkey	Poland	Turkey	Poland	Turkey
Mean	2,701	814	1,006	384	2,246	1,897	5,954	3,095
Standard dev	2,580	1,678	1,143	950	1,642	1,680	3,815	2,734
Median	2,160	0	660	0	2,574	1,386	5,289	2,772
Min	0	0	0	0	0	10	990	10
Max	10,080	7,200	5,040	3,600	6,930	8,316	19,278	11,100
p-value	<0.0001		<0.0001		0.298		0.0001	

Physical activity contrasts were further exemplified between genders. Polish women engaged in significantly more ($p < 0.05$) total physical activity than Turkish women (Table 3). Polish women were significantly more engaged in high-level physical activity than Turkish women, yet they were significantly less engaged in moderate levels of physical activity ($p < 0.05$). Total physical activity, high-level physical activity, and moderate-level physical activity differences were not significant ($p < 0.05$) between Polish and Turkish men (Table 4). Low-level physical activity differences were not significant ($p < 0.05$) between nationalities for either gender.

Table 3. The level of physical activity of female university students in Poland and Turkey expressed in MET-minutes/week. Bolded p-values denote statistical significance ($p < 0.05$)

Physical activity	Vigorous – intensity		Moderate – intensity		Walking		Total	
	Poland	Turkey	Poland	Turkey	Poland	Turkey	Poland	Turkey
Mean	2,224	400	1,110	235	2,264	1,904	5,599	2,539
Standard dev	2,776	1,270	1,305	730	1,501	1,802	4,514	2,244
Median	1,920	0	720	0	2,376	1,386	4,758	2,376
Min	0	0	0	0	198	10	990	10
Max	10,080	5,760	5,040	3,360	4,158	8,316	19,278	9,564
p-value	<0.0001		<0.0001		0.253		0.001	

Among some students, "low-level" physical activity (i.e. walking) was the predominant component of physical activity. This was particularly evident among female Turkish students, whose ratio of the correlation value of walking (MET-minutes/week) to total physical activity (MET-minutes/week) was mostly positive and statistically significant ($p < 0.05$), especially at low and moderate physical activity levels (Table 5). Male Turkish students, who exhibited

"high" levels of physical activity, showed similar significant differences in the ratio of their correlation value of walking (MET-minutes/week) compared to total physical activity (MET-minutes/week).

Table 4. The level of physical activity of male university students in Poland and Turkey expressed in MET-minutes/week

Physical activity	Vigorous – intensity		Moderate – intensity		Walking		Total	
	Poland	Turkey	Poland	Turkey	Poland	Turkey	Poland	Turkey
Mean	3,178	1,880	902	769	2,228	1,878	6,308	4,527
Standard dev	2,327	2,139	969	1,322	1803	1,377	3,013	3,398
Median	3,200	,1080	540	0	2,772	1,683	5,493	4,161
Min	0	0	0	0	0	10	1,200	33
Max	10,080	7,200	3,600	3,600	6,930	4,620	14,532	11,100
p-value	0.069		0.183		0.759		0.092	

Table 5. Correlation between walking and total physical activity in MET-minutes/week in Polish and Turkish university females relative to different levels of physical activity. Bolded p-values denote statistical significance ($p < 0.05$)

Physical activity	All women			Turkey			Poland		
	LA*	MA*	HA*	LA*	MA*	HA*	LA*	MA*	HA*
Walking MET-min/week	0.859	0.835	0.119	0.859	0.959	–0.115	X*	–0.167	0.081
p-value	**0.006**	**<0.0001**	0.587	**0.006**	**<0.0001**	0.826	X*	0.691	0.755

* LA – low activity (i.e. walking); MA – moderate activity; HA – high activity; X – no data

Table 6. Correlation between walking and total physical activity in MET-minutes/week in Polish and Turkish males relative to different levels of physical activity. Bolded p-values denote statistical significance ($p < 0.05$)

Physical activity	All men			Turkey			Poland		
	LA*	MA*	HA*	LA*	MA*	HA*	LA*	MA*	HA*
Walking MET-min/week	–0.577	0.678	0.607	X*	0.900	0.889	X*	X*	0.5481
p-value	0.666	0.093	<0.0001	X*	0.373	0.007	X*	X*	0.888

* LA – low activity (i.e. walking); MA – moderate activity; HA – high activity; X – no data.

Discussion

Our study was conducted using the short version of the International Physical Activity Questionnaire (IPAQ). The IPAQ is the most widely used and comprehensive evaluation tool that accounts for all domains of moderate and vigorous exercise (e.g. exercise performed during leisure time, work, transportation, etc.) (Brown et al., 2004; Abu-Omar, Rütten, Robine, 2004; Rütten et al., 2003).

The average level of total physical activity was higher for Polish men (6,308 MET-minutes/week), than for Polish women (5,599 MET). Turkish students, particularly women, declared much lower levels of physical activity compared to Polish students (2,539 MET for women and 4,527 MET for men). However, our study may be slightly confounded since our relatively small sample size of students was taken from university programs focused on

physical education and recreation. Students were also asked to self-report their activity levels, a technique that inherently introduces a certain level of bias.

Our results are consistent with findings from other authors. A study by Suğuksu (2011) comparing Polish and Turkish students showed that Polish students (3,720 MET for women and 5,045 MET for men) had higher physical activity levels than Turkish students (1,690 MET for women and 2,590 MET for men). Haase et al. (2004) found similar results and exhibited that Central and Eastern European university students were more active during their leisure time (70% of students) than Mediterranean students (61% of students). Variations in physical activity levels between cultures may be driven by a complex suite of interwoven socioeconomic development, technology, and urbanization factors. Perceptions of external sociological barriers, such as prioritization of academics over exercise and a perceived paucity of time due to a busy schedule and responsibilities related to family and social environment, likely play a key role in dictating university students' physical activity patterns (Daskapan, Emine, Levent, 2006).

An individual's level of physical activity can significantly contribute to the onset of both obesity and cardiovascular disease. It is imperative to assess physical activity levels to better understand the association between physical activity and health. Yet this can be a hurdle when comparing results among different socio-occupational and cultural groups, as methods and terminologies often vary.

In 2010, the World Health Organization (WHO) published guidelines on the minimum level of physical activity required to preserve human health (Global Recommendations on Physical Activity for Health). The minimum level of physical activity recommended by the WHO for adults is 150 minutes of moderate physical activity per week, or 75 minutes of vigorous physical activity per week, or an equivalent combination of vigorous and moderate physical activity. Our findings showed that 94% of Polish students (92% of women and 96% of men) and 40% of Turkish students (28% of women and 79% of men) reached or exceeded the recommended minimum of 75 minutes of vigorous physical activity per week, or an equivalent combination of vigorous and moderate physical activity per week.

While culture remains an important indicator of physical activity engagement, gender may also play a pivotal role. A study comparing physical activity levels between Czech students at the University of Olomouc with Chinese students from the University of Beijing, also found that men were generally more engaged in physical activity than women. Czech men engaged in 6,456 MET-minutes/week compared to 5,296 MET-minutes/week for women, while Chinese men engaged in 2,843 MET-minutes/week compared to 1,982 MET-minutes/week for women (Zhao, Sigmund, Sigmundová, Lu, 2007).

Other Polish literature has supported our findings that women engage in less physical activity than men (Bergier, Stępień, Niźnikowska, Bergier, 2014; Sokołowski, 2008). Similar results were also found in Brazil (Florindo et al., 2009), several member states of the Gulf Cooperation Council (Mabry, Reeves, Eakin, Owen, 2010), Jordan (Ammouri, Neuberger, Nashwan, Al-Haj, 2007), Turkey (Karaca, Caglar, Cinemre, 2009), and China (Zhao, Sigmund, Sigmundová, Lu, 2007).

Additionally, a study on physical activity that spanned 20 countries exhibited similar conclusions. Men, particularly at the university level, self-reported more physical activity than women. In general, physical activity among women decreased with age. Approximately 50% of women younger than 20 years-old were not physically active enough to meet the WHO minimum requirement needed to preserve human health. As female ages increased, the percentage of those meeting the WHO minimum requirement dropped proportionately (Bauman et al., 2009). WHO (2013) later published a study that showed physical inactivity was consistently higher among

women (34%) than men (28%) across cultures. Differences in physical activity levels among genders may be driven by perception of an overarching exercise. A review of 51 cross-sectional studies elucidated that men were more positively associated with physical activity (Van der Horst, Paw, Twisk, Van Mechelen, 2007). Other studies have exhibited that physical activity levels among adolescent and university males are generally higher than those of adolescent and university females (Daskapan, Emine, Levent, 2006; El-Gilany, Badawi, El-Khawaga, Awadalla, 2011; Irwin, 2004). In Mediterranean cultures, in particular, social pressures historically linked to masculinity, such as power and athleticism, and to femininity, such as avoidance of vigorous activity and physical sports, may also contribute to gender disparities related to physical activity levels (Shafy, 1998).

The type of university students enroll in may also be indicative of their physical activity habits. Our results indicate that students enrolled at sports-centric universities may have higher levels of physical activity than students enrolled at traditional universities, where physical education faculties are not the central focus of education. This may be explained by the overarching mentality and culture of students enrolled at sports-centric universities, who may place greater emphasis on physical activity, and may have better access to exercise programs and facilities.

Here, we've shown that physical activity habits vary by both culture and gender. Our study exhibits current physical activity habits among university students in disparate cultures. This study can be utilized to improve methods for encouraging students to actively participate in physical activity. A better understanding of the underlying mechanisms that dictate physical activity decisions across cultures is needed to facilitate the development of local and international health programs.

Conclusions

1. Polish university students engage in more physical activity than Turkish students.
2. More than half of Turkish students do not meet the World Health Organization's minimum weekly physical activity recommendations for preserving health.
3. Polish university students engage in more vigorous physical activity while Turkish university students engage in more moderate physical activity.
4. Female Polish university students engage in more vigorous and moderate intensity exercise than female Turkish university students by a large margin.
5. Walking is a significant contributor to physical activity habits in Poland and Turkey.

References

Abu-Omar, K., Rütten, A., Robine, J.M. (2004). Self-rated health and physical activity in the European Union. *Social and Preventive Medicine*, *49*, 235–242.

Ammouri, A.A., Neuberger, G., Nashwan, A.J., Al-Haj, A.M. (2007). Determinants of self-reported physical activity among Jordanian adults. *Journal of Nursing Scholarship*, *39* (4), 342–348.

Bauman, A., Bull, F., Chey, T., Craig, C.L., Ainsworth, E.B., Sallis, J.F., Bowles, H.R., Hagstromer, M., Sjostrom, M., Pratt, M., The IPS Group. (2009). The International Prevalence Study on Physical Activity: results from 20 countries. *International Journal of Behavioral Nutrition and Physical Activity*, *6*, 21. DOI:10.1186/1479-5868-6-21.

Bergier, B., Stępień, E., Niźnikowska, E., Bergier, J. (2014). Aktywność fizyczna kobiet i mężczyzn studiujących w Państwowej Szkole Wyższej w Białej Podlaskiej. *Medycyna Ogólna i Nauki o Zdrowiu*, *20* (2), 166–170.

Booth, M.L. (2000). Assessment of Physical Activity: An International Perspective. *Research Quarterly for Exercise and Sport*, *71*, 114–120. DOI: 10.1080/02701367.2000.11082794.

Brown, W.J., Trost, S.G., Bauman, A., Mummery, K., Owen, N. (2004). Test-retest reliability of four physical activity measures used in population surveys. *Journal of Science and Medicine in Sport*, *7*, 205–215.

Bruunsgaard, H. (2005). Physical activity and modulation of systemic low-level inflammation. *The Journal of Cell Biology*, *78*, 1–17. DOI: 10.1189/jlb.0505247.

Craig, C.L., Marshall, A.L., Sjøstrom, M., Bauman, A.E., Booth, M.L., Ainsworth, B.E., Pratt, M., Ekelund, U., Yngve, A., Sallis, J.F., Oja, P. (2003). International Physical Activity Questionnaire: 12-country reliability and validity. *Medicine and Science in Sports and Exercise*, *35*, 1381–1395. DOI: 10.1249/01.MSS.0000078924.61453.FB.

Daskapan, A., Emine, H.T., Levent, E. (2006). Perceived Barriers to Physical Activity in University Students. *Journal of Sports Science and Medicine*, *5*, 615–620.

Drygas, W., Jegier, A., Bednarek-Gejo, A., Kostka, T. (2005). Long-term effects of various physical activity levels in preventing obesity an metabolic syndrome in Middle-aged men. *The European Journal of Cardiovascular Prevention and Rehabilitation*, *12*, 28–34.

El-Gilany, A.H., Badawi, K., El-Khawaga, G., Awadalla, N. (2011). Physical activity profile of students in Mansoura University, Egypt. *Eastern Mediterranean Health Journal*, *17* (8), 694–702.

Florindo, A.A., Guimarães, V.V., Caesar, C.L.G., Barros, M.B.A., Alves, M.C.G.P., Goldbaum, M. (2009). Epidemiology of leisure, transportation, occupational, and household physical activity: Prevalence and associated factors. *Journal of Physical Activity and Health*, *6*, 625–632.

Haase, A., Steptoe, A., Sallis, J.F., Wardle, J. (2004). Leisure-time physical activity in university students from 32 countries: associations with health beliefs, risk awareness and national economic development. *Preventive Medicine*, *39* (1), 182–190.

Haskell, W.L., Lee, I.M., Pate, R.R., Powell, K.E., Blair, S.N., Franklin, B.A., Macera, CA., Heath, GW., Thompson, PD., Bauman, A. (2007). Physical activity and public health: updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. *Medical and Science in Sports and Exercise*, *39* (8), 1423–1434. DOI: 10.1249/mss.0b013e3180616b27.

Irwin, J.D. (2004). Prevalence of university students' sufficient physical activity: a systematic review. *Perceptual and Motor Skills*, *98* (1), 927–943.

Janssen, I., Leblanc, A.G. (2010). Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. *International Journal of Behavioral Nutrition and Physical Activity, 7*, 40–56. DOI: 10.1186/1479-5868-7-40.

Karaca, A., Caglar, E., Cinemre, S.A. (2009). Physical activity levels of the young adults in an economically developing country: The Turkish sample. *Journal of Human Kinetics*, *22*, 91–98.

Katzmarzyk, P.T., Church, T.S., Craig, C.L., (2009). Bouchard C. Sitting time and mortality from all causes, cardiovascular disease, cancer. *Medical and Science in Sports and Exercise*, *41*, 998–1005. DOI: 10.1249/MSS.0b013e3181930355.

Mabry, R.M., Reeves, M.M., Eakin, E.G., Owen, N. (2010). Evidence of physical activity participation among men and women in the countries of the Gulf Cooperation Council: a review. *Obesity Review,11*, 457–464.

Malina, R.M., Katzmarzyk, P.T. (2006). Physical activity and fitness in an international growth standard for preadolescent and adolescent children. *Food and Nutrition Bulletin*, *27* (5), 295–313.

Mussino, A. (1999). *Conceptual and operational problems in measuring participation in Sports*. Bulletin 52nd Session of the International Statistical Institute. Helsinki.

Narring, F., Cauderay, M., Cavadini, C., Michaud, P.A. (1999). Physical fitness and sport activity of children and adolescents: methodological aspects of a regional survey. *Social and Preventive Medicine, 44*, 44–54. DOI: 10.1007/BF01667126.

Nelson, M.E., Rejeski, W.J., Blair, S.N., Duncan, P.W., Judge, J.O., King, A.C., Macera, C.A., Castaneda-Sceppa, C. (2007). Physical activity and public health in older adults: recommendation from the American College of Sports Medicine and The American Heart Association. *Medical and Science in Sports and Exercise*, *39* (8), 1435–1445. DOI: 10.1161/CIRCULATIONAHA.107.185650.

Penedo, F.J., Dahn, J.R. (2005). Exercise and Well-Being: A review of mental and physical health benefits associated with physical activity. *Current Opinion in Psychiatry*, *18* (2), 189–193.

Rütten, A., Vuillemin, A., Ooijendijk, W.T., Schena, F., Sjostrom, M., Stahl, T., Vanden Auweele, Y., Welshman, J., Ziemainz, H. (2003). Physical activity monitoring in Europe. The European Physical Activity Surveillance System (EUPASS) approach and indicator testing. *Public Health Nutrition*, *6*, 377–384.

Shafy, H.E. (1998). Leisure time and its implication. In: *Adolescence and state policy in Egypt, Ch VI. Cairo, Egypt, The Population Council.* Regional Office for West Asia and North Africa.

Sokołowski, M. (2008). Międzynarodowy Kwestionariusz Aktywności Fizycznej (IPAQ) jako miernik oceny aktywności fizycznej studentów Akademii Wychowania Fizycznego. In: E. Szczepanowska, M. Sokołowski, (eds.), *Aktywność fizyczna i odżywianie*

się, jako uwarunkowania promocji zdrowia (pp. 113–124). Poznań: Wielkopolska Wyższa Szkoła Turystyki i Zarządzania w Poznaniu.

Suğuksu, K. (2011). Physical activity level between Polish and Turkish university students (IPAQ). In: B. Bergier (ed.), *Physical activity in health and disease* (pp. 19–27). Biała Podlaska: Pope John Paul II State School of Higher Education in Biała Podlaska.

Touvier, M., Bertrais, S., Charreire, H., Vergnaud, A.C., Hercberg, S., Oppert, J.M. (2010). Changes in leisure-time physical activity and sedentarny behaviour at retirement: a prospective study in Middle-aged French subjects. *International Journal of Behavioral Nutrition and Physical Activity*, *7*, 14. DOI: 10.1186/1479-5868-7-14.

Van Bottenburg, M., Rijnen, B., van Sterkenburg, J. (2005). Sports participation in the European Union. Trends and differences. Nieuwegein/'sHertogenbosch: Arko Sports Media/W.J.H. Mulier Institute.

Van der Horst, K., Paw, M., Twisk, J.W., Van Mechelen, W. (2007). A brief review on correlates of physical activity and sedentariness in youth. *Medicine and Science in Sport and Exercise*, *39* (8), 1241–1250.

WHO 2013. Global Health Observatory, Prevalence of insufficient Physical activity. Retreived from http://www.who.int/gho/ncd/risk_factors/physical_activity_text/en (July 2014).

www.ess.nsd.uib.no.

www.healthcanada.ca/paguide Handbook for Canada's physical activity guide to healthy active living, Health Canada, Canadian Society for Exercise Physiology.

www.ipaq.ki.se.

Zhao, Y., Sigmund, E., Sigmundová, D., Lu, Y. (2007). Comparison of physical activity between Olomouc and Beijing university students using an International Physical Activity Questionnaire. *Acta Universitatis Palackianae Olomucensis. Gymnica*, *37* (4), 107–114.

Zatoński, W.A, (2011). HEM Project team. Epidemiological analisys of health situation development in Europe and its causes until 1990. *Annals of Agriculture and Environmental Medicine*, *18* (2), 194–202.

Zoeller, F.R.Jr. (2007). Physical activity and obesity: their interaction and implications for disease risk and the role of physical activity in healthy weight management. *American Journal of Lifestyle Medicine*, *1* (6), 437–446. DOI: 10.1177/1559827607306889.

Cite this article as: Bednarek, J., Pomykała, S., Bigosińska, M., Szyguła, Z. (2016). Physical Activity of Polish and Turkish University Students as Assessed by IPAQ. *Central European Journal of Sport Sciences and Medicine*, *16* (4), 13–22. DOI: 10.18276/cej.2016.4-02.

DIVERSITY OF NUTRITION AMONG MALE AND FEMALE UKRAINIAN STUDENTS

Józef Bergier,[1, A, B, C, D, E] Barbara Bergier,[1, A, B, C, D, E] Anatolii Tsos[2, A, B, C, D, E]

[1] Pope John Paul II State School of Higher Education, Biała Podlaska, Poland
[2] Lesya Ukrainka Eastern European National University in Lutsk, Ukraine
[A] Study Design; [B] Data Collection; [C] Statistical Analysis; [D] Manuscript Preparation; [E] Funds Collection

Address for correspondence:
Józef Bergier
Pope John Paul II State School of Higher Education
Sidorska 95/97, 21-500 Biała Podlaska, Poland
E-mail: rektor@pswbp.pl

Abstract Adequate nutrition is one of the most important factors of a good state of health. The objective of the study was recognition of the mode of nutrition and behaviours related with concern about silhouette among students from the Ukraine.
Materials and Method. The study was conducted in 2013 among 2,125 students, including 1,291 females and 834 males, from 12 study specialties at the National University in Lutsk. The method of a diagnostic survey was applied with the use of a questionnaire. The study showed significant differences in the regularity of consumption of meals to the benefit of males. Females, in their behaviours, more frequently avoided eating, felt fear of gaining weight, and lost control over eating. With respect to behaviours related with concern about silhouette, females significantly more often applied exercises in order to reduce body weight, while males in order to gain body weight. A positive behaviour in both sexes was a trace application of drugs and other pharmacological means to improve own silhouette.

Key words nutrition, female students, male students, Ukraine

Introduction

Nutritional habits and their regularity exert a great effect on our health. An important issue is the current investigation of nutritional behaviours of students from various countries due to their cultural specificity (Antal et al., 2006; Brunt, Rhee, 2008; Delinsky, Willson, 2008; Kiziltan, Karabudak, Unver, Sezgin, Unal, 2006; Mammas, Bertsias, Linardakis, Moschandreas, Kafatos, 2006; Popowa-Ramova, 2015). Polish studies conducted in 2000 showed that the majority of the population (68%) consider that they eat healthily; however, as many as 21% had an opposite opinion concerning this problem (Falkowska, 2000).

In Poland, studies concerning nutrition among female students are relatively common and pertain to very different types of universities, mainly medical (Karina, Rektor, 2005; Krzych, 2004; Olędzka, Węgłowska, Szczepańska-Chudy, Bobrowska, 2004; Paśko, Krośniak, Chłopicka, Zachwieja, 2005; Smorczewska-Czupryńska, Ustymowicz-Farbiszewska, Cymek, Dubiel, Karczewski, 2009; Stefańska, Ostrowska, Czapska, Karczewski, 2005; Szponar, Krzyszycha, 2009; Zarzecka-Baran, Wojdak-Haasa, 2008), physical education (Gacek, 2004; Medrela-Kuder,

2003) pedagogical (Mięsowicz, Palus, 2002), agricultural (Wyka, Żechałko-Czajkowska, 2007), and universities of technology (Malara, Góra-Kupilas, Jośko, 2006; Olędzka, Moczydłowska, Rogalska-Niedźwiedź, 2002).

The researchers also undertook studies concerning the specificity of nutrition of female students (Jasnos et al., 2003; Rasińska, 2009; Smorczewska-Czupryńska, Ustymowicz-Farbiszewska, Cymek, Dubiel, Karczewski, 2009; Socha, Borawska, Markiewicz, Charkiewicz, 2009; Wojciechów-Gazel, Mickiewicz, Krzyśków, 2013).

The following of nutritional habits and health behaviours related with concern about silhouette among students, with consideration of specificity of males and students, allows even more comprehensive recognition of their preferences and factors which condition these preferences. The importance of the problem encouraged the authors to recognize the mode of nutrition of female and male students in Ukraine.

Methodology of research

The objective of the study was recognition of the mode of nutrition of students from Ukraine, with consideration of the specificity of sex.

Material and methods

The study was conducted in 2013 among 2,125 students, including 1,291 females and 834 males, aged 17–22 from 12 study specialties: philology, international relations, national sciences, physical culture and health, pedagogy, law, biology, geography, history, physics, fine arts, and mathematics, at the National University in Lutsk, Ukraine. The method of a diagnostic survey was applied, using a questionnaire designed at the Institute of Rural Health in Lublin, Poland, which contained questions concerning nutritional behaviours, behaviours concerning silhouette, and including the application of exercises in order to gain or reduce body weight.

Results

While analysing differences in nutrition among male and female students the following was considered: number of meals consumed per day, place of their consumption, behaviours related with nutrition, and behaviours related with concern about the appearance of the silhouette. Statistical analysis was performed using the software STATISTICA V10; significance level was set at $p = 0.05$.

Number of meals consumed during the day

Students from Ukraine most frequently consumed 3 meals per day (47%), and in a similar proportion – 4 and more meals (28%), and 1–2 meals (24.5%) (Table 1).

Males consumed meals significantly more often than females. In the case of 4 and more meals, their indicators were 36.6% and 23.2%, respectively. In turn, females more often consumed 1–2 meals, 29.9% and 16.2%, respectively. Possibly, the observed differences resulted from the fact that females try to eat more rarely in concern about their silhouette, which is not favourable for health.

It is also noteworthy that males significantly more frequently consumed main meals every day. This concerned the first and second breakfast, afternoon snack and supper. No significant differences between males and females were found according to the consumption of dinner. Females, to a higher extent, did not consume main meals: first breakfast – 34.5%, compared to 27.7% of males, second breakfast – 12.4%, compared to 6.5% of males, afternoon

snack – 17.8%, compared to 12.8% of males, and supper – 7.8%, compared to 2.0% of males. The positive phenomenon was the fact that only approximately 1% of both males and females did not eat dinner. The problem of consumption preferences of individual product groups has not been undertaken in this study.

Table 1. Number of frequency of consumption of meals by students from Ukraine, according to sex*

Number of meals consumed per day				
Sex	1–2	3	4 or more	Statistics
Females	351 (29.9%)	550 (46.9%)	272 (23.2%)	$X^2 = 64.78$ $p < 0.0001$*
Males	124 (16.2%)	362 (47.3%)	280 (36.6%	
Total	475 (24.5%)	912 (47.0%)	552 (28.5%)	
Frequency of consumption of first breakfast				
Sex	Every day	Several times a week	I do not eat	Statistics
Females	427 (39.8%)	276 (25.7%)	370 (34.5%)	$X^2 = 13.14$ $p = 0.0014$*
Males	270 (39.7%)	222 (32.7%)	188 (27.7%)	
Total	697 (39.8%)	498 (28.4%)	558 (31.8%)	
Frequency of consumption of second breakfast				
Sex	Every day	Several times a week	I do not eat	Statistics
Females	439 (39.8%)	528 (47.8%)	137 (12.4%)	$X^2 = 31.43$ $p < 0.0001$*
Males	378 (51.2%)	312 (42.3%)	48 (6.5%)	
Total	817 (44.4%)	840 (45.6%)	185 (10.0%)	
Frequency of consumption of dinner				
Sex	Every day	Several times a week	I do not eat	Statistics
Females	997 (79.4%	241 (19.2%)	17 (1.4%)	$X^2 = 2.40$ $p = 0.3008$
Males	630 (78.4%)	168 (20.9%)	6 (0.8%)	
Total	1,627 (79.0%)	409 (19.9%)	23 (1.1%)	
Frequency of consumption of afternoon snack				
Sex	Every day	Several times a week	I do not eat	Statistics
Females	377 (34.4%)	523 (47.8%)	195 (17.8%)	$X^2 = 15.42$ $p = 0.0005$*
Males	294 (42.7%)	306 (44.5%)	88 (12.8%)	
Total	671 (37.6%)	829 (46.5%)	283 (15.9%)	
Frequency of consumption of supper				
Sex	Every day	Several times a week	I do not eat	Statistics
Females	780 (64.6%)	333 (27.6%)	94 (7.8%)	$X^2 = 133.24$ $p < 0.0001$*
Males	714 (87.5%)	86 (10.5%)	16 (2.0%)	
Total	1,494 (73.9%)	419 (20.7%)	110 (4%)	

*The number of answers is smaller than the total number of respondents, because they did not always reply to all of the questions. Statistical significance at $p < 0.05$.

Place of consumption of meals

The analysis covered 5 main meals, with the indication of their consumption at home or outside home. The students ate breakfasts and suppers nearly exclusively at home, 96.0% and 93.8%, respectively (Table 2).

Approximately 70% of students consumed the remaining meals at home. Females significantly more often than males had breakfast at home, while males – the second breakfast – 77.1% and 65.9%, respectively. Considering the place of consumption of the remaining meals, i.e. dinner, afternoon snack and supper, no significant differences were observed.

Table 2. Place of consumption of meals by students from Ukraine, according to sex*

Where do you eat first breakfast?			
Sex	At home	Outside home	Statistics
Females	716 (97.0%)	22 (3.0%)	$X^2 = 4.43$ $p = 0.0352$*
Males	498 (94.7%)	28 (5.3%)	
Total	1,214 (96.0%)	50 (4.0%)	
Where do you eat second breakfast?			
Sex	At home	Outside home	Statistics
Females	679 (65.9%)	351 (34.1%)	$X^2 = 25.77$ $p < 0.0001$*
Males	560 (77.1%)	166 (22.9%)	
Total	1,239 (70.6%)	517 (29.4%)	
Where do you eat dinner?			
Sex	At home	Outside home	Statistics
Females	884 (70.7%)	366 (29.3%)	$X^2 = 0.77$ $p = 0.3811$
Males	554 (68.9%)	250 (31.1%)	
Total	1,438 (70.0%)	616 (30.0%)	
Where do you eat afternoon snack?			
Sex	At home	Outside home	Statistics
Females	704 (74.7%)	238 (25.3%)	$X^2 = 0.17$ $p = 0.6825$
Males	468 (73.8%)	166 (26.2%)	
Total	1,172 (74.4%)	404 (25.6%)	
Where do you eat supper?			
Sex	At home	Outside home	Statistics
Females	1,043 (93.5%)	73 (6.5%)	$X^2 = 0.52$ $p = 0.4707$
Males	756 (94.3%)	46 (5.7%)	
Total	1,799 (93.8%)	119 (6.2%)	

* The number of answers is smaller than the total number of respondents, because they did not always reply to all of the questions. Statistical significance at $p < 0.05$.

Behaviours related with nutrition

The analysis included five behaviours, which in as many as four cases significantly differentiated the attitudes of males and females. Females more often reported: avoidance of eating meals, and loss of control over eating – 29.8%, compared to 23.3% of their male colleagues (Table 3).

No significant differences were found only with respect to the irregularity of nutrition, which concerned 28.7% of females and 26.4% of males.

Also, females significantly more frequently than males provoked vomiting, 10.8% and 6.5%, respectively; however, these behaviours were relatively rare.

The results obtained indicate that the mode of nutrition in females is far from being the correct behaviour.

Table 3. Behaviours related with nutrition among Ukrainian students, according to sex

Loss of control over eating			
Sex	No	Yes	Statistics
Females	906 (70.2%)	385 (29.8%)	$X^2 = 11.00$ p = 0.0009*
Males	640 (76.7%)	194 (23.3%)	
Total	1,546 (72.8%)	579 (27.2%)	
Fear of gaining weight			
Sex	No	Yes	Statistics
Females	1,004 (77.8%)	287 (22.2%)	$X^2 = 142.94$ p < 0.0001*
Males	806 (96.6%)	28 (3.4%)	
Total	1,810 (85.2%)	315 (14.8%)	
Provoking vomiting			
Sex	No	Yes	Statistics
Females	1,152 (89.2%)	139 (70.8%)	$X^2 = 11.30$ p = 0.0008*
Males	780 (93.5%)	54 (6.5%)	
Total	1,932 (90.9%)	193 (9.1%)	
Avoiding eating			
Sex	No	Yes	Statistics
Females	833 (64.5%)	458 (35.5%)	$X^2 = 108.20$ p < 0.0001*
Males	710 (85.1%)	124 (14.9%)	
Total	1,543 (72.6%)	582 (27.4%)	
Irregular nutrition			
Sex	No	Yes	Statistics
Females	921 (71.3%)	370 (28.7%)	$X^2 = 1.31$ p = 0.2516
Males	614 (73.6%)	220 (26.4%)	
Total	1,535 (72.2%)	590 (27.8%)	

Statistical significance at $p < 0.05$.

Behaviours related with concern about own silhouette

It is commonly considered that especially women during the period of their youth, and certainly during the period of university studies, are particularly concerned about the appearance of their silhouette. Thus, there arises the question whether the behaviours of female students are accompanied by their attitudes promoting health. Unfortunately, this image is only half-way positive with respect to physical exercises performed in order to reduce body weight, which are applied by slightly more than a half of the students – 53.1% (Table 4).

In this respect, female students may be distinguished among whom as many as 71.3% took care of physical activity, and significantly more often appreciated the role of exercises in concern about body weight loss. Males, in concern about their silhouette, very frequently (64%) applied physical exercises to gain body weight, and their behaviours were significantly different from those of females. Only 15.8% of female students used physical exercises in order to gain body weight.

A positive phenomenon among both male and female students was a trace use of practices which are dangerous for the organism, i.e. the taking of weight loss drugs, weight gain medicines, laxatives, diuretics, and anabolic steroids.

The taking of weight loss drugs concerned 1.2% of males and 2.6% of females; taking diuretics – 1.4% and 2.9%, respectively; laxatives – 1.2% and 2.3%, and weight gain medicines – 6.5% and 0.5%. The indicator concerning the use of anabolic steroids was even lower – 1.9% of males and 0.4% of females (Table 4). Despite trace indicators of use of dangerous agents, females significantly more frequently than males used weight loss drugs and diuretics, whereas males – weight gain medicines and anabolic steroids.

Table 4. Behaviours related with concern about own silhouette by students from Ukraine, according to sex

Performance of physical exercises to lose weight			
Sex	No	Yes	Statistics
Females	370 (28.7%)	921 (71.3%)	$X^2 = 438.06$ $p < 0.0001^*$
Males	626 (75.1%)	208 (24.9%)	
Total	996 (46.9%)	1,129 (53.1%)	
Performance of physical exercises to gain weight			
Sex	No	Yes	Statistics
Females	1,089 (84.2%)	204 (15.8%)	$X^2 = 519.88$ $p < 0.0001^*$
Males	300 (36.0%)	534 (64.0%)	
Total	1,387 (65.3%)	738 (34.7%)	
Taking weight loss drugs			
Sex	No	Yes	Statistics
Females	1,258 (97.4%)	33 (2.6%)	$X^2 = 4.71$ $p = 0.0300^*$
Males	824 (98.8%)	10 (1.2%)	
Total	2,082 (98.0%)	43 (2.0%)	
Taking weight gain drugs			
Sex	No	Yes	Statistics
Females	1,285 (99.5%)	6 (0.5%)	$X^2 = 66.70$ $p < 0.0001^*$
Males	780 (93.5%)	54 (6.5%)	
Total	2,065 (97.2%)	60 (2.8%)	
Taking laxatives			
Sex	No	Yes	Statistics
Females	1,262 (97.8%)	29 (2.3%)	$X^2 = 3.08$ $p = 0.0790$
Males	824 (98.8%)	10 (1.2%)	
Total	2,086 (98.2%)	39 (1.8%)	
Taking diuretics			
Sex	No	Yes	Statistics
Females	1,254 (97.1%)	37 (2.9%)	$X^2 = 4.58$ $p = 0.0323^*$
Males	822 (98.6%)	12 (1.4%)	
Total	2,076 (97.7%)	49 (2.3%)	
Taking anabolic steroids			
Sex	No	Yes	Statistics
Females	1,286 (99.6%)	5 (0.4%)	$X^2 = 12.14$ $p = 0.0005^*$
Males	818 (98.1%)	16 (1.9%)	
Total	2,104 (99.0%)	21 (1.0%)	

Statistical significance at $p < 0.05$.

Discussion

The studies concerning the mode of nutrition of students, irrespective of the academic environment, revealed many abnormalities. One of the important issues of the equality of nutrition is the number and frequency of consumption of meals.

The Ukrainian adolescents in the study most often consumed three meals per day. Males significantly more frequently consumed four or more meals per day, and to a greater degree than females, ate two basic meals, i.e. breakfast and supper. No significant differences between sexes were found with respect to the consumption of dinner.

The number of meals consumed by the respondents was lower than that recommended by the Polish Institute of Food and Nutrition, which recommends five meals per day, but, simultaneously, indicates that this habit is observed by approximately 20% of Poles (Falkowska, 2000). The studies conducted among students of universities in Poznań (Karina, Rektor, 2005) showed that the dominant number of meals per day was three or four, which was more often reported by males, and is equivalent to the results obtained by the students from Ukraine. Different results concerning the regularity and preference of meals were obtained among students of various specialties at the Medical University in Lublin (Szponar, Krzyszycha, 2009). The dominant number of meals was from three to five per day, which was more frequently mentioned by females, who also significantly more often consumed breakfast every day. Other studies (Jasnos et al., 2003) confirmed that only 40% of female students regularly consume meals.

Female students from Ukraine do not significantly differ from their contemporaries with respect to behaviours related with nutrition. Females more often indicated the avoidance of eating, fear of gaining weight, and loss of control over eating, which may mean that their mode of nutrition is not proper. These behaviours are probably related with concern about own silhouette and wish to be attractive. It is commonly known that females, and certainly during the period of university studies, care about their silhouette. The image of female students from Ukraine is only half-way positive. More than a half of them perform exercises in order to reduce body weight. Studies among female students from the Medical University of Silesia (Jasnos et al., 2003) showed that more than a half of them applied weight loss diet at least once in their lives. In the case of males, they more often than their female colleagues applied exercises to gain weight. This was confirmed by the studies of Rasińska who found that the meals of the majority of female students were characterized by a low calorific value, which indicated a clear tendency towards slimming, also confirmed by other researchers (Jasnos et al., 2003; Wojciechów-Gazel Mickiewicz, Krzyśków, 2013). A positive phenomenon among male and female students is the trace usage of practices dangerous for the organism, such as the taking of weight loss drugs, weight gain medicines, laxatives, diuretics, and anabolic steroids. Despite the trace use of the above-mentioned agents, female students significantly more frequently consume weight loss drugs and diuretics, while males more often take medicines for gaining body weight and steroids. Studies conducted among students of the Medical University in Łódź (Łaszek, Nowacka, Gawron-Skarbek, Szatko, 2011) showed that only 0.7% of respondents regularly applied steroids. A very low percentage of males (2.8%), and only 0.4% of females admitted that they sporadically applied steroids.

Conclusions

1. Adolescents attending universities consumed breakfast and supper nearly exclusively at home. Females significantly more often consumed breakfast at home, whereas males – second breakfast.

2. Nearly a half of the students most frequently consumed three meals per day; nevertheless, males significantly more often ate more meals. No significant differences between sexes were found according to the consumption of dinners.

3. Significant differences were observed in the behaviours of students concerning nutrition. Females more often than males avoided eating, felt fear of gaining weight, lost control over eating, and provoked vomiting.

4. In concern about own silhouette, females significantly more often performed exercises in order to lose weight, while males in order to gain weight.

5. Trace use of medicines and other agents for improvement of the silhouette was observed . Only the taking of weight gain drugs was slightly higher, which was significantly more often noted in males.

References

Antal, M., Nagy, K, Regöly-Mérei, A., Bíró, L., Szabó, C., Rabin, B. (2006). Assessment of cardiovascular risk factors among Hungarian university students in Budapest. *Ann Nutr Met*, *50*, 103–107. DOI: 10.1159.

Brunt, A.R., Rhee, Y.S. (2008). Obesity and lifestyle in U.S. college students related to living arrangements. *Appetite*, *51*, 615–621.

Delinsky, S.S., Wilson, G.T. (2008). Weight gain, dietary restraint, and disordered eating in the freshman year of college. *Eating Beh*, *9*, 82–90.

Falkowska, M. (2000). Raport COBOS – komunikat z badań: nawyki żywieniowe i upodobania kulinarne Polaków. Retrived from: www.cobos.pl (17.11.2007).

Gacek, M. (2004). Ilościowa ocena sposobu odżywiania się i preferencje żywieniowe studentów specjalizacji trenerskiej w Krakowie. *Kul. Fiz*., *9–10*, 15–16.

Jasnos, I., Anuszewska-Mastalerz, K., Gój, K., Cieślik, A., Włodarczyk, I., Wanot, J. (2003). Styl żywienia studentek zamieszkujących w domach akademickich. *Annales Universitatis Mariae-Curie Skłodowska Lublin Polonia*, *LVIIII*, Suppl. XIII, Sectio D, *98*, 531–535.

Karina, S., Rektor, Z. (2005). Wybrane elementy stylu życia studentów kształcących się na specjalnościach związanych z medycyną. *Annales Universitatis Mariae-Curie Skłodowska Lublin Polonia*, *LX*. Suppl. XVI, Sectio D, *481*, 125–129.

Kiziltan, G., Karabudak, E., Unver, S., Sezgin, E., Unal, A. (2006). Prevalence of bulimic behaviours 54321and trends in eating attitudes among Turkish late adolescents. *Adolescence*, *41*, 677–689.

Krzych, Ł. (2004). Analiza stylu życia studentów Śląskiej Akademii Medycznej. *Zdr. Publ*., *114* (1), 67–70.

Łaszek, M., Nowacka, E. Gawron-Skarbek, A., Szatko, F. (2011). Negatywne wzorce zachowań zdrowotnych studentów. Część III. Aktywność ruchowa i nawyki żywieniowe. *Probl. Hig. Epidemiol*., *92* (3), 461–465.

Malara, B., Góra-Kupilas, K., Jośko, J. (2006). Odżywianie się i inne elementy stylu życia studentów Politechniki Śląskiej – doniesienia wstępne. *Zdr. Publ*., *116* (1), 132–134.

Mammas, I., Bertsias, G., Linardakis, M., Moschandreas, J., Kafatos, A. (2006). Nutrient intake and food consumption among medical students in Greece assessed during a clinical nutrition course. *Int J Food Sci Nutr*, *55*, 17–26.

Medrela-Kuder, E. (2003). Zainteresowanie problematyka żywienia przez studentów krakowskiej Akademii Wychowania Fizycznego. *Żyw. Człow. Metab*., *2* (30), 1–2.

Mięsowicz, I., Palus, D. (2002). Zachowania prozdrowotne studentów Akademii Pedagogiki Specjalnej. In: A. Malinowski (ed.), *Ontogeneza i promocja zdrowia w aspekcie medycyny, antropologii i wychowania fizycznego* (pp. 182–188). Zielona Góra: Wydawnictwo Uniwersytetu Zielonogórskiego.

Olędzka, R., Moczydłowska, I., Rogalska-Niedźwiedź, M. (2002). Ocena ilościowa sposobu żywienia studentów Wydziału Chemicznego Politechniki Warszawskiej w roku akademickim 1999/2000. *Bromat. Chem., Toksykol*., *35* (4), 310–322.

Olędzka, R., Węgłowska, K., Szczepańska-Chudy, A., Bobrowska, B. (2004). *Ocena ilościowa sposobu żywienia studentów Wydziału Farmaceutycznego Akademii Medycznej w Warszawie w roku akademickim 2002/2003*. XIX Naukowy Zjazd Polskiego Towarzystwa Farmaceutycznego „Farmacja – tradycja i nowoczesność". Wrocław.

Paśko, P., Krośniak, M., Chłopicka, J. Zagrodnik, I., Zachwieja, Z. (2005). Ocena sposobu żywienia studentów Wydziału Farmaceutycznego Collegium Medium Uniwersytetu Jagiellońskiego w Krakowie w latach 2003 i 2004. Część I: Składniki mineralne. *Żyw. Człow. Metab*., *32*, 660–667.

Popova-Ramova, E. (2015). Healthy lifestyle behaviors and nutritional habits of medical staff students. *International Journal of Current Microbiology and Applied Sciences*, *4* (10), 256–262.

Rasińska, R. (2009). Nawyki żywieniowe studentów w zależności od płci. *Nowiny Lekarskie*, *81*, 354–359.

Smorczewska-Czupryńska, B., Ustymowicz-Farbiszewska, J., Cymek, P., Dubiel, J., Karczewski, J. (2009). Analiza wartości energetycznej całodziennych racji pokarmowych (CRP) studentek UM w Białymstoku oraz zawartości w nich podstawowych składników odżywczych. *Bromat. Chem. Toksykol*., *XLII* (3), 714–717.

Socha, K., Borawska, H.M., Markiewicz, R., Charkiewicz, W. (2009). Ocena sposobu odżywiania studentek Wyższej Szkoły Kosmetologii i Ochrony Zdrowia w Białymstoku. *Bromat. Chem. Toksykol*., *XLII* (3), 704–708.

Stefańska, E., Ostrowska, J., Czapska, D, Karczewski, J. (2005). Ocena poziomu spożycia wybranych składników mineralnych (Na, K, P, Ca, Mg, Fe, Zn) występujących w całodziennych racjach pokarmowych studentów AMB. *Bromat. Chem. Toksykol*., *38*, 209–211.

Szponar, B., Krzyszycha, R. (2009). Ocena sposobu odżywiania studentów Uniwersytetu Medycznego w Lublinie w roku akademickim 2007–2008. *Bromat. Chem. Toksykol*., *XLII* (2), 111–116.

Wojciechów-Gazel, M., Mickiewicz, A., Krzyśków, A. (2013). Aktywność fizyczna i sposób odżywiania studentek fizjoterapii i europeistyki, a styl ich życia. *Zdr. Publ*., *123* (1), 19–23.

Wyka J., Żechałko-Czajkowska, A. (2007). Ocena sposobu żywienia studentów I roku Akademii Rolniczej we Wrocławiu. *Roczn. PZH*., *51*, 1, 327–332.

Zarzecka-Baran, M., Wojdak-Haasa, E. (2008). Zachowania zdrowotne studentów Akademii Medycznej w Gdańsku – sposób odżywiania. *Probl. Hig. Epidemiol*., *89* (1),146–150.

Cite this article as: Bergier, J., Bergier, B., Tsos, A. (2016). Diversity of Nutrition among Male and Female Ukrainian Students. *Central European Journal of Sport Sciences and Medicine*, *16* (4), 23–31. DOI: 10.18276/cej.2016.4-03.

THE PRIMARY PUPILS' KNOWLEDGE LEVEL ABOUT THE WINTER OLYMPIC GAMES

Karol Görner, Tomáš Kolofík

Department of Physical Education and Sport, Faculty of Arts, Matej Bel University, Banská Bystrica, Slovak Republic
[A] Study Design; [B] Data Collection; [C] Statistical Analysis; [D] Manuscript Preparation; [E] Funds Collection

Address for correspondence:
Karol Görner
Filozofická Fakulta
Univerzita Mateja Bela v Banskej Bystrici
Tajovského 40, Banská Bystrica 974 01, Slovensko/Slovakia
E-mail: karol.gorner@umb.sk

Abstract The aim of this research was to find out the primary pupils´ knowledge level about the Winter Olympic Games in Banska Bystrica. The research file consisted of 261 second stage primary pupils, 145 boys and 116 girls at the age from 10 to 15, who filled in the questionnaire ten days after finishing of the Winter Olympic Games held in Sochi. We used 14 questions in the questionnaire, consisting of the closed, half-open and open questions and 3 identification questions related to the sex of a respondent, age and respective school year of individual respondents. We can claim that among the most interesting findings there were: Firstly, more than 95% pupils knew what town was the organiser of the Winter Olympic Games in 2014. Secondly, more than 75% of the pupils were watching these Winter Olympic Games too. The most information about the Winter Olympic Games the pupils gained was via the TV and the internet. The favourite sports watched by the pupilswere ice hockey, biathlon, ski-jump and snowboarding. Almost 60% of the pupils could answer the question: "Which town will be the Winter Olympic Games organiser in 2018?" What is more, it is really pleasing to note that the Winter Paralympic Games have started to be in the primary pupils´ attention as well.

Key words Olympic education, knowledge level, Winter Olympic Games, primary school pupils

Introduction

Coubertin himself used the term "Sporting Education" instead of "Olympic Education" (Műller, 1986). This terminology appeared for the first time in sport education and Olympic research only by the 1970's. There is not an official concept of what it means but, even emphasising different areas, many scholars who studied the topic (Bruce-Culpan, 2008) agree that it is completely based in the values proposed in the Olympic Charter. It is educating in the universal values through sport and culture. And for the purposes of this paper, that is the idea we will consider when talking about Olympic Values Educational programmes and initiatives.

Olympic education is a process of educating and developing the individual according to universal values and ideals of Olympism. The principles and values of Olympism as special life attitudes and behaviours can be

understood, accepted and assimilated by means of a pedagogical approach, notably through sporting and cultural activities (Georgiadis, 2009).

Gessmann (1992), among others, emphasizes that "Olympic education" must be capable of the most positive association possible with the Olympic Games as an event. This is not self-evident, since the public – in view of the violations of the Olympic philosophy and the tangle of political, commercial and drug-related intrigue surrounding top-level sport – perceives the Olympic Games as an event that is rarely exemplary and is not to be taken seriously educationally. The negative examples cannot basically erase the validity of Olympic values as an educational idea. Ideals are never completely achieved – there are always compromises. So the battle for meaning has to be constantly re-thought. What educational models can be created by the Olympic Games as an event? People of all nations come together, some as competitors and others as spectators, in the utmost spirit of friendship. Through the media, the Olympic family at the venue of the Games becomes the symbol of the Olympic concept of universalism. The great achievements of the participants symbolize the striving and achievement of all humanity. If this symbol is also associated with fair play and mutual respect, the athletes set an example of successful coexistence between people in critical situations. The ceremonial character of the Olympic Games gives their achievements particular significance. It is in this context that the Olympic Games, as an event, must be critically considered and put to educational use (Gessmann, 1992; Booth, 1999; Culpan, 2002).

The Olympism as a system of ideas, principles, philosophy and visions have been formulated by Pierre de Coubertin at the beginning of the 20th century. The philosophy is not unchangeable; it is always in development what also applies to the philosophy of the Olympism which connects the physical ability, will and spirit in one unit in a well-balanced way. By connecting the sport with culture and education, the Olympism tries to create a way of life based on the joy of given efforts, on the educational value of a good example and on respecting the universal basic ethical principles. The meaning of the Olympism it is to involve sport anywhere in the process of the harmonic development of a human being, aiming to create a peaceful society, keeping the human dignity (Grexa et al., 2006).

According to Grexa et al. (2006), the Olympic Games may be considered as an important tool of education in the schools. It is therefore necessary that the Olympism becomes a part of the curricula in the elementary and secondary schools and that it is an unchangeable part of the curricula not only of physical and sport education, but also of the subjects where the ideas of the Olympism have their position. An important step to promotion of the Olympic ideas in the schools in Slovakia was realised during 1995–1997 where the topic of the Olympism became a part of the curricula in the elementary and secondary schools. It is a pity that this topic is only comprised in the subject of Physical and Sport Education; it is not comprised in other subjects. Except for the Physical and Sport Education, practically all the educational subjects may participate in the introduction of the Olympic education into the schools. We state following subjects and topics as the examples:

1. **History:** ancient Olympic games in the context with the cultural development of the Old Greeks, sport in the Middle Age, personality of baron Pierre de Coubertin.
2. **Geography:** scenes of organising the Olympic games, their demographic, climatic conditions, inhabitants, regional geography.
3. **Biology:** fauna and flora in the scene of the Olympic games, biological rudiments of the training process, nutrition of a sportsman, doping.
4. **Mother tongue:** sport terminology, creation of new names.

5. **Foreign language:** communication of the sportsmen from various countries, foreign languages learning.
6. **Graphic Art education:** graphical presentation of the sport events.

Aim

The aim of this research was to find out the primary pupils´ knowledge level about the Winter Olympic Games in Banska Bystrica. We based on the content standard of the thematic unit of knowledge from the physical education and sport which is a part of the subject Physical and Sport Education in the 5th through 9th year of elementary schools (Mikuš, Bebčáková, Sivák, 1999).

Methodology

We realised our research in the Elementary school Bakossova, Elementary school of Slobodného slovenského vysielača and Elementary school Radvanská which are located in Banská Bystrica. The questionnaire was distributed among 300 pupils of thesecond grade of the elementary schools ten days after the end of the Winter Olympic Games. We received 261 correctly filled questionnaires out of the total number of the questionnaires that we evaluated. There were in total 145 boys and 116 girls in the age of 10 to 15 years evaluated. 59 children were from the 5th year, 42 children from the 6th year, 59 children from the 7th year, 65 children from the 8th year and 36 children from the 9th year.

We used 14 questions in the questionnaire, consisting fof the closed, half-open and open questions and 3 identification questions related to the sex of a respondent, age and respective school year of individual respondents.

Results

The first question was aimed at finding whether the pupils watched the happening at Winter Olympic Games 2014. Out of the total number of the questioned pupils, 85 pupils (32.6%) answered definitely yes, 116 pupils (44.4%) more yes, 46 pupils (17,6%) more no and only 14 pupils (5.4%) answered they did not watch the Winter Olympic Games 2014 at all. We can be pleased by this fact because it is the evidence that the Winter Olympic Games are an event within the sphere of interest of the school population.

Table 1. Answers for the first question

	Definitely yes	More yes	More no	Definitely no
N	85	116	46	14
%	32.6	44.4	17.6	5.4

The second question was aimed at finding whether the pupils know which country hosted the Winter Olympic Games 2014. Basing on the answers from pupils we can claim that as many as 242 pupils (92.7%) knew the correct answer. Incorrect answers were given by 9 pupils (3.5%) and 10 pupils (3.8%) did not know the answer.

Table 2. Answers for the second question

	Correct answer	Incorrect answer	No answer
N	242	9	10
%	92.7	3.5	3.8

Even better results were achieved by the question: "Which city organised the Winter Olympic Games 2014?" There were only 4 incorrect answers (1.5%), 7 questioned pupils did not know the answer (2.7%). As many as 250 pupils (95.8%) gave the correct information.

Table 3. Answers for the third question

	Correct answer	Incorrect answer	No answer
N	250	4	7
%	95.8	1.5	2.7

Next question was related to the opening ceremony of the Winter Olympic Games. 134 pupils watched it in a live transmission (51.4%), 34 pupils watched it from the tele-recording (13.0%), 93 pupils (35.6%) did not watch it.

Table 4. Answers for the fourth question

	Live transmission	Tele-recording	Did not watch it
N	134	34	93
%	51.4	13	35.6

Through the fifth question we found out that the pupils acquired the majority of information about happening at Winter Olympic Games from the television – 86.6%, from the Internet – 48.7%, from the discussions with friends – 34.5%, from the discussions with family relatives – 32.2%, from the broadcasting – 16.1%, from the press – 8.4%, from the discussions with the coaches – 6.1%, from the discussions with teachers – 5.0% and from other resources – 1.5% (here the mobile phones applications prevailed). These answers are the evidence that the media have a premium position in the source of information on Winter Olympic Games. Friends and family also play the role. We were very surprised by a small percentage of answers related to the information from teachers. The issue of information from the coaches cannot be analysed as we did not find out how many out of the questioned pupils active sportsmen were.

Table 5. Answers for the fifth question

	Television	Internet	Friends	Family	Broadcasting
%	86.6	48.7	34.5	32.2	16.1
	Press	Coaches	Teachers	Other resources	
%	8.4	6.1	5.0	1.5	

Out of the individual sports at the Winter Olympic Games, majority of respondents - 89% watched the hockey, 65% stated biathlon, 39% ski jumping, 38% snowboarding, 32% Alpine skiing, 29% speed skating, 28% figure skating, 25% bobsleigh, 19% Nordic skiing, 12% curling, 10% luge, 7% Nordic combined. The smallest number of respondents watched the short track – 4% and skeleton – 3%. It is obvious from these answers that the absolute dominancy in the watching was confirmed by the hockey; however biathlon also became a part of the sphere of interest.

Table 6. Answers for the sixth question

	Hockey	Biathlon	Ski jumping	Snowboarding	Alpine skiing
%	89	65	39	38	32
	Speed skating	Figure skating	Bobsleigh	Nordic skiing	Curling
%	29	28	25	19	12
	Luge	Nordic combined	Short track	Skeleton	
%	10	7	4	3	

The next question was aimed at finding out the performance of which Slovak sportsman/woman or collective team at the Winter Olympic Games are considered by the pupils as the best ones. As many as 224 pupils (85.8%) stated the biathlete Anastasiya Kuzmina. Except for her, 34 pupils (13%) stated the Alpine skier Adam Žampa and 13 pupils (5%) stated goalie Ján Laco.

Table 7. Answers for seventh question

	Anastasiya Kuzmina	Adam Žampa	Ján Laco
N	224	34	13
%	85.8	13	5

The biggest disappointment from the Slovak representation at the Winter Olympic Games was stated for the performance of our ice hockey players (78%). Further, the pupils stated the disappointment from the performance of Zdeno Chára (5.8%), Marián Hossa (1.9%), biathlon relay of women (1.5%) and Alena Procházková (1.2%).

Table 8. Answers for the eighth question

	Ice hockey players	Zdeno Chára	Marián Hossa
%	78	5.8	1.9
	Biathlon relay of women	Alena Procházková	
%	1.5	1.2	

Ice hockey players of Canada were considered as the most successful sportsmen of the Winter Olympic Games in Sochi by 23.8%, biathlete Darya Domracheva 6.1%, biathlete Ole Einar Bjørndalen 3.8%, ice hockey

players of the USA 3.5% and short track representative Viktor Ahn 1.9% of pupils. As many as 48.7% of the total number of respondents could not specify any sportsman / woman or collective team.

Table 9. Answers for the ninth question

	Ice hockey players of Canada	Darya Domracheva	Ole Einar Bjørndalen
%	23.8	6.1	3.8
	Ice hockey players of the USA	Viktor Ahn	
%	3.5	1.9	

Even bigger number of pupils – 69.3% could not specify a foreign sportsman who was the biggest disappointment at the Winter Olympic Games. Russian ice hockey players were stated by 10.3%, Czech ice hockey players by 3.5% and figure skater Evgeni Plushenko by 1.2% respondents.

Table 10. Answers for the tenth question

	Russian ice hockey players	Czech ice hockey players	Evgeni Plushenko
%	10.3	3.5	1.2

The question: „Which country won the medal balance of the countries at the Winter Olympic Games 2014?“ was correctly answered by 114 pupils (43.7%). Incorrect information was given by 133 pupils (50.9%) and 14 pupils (5.4%) did not know the answer.

Table 11. Answers for the eleventh question

	Correct answer	Incorrect answer	No answer
N	114	133	14
%	43.7	50.9	5.4

The question which city will be organising the next Olympic Games 2016 was correctly answered by 144 respondents (55.2%). Incorrect answer was given by 69 respondents (26.4%) and 48 respondents did not know the answer (18.4%).

Table 12. Answers for the twelfth question

	Correct answer	Incorrect answer	No answer
N	144	69	48
%	55.2	26.4	18.4

Little bit better results were achieved by the question which city will be organising the next Winter Olympic Games 2018. The correct answer was stated by 154 respondents (59.0%), 46 respondents provided incorrect answer (17.6%) and 61 respondents (23.4%) did not know the answer.

Table 13. Answers for the thirteenth question

	Correct answer	Incorrect answer	No answer
N	154	46	61
%	59	17.6	23.4

The last question was investigating whether the pupils know what important world event takes place in the place of the Winter Olympic Games from 7th until 16th March 2014. It was correctly answered by 187 pupils (71.6%), 59 pupils (22.6%) did not know the answer and 15 pupils (5.7%) stated incorrect information. Based on this answer we can claim that the Winter Olympic Games are starting to get into the sphere of the focus of our youth.

Table 14. Answers for the fourteenth question

	Correct answer	Incorrect answer	No answer
N	187	15	59
%	71.6	5.7	22.6

Discussion

Similar researches but with other age categories and other questions were realised by Hrčka (1998), Bebčáková, Mikuš (1999), as well as Glesk (2000).

However, the results of our research can partially be compared only with the research of Görner (2001, 2002, 2004), who dealt with the retrospective of the Olympic Games 2000 and Winter Olympic Games 2004 in the same age category. Of course, we can only compare those questions where we can omit the fact that in one case therewere the Olympic Games, in other case there were the Winter Olympic Games.

Within our research, the correct answer to the question which city was organising the Winter Olympic Games was given by as many as 95.8% respondents. Within the Görner´s research (2001) the correct organiser of the Olympic Games was given "only" by 75.5% respondents. Both the researches further revealed that the pupils got more information on the Winter Olympic Games Sochi in comparison to the Olympic Games Sydney from the television (increase from 72 to 86.6%) and the Internet became a very important source of information in the meantime (increase from 3 to 48.7%). On the contrary, discussions with friends were stated as less valuable sources of information (drop from 64 to 34.5%), discussions with family relatives (drop from 49 to 32.2%), broadcasting (drop from 44 to 16.1%) as well as discussions with teachers (drop from 22 to 5%). The opening ceremony of the Olympic Games in Sydney was watched by more respondents – 62% of respondents watched it in live transmission while the opening ceremony in Sochi was watched "only" by 51.4% of respondents. We can also compare the answers to

the question which city will be organising the next Olympic or Winter Olympic Games. Definitely bigger success rate of the correct answers was achieved by pupils in our research (59% in comparison to 15.6%). Similar results were achieved in the question what important event takes place after the end of Olympic or Winter Olympic Games in the place of their happening. The correct answer in our research was given by as many as 71.6% of the pupils, while in Görner´s research (2001) it was only 16.9 of the pupils.

Based on this short comparison we can assume that the Olympic topic gradually gets into the sphere of attention of our youth more and more.

Conclusions

The aim of this research was to find out the primary pupils´ knowledge level about the Winter Olympic Games in Banska Bystrica. We are aware that based on the questionnaire method through which we gained the data from 261 pupils we cannot provide generally binding conclusions. Despite the stated facts we assume that we managed to realise the goal that we defined and we can fully submit the results of our research.

We can claim that among the most interesting findings belonged: Firstly, more than 95% pupils knew what town was the organiser of the Winter Olympic Games in 2014. Secondly, more than 75% of the pupils were watching these Winter Olympic Games too. The most information about the Winter Olympic Games the pupils gained was via the TV and the internet. The most favourite watching sports were ice hockey, biathlon, ski-jump and snowboarding. Almost 60% of the pupils could answer the question: "Which town will be the Winter Olympic Games organizer in 2018?" What is more, it is really pleasing to note that the Winter Paralympic Games have started to be in the primary pupils´ attention as well.

References

Bebčáková, V., Mikuš, M. (1999). Prínos školskej telesnej výchovy k výchove olympizmu. In: *Zborník zo seminára SOA* (pp. 70–73). Bratislava: Slovenský olympijský výbor.

Booth, D. (1999). "Gifts or Corruption?: Ambiguities of Obligation in the Olympic Movement, Olympika." *International Journal of Olympic Studies, 8* (1), 43–68.

Bruce, J., Culpan, I. (2008). Olympic education, Olympism and the need for a critical pedagogy. Proceedings of the International Convention on Science. *Education and Medicine in Sport. China*, *1*, 39–42.

Culpan, I. (2002). Olympism, Education and Sport: Beyond Mediocrity. *Olympic*, *3* (Winter), 3–5.

Georgiadis, K. (2009). Olympic education: A Theoretical Framework: In: IOA&IOC (ed), *Proceedings of the 2nd International Session for Olympic Medallists*. Ancient Olympia 4–20 July.

Gessmann, R. (1992). Olympische Erziehung und ihre schulische Umsetzung. In: NOK für Deutschland (red.), *Olympische Erziehung in der Schule unter besonderer Berücksichtigung des Fair – Play – Gedankens* (pp 39–40). Frankfurt: NOK.

Glesk, P. (2000). Informovanosť študentov univerzity o olympizme. In: *Zborník – Olympijské ideály v současném světe* (pp. 41–44). Olomouc : Univerzita Palackého.

Görner, K. (2001). Pohľad na olympijské a paralympijské hry Sydney 2000 očami žiakov druhého stupňa základných škôl v Banskej Bystrici. *In Telesná výchova a šport*, *11* (1), 16–19.

Görner, K. (2002). Olympic and paralympic Games as an educational and motivational Factor for Pupils of primary Schools. In: *Rocznik naukowy*. Biała Podlaska: Akademia Wychowania Fizycznego, 207–212.

Görner, K., Prusik, K. (2004).The Level of Olympic Education about the Winter Olympic Games in Older Pupils of Primary School. In: *Research Yearbook: studies in the Theory of Physical Education and Sport* (pp. 10, 17–21). Gdańsk: Akademia Wychowania Fizycznego i Sportu.

Grexa, J. (2006). *Olympijská výchova*. Bratislava: Slovenský olympijský výbor.

Hrčka, J. (1998). K súčasným výchovným tendenciám v olympizme. In: *Zborník zo seminára SOA* (pp. 52–60). Bratislava: Slovenský olympijský výbor.

Mikuš, M., Bebčáková, V., Sivák, J. et al. (1999). *Vzdelávací štandard z telesnej výchovy pre 2.stupeň základných škôl.* Bratislava: Štátny pedagogický ústav.

Műller, N. (1986). *Pierre de Coubertin: textes choisis. Vol. I. Revélation*. Zurich: Weidmann.

Cite this article as: Görner, K., Kolofík, T. (2016). The Primary Pupils' Knowledge Level about the Winter Olympic Games. *Central European Journal of Sport Sciences and Medicine*, *16* (4), 33–41. DOI: 10.18276/cej.2016.4-04.

CO-EXISTENCE OF PHYSICAL ACTIVITY (PA) AND OTHER ENERGY-BALANCE RELATED BEHAVIOURS AMONG ADOLESCENTS PARTICIPATING IN PA INTERVENTION IN POLAND

Paweł Zembura,[A, B, C, D] Aleksandra Gołdys[A, B, D]

Robert B. Zajonc Institute of Social Science, Social Challenges Unit, University of Warsaw, Poland
[A] Study Design; [B] Data Collection; [C] Statistical Analysis; [D] Manuscript Preparation; [E] Funds Collection

Address for correspondence:
Paweł Zembura
Centrum Wyzwań Społecznych Uniwersytetu Warszawskiego
DELab UW
Dobra 56/66, 00-312 Warszawa, Poland
E-mail: pzembura@wp.pl

Abstract The aim of this study was to identify clusters based on four energy – balance related behaviours (EBRBs) – moderate-vigorous physical activity, screen time, breakfast consumption and sweet drinks consumption – among adolescents participating in a governmental programme to increase their sport participation. The study was a part of the monitoring and evaluation process of a nationwide sport intervention in Poland. The sample consisted of 367 participants (180 females and 187 males, mean age 15.18 ±1.67). Data was self-reported. Based on combination of cluster analysis, a five-cluster solution was found the most suitable. Some patterns of EBRBs were similar to the results obtained in previous studies conducted on the general population on, for example "sedentary-snacking" or "all-round-healthy" clusters. The amount of the clusters which accumulated most of the negative or positive behaviours were small, and most clusters presented a mix of behavioural patterns influencing energy balance in both positive and negative ways. The structure of the clusters differed based on adolescents' gender and, for male participants, fathers' education ($p < 0.05$).

Key words cluster analysis, co-occurrence, sport intervention, MVPA, screen time

Introduction

Overweight and obesity are the effects of a positive energy balance over time (Hill, Wyatt, Peters, 2012). In Poland most children and adolescents fail to meet guidelines regarding behaviours that positively influence energy balance (Jodkowska, Oblacińska, Tabak, 2014; Mazur, 2015). For example, in a recent Health Behaviour in School-aged Children (HBSC) study only about 18% of 15-years old teenagers reached the recommended 1 hour of moderate or vigorous physical activity (MVPA) daily and this level has not significantly changed during last 4 years (Mazur, 2015). Furthermore, the conclusion from the HBSC study is that meeting recommendations regarding physical activity (PA) and sedentary time is less common in older age groups of children (Mazur, 2015).

Given these alarming patterns, since 2014 several nationwide sport interventions aiming to increase PA among schoolchildren have been introduced in Poland. The programmes, co-financed by Ministry of Sport and Tourism, are based on a simple model – afterschool, multisport classes organised 3 times a week and intended to reach children and adolescents previously not involved in organized sport. None of the programmes aimed to influence any other EBRBs, particularly sedentarism or eating habits. The emphasis has been strictly on MVPA.

From the public health perspective narrowing interventions, targeted to adolescents endangered by lack of PA, merely to sport could be viewed as a wasted opportunity, as they limit potential impact to just one behaviour. In multiple studies it has been shown, that among children and adolescents risks associated with modifiable health related behaviours coexist together within individuals (Fernández-Alvira et al., 2013; Leech, McNaughton, Timperio, 2014). Furthermore, they may carry synergetic influence on health outcomes (Busch, Van Stel, Schrijvers, de Leeuw, 2013; Gubbels, van Assema, Kremers, 2013). This has lead to extensive studying of clusters of children and adolescents who show similar behavioural patterns. One of the repeated conclusions included in the Leech et al. (2014) review was, that if the goal of the intervention is to prevent negative health outcomes, some behaviours might be targeted simultaneously.

In this study, our aim was to identify co-occurrence of EBRBs among adolescents involved in the intervention to increase physical activity. We were aware that behavioural patterns among adolescents involved in PA interventions might be very different from EBRBs coexistence in the general population. A better understanding of patterns, especially in comparison to population, should enable a data-driven re-shaping of the intervention (Gubbels et al., 2013). Moreover, information about clustering patterns for EBRBs is inconclusive (Leech et al., 2014). Cluster analysis is usually conducted to find populational patterns, and clusters are specific and not aimed to generalise (Leech et al., 2014). Finally, overall data about the coexistence of health-related behaviours in Poland among adolescents is scarce, apart from the work of Jodkowska et al. (2014), Mazur et al. (2014) and Zalewska et al. (2015).

For clustering, we chose four established EBRBs: level of MVPA; screen time spent watching TV and/or playing computer or console games as representative of a sedentary lifestyle; and two factors representing dietary habits: soft drinks consumption and frequency of breakfast consumption. Previous studies and reviews showed evidence that PA, sedentary behaviour, breakfast consumption, and soft drink consumption are related to overweightness and obesity among children (Chinapaw, Proper, Brug, Van Mechelen, Singh, 2011; De Bourdeaudhuij et al., 2013; Massougbodji, Bodo, Fratu, Wals, 2014; Mitchell, Rodriguez, Schmitz, Audrain-McGovern, 2013; Rey-Lopez, Vicente-Rodríguez, Biosca, Moreno, 2008; Rezende, Rodrigues Lopes, Rey-López, Matsudo, Luiz, 2014; Szajewska Ruszczynski, 2010). A comprehensive review conducted as part of the ENERGY project acknowledged that the most evidence for an association with overweight and obesity in 10–12-year-old children was found for these four EBRBs (Douthwaite, Summerbell, Moore, 2012).

To obtain wider information about the clusters we compared them based on gender, age, parents' education and place of living. These factors were frequently investigated in previous studies, and several EBRBs consistently showed differences based on them (Brug et al., 2012; Gubbels et al., 2013; Leech et al., 2014; Ottevaere et al., 2011; Stierlin et al., 2015). For example, levels of physical activity tend to decrease with age as lower numbers of adolescents reach recommended MVPA when transitioning to adulthood (Mazur, 2015).

Objectives

1. Identifying clusters based on EBRBs among adolescents participating in a PA intervention.
2. Comparing the obtained clusters based on socio-demographical variables.

Methods

Study settings

Data comes from the monitoring and evaluation stage of the intervention, in which one of the tools was an online questionnaire which participants were asked to complete. Parents or legal guardians provided written informed consent about their children's participation in the study. This nationwide intervention reaches about 35 thousand adolescents per annum. The goal of this programme is to organise systematic, free-of-charge, accessible training for adolescents from lower- and higher-middle schools. Each "Animator" (trainer) conducts three 90 minutes training sessions per week. Training sessions take place in sport clubs (which are frequently located on school grounds). Adolescents participating in the intervention were recruited primarily by physical education teachers, sport clubs, and trainers, so it was hypothesized that some of the participants might be already active.

For the purpose of the study subjective measurements were used, as all the behaviours were self-reported by adolescents through the online survey. Questionnaires were conducted during the first week of November, as recommended by IPAQ protocol (IPAQ Research Committee, 2005). Data collection was anonymous and the demographic information collected did not permit identification of the individual participant.

Participants

Data was gathered from 624 participants, however after omitting individuals with any missing values and extreme values the dataset was limited to 367 participants (59%, 180 girls and 187 boys). The mean age in the sample was 15.18 years (SD 1.67).

Measurements

Physical activity

To assess physical activity, a short form of IPAQ (IPAQ Research Committee, 2005) was used. The original IPAQ is a self-administered questionnaire, which was primarily developed as a cross-national tool for monitoring PA and inactivity in adults and adolescents (15–69 years). In Poland, the short version of IPAQ is a frequently used measurement tool, even though its reliability and validity has not been extensively tested. The questionnaire enquires about activity during the previous week. The questions refer to four activity types of behaviour: "vigorous activity" periods for at least 10 min; "moderate activity" periods for at least 10 min, "walking" periods for at least 10 min and time spent "sitting" on weekdays. Frequency of activity is measured in days and duration in minutes. For the cluster analyses, the total time spent on moderate and vigorous activity was calculated and divided by 7. The World Health Organization (WHO) recommends that children and adolescents aged 5–17 should undertake at least 60 minutes of moderate to vigorous intensity PA per day (Currie, 2012). For the purpose of descriptive statistics we examined how many participants reached a total of 7 days of vigorous and moderate physical activity per week

and 60 minutes of vigorous and moderate activity per day. However, due to characteristics of IPAQ it is not possible to directly compare this result with the levels recommended by World Health Organization.

Screen-based Sedentary Behaviours (SB)

The average time spent per day engaged in screen activities was calculated as a proxy for sedentary behaviour. Screen time was assessed separately for weekdays and weekend days. We used items from the HBSC questionnaire describing two types of screen time behaviour (Currie, 2012; Mazur, Małkowska-Szkutnik, 2011):

– watching television (including videos and DVDs),
– playing computer or console games (such as Playstation, Xbox).

Adolescents were asked to declare the amount of time spent, on average, on each activity in one day. Weighted mean duration of each behaviour per day ((5 weekday min/d + 2 weekend min/d)/7) was derived and calculated to provide the measure of screen time used in the cluster analysis.

For the purpose of descriptive statistics, the answers provided by adolescents for both questions were calculated and then categorized according to screen time recommendations for children and adolescents (>2 hr/day; and ≤2 hr/day) provided by the American Academy of Pediatrics. Sedentary behaviour for more than 2 hours per day has also been mentioned by Tremblay et al. (2011) as being associated with unfavourable body composition, decreased fitness, lowered scores for self-esteem and pro-social behaviour, and decreased academic achievement in school-aged children and youths.

Frequency of eating breakfast

For breakfast consumption, we used HBSC items, previously translated to Polish (Currie, 2012; Mazur, Małkowska-Szkutnik, 2011). It comprised of two questions relating to weekdays and weekends: “How often do you usually have breakfast (more than a glass of milk or fruit juice)?” The response options for weekdays were “I never have breakfast during weekdays/one day” / “two days” / “three days” / “four days” / “five days” and for weekends “I never have breakfast during the weekend” / “I usually have breakfast on only one day of the weekend (Saturday or Sunday)” / “I usually have breakfast on both weekend days (Saturday and Sunday)”. For cluster analysis, we used number of days of breakfast consumption. For the purpose of descriptive statistics, adolescents were considered regular breakfast eaters if they consumed breakfast 7 days a week.

Consumption of sweet beverages

For sugary drink consumption, another HBSC item was used (Mazur, Małkowska-Szkutnik, 2011). Participants answered the question “How many times a week do you consume sweetened soft drinks” with response options “never/less than once a week” / “two to four times a week” / “five to six times a week” / “once a day” / “more than once a day”. For cluster analysis, we used representation of the scale from 1 (“never”) to 6 (“more than once a day”). For the purpose of descriptive statistics children were divided into two groups – those who consumed sweet drinks less than twice per week (“1”) versus those who consumed two or more times (“0” – was considered the unhealthy lifestyle behaviour group).

Socio-demographical variables

Clusters were compared based on socio-demographical variables: gender, age, place of living, parents' education level (mother's education level, father's education level). Categorical variables were created for this purpose. In reference to age, participants were divided to younger (12–14) and older (15–19) groups. For place of living, three classes were created: countryside, small towns (up to 20 thousand citizens), medium and large cities (above 20 thousand). For educational level, we created a binary variable where upper middle education was the highest level of lower class, and post-upper middle education was considered upper class.

Statistical analysis

First, we excluded outliers and truncated IPAQ data based on processing rules featured in the protocol, and excluded extreme values from the screen time variable (IPAQ Research Committee, 2005). Regarding moderate and vigorous physical activity we excluded maximal outliers (>960 total minutes per day including time spent walking) and truncated remaining high values of a particular type of activity to a maximum of 180. For screen time, we excluded observations where screen time average exceeded 12 hours daily and truncated other high results of any type of screen time to 8 hours per day. Data was excluded from the analysis if time spent on all screen time activities (including another item describing time working on a computer) reached 16 hours or above or if a single activity reached or exceeded an average of 8 hours per day. For the purpose of descriptive statistics, meeting the cut-off criteria in the sample was compared based on gender using χ^2.

As the factors were assessed on different scales, the variables included in the analysis were transformed to Z-scores (with mean = 0 and SD = 1) to equalize their contribution in the cluster analysis (Hair, Black, 2000). Before clustering, we checked for multicollinearity and Pearson's correlations between variables.

A combination of hierarchical method and k-means cluster analysis was used to identify clusters for four EBRBs (Everitt, Landau, Leese, Stahl, 2011). First, we conducted hierarchical cluster analysis using the Ward method based on squared Euclidian distances. This step was used to identify and compare several possible cluster solutions based on the elbow method, dendogram solution and average silhouette width. In the second step, we used k-means cluster analysis to refine the solution from hierarchical clustering. A third step was the examination of stability (reliability of the final cluster solutions). This was done by randomly taking subsamples of the data (50 and 70% of observations from the dataset) separately conducting the two aforementioned clustering analyses and comparing the classification of the observations with the final cluster solution using kappa statistics.

To compare z-scores for EBRBs between the clusters, ANOVA and Games–Howell post hoc tests were used.

χ^2 tests were used to examine gender distribution between the clusters. After clusters were stratified for gender, χ^2 tests were performed to compare cluster distributions for age, place of living and parents' education.

Cluster analysis was carried out using R 3.2.3 with NbClust for analysing cluster solutions (Charrad, Ghazzali, Boiteau, Niknafs, Charrad, 2014). The remaining analyses were carried out using SPSS 21.

Results

Comparison of the proportion of participants meeting established cut-off levels of EBRB showed differences based on gender. A non-significant relationship was found only in the case of MVPA, while the larger proportion of

females met cut-offs regarding screen time and sweet beverage consumption and the larger proportion of males regularly ate breakfast.

Table 1. Differences in meeting cut-off points of particular EBRB in the sample, based on gender

	% of participants meeting cut-off levels		χ^2	p
	no	yes		
MVPA indicator			0.005	0.943
Female	61.7	38.3		
Male	62.0	38.0		
Screen time indicator			12.901	0
Female	42.2	57.8		
Male	61.0	39.0		
Breakfast consumption indicator			4.969	0.026
Female	42.2	57.8		
Male	31.0	69.0		
Sweet beverages consumption indicator			7.060	0.008
Female	29.4	70.6		
Male	42.8	57.2		

Cut-off points regarding EBRB:
MVPA – days of moderate activity + days of vigorous activity ≥7 days per week and average time of moderate activity per day + average time of vigorous activity per day ≥60 min.
Screen time – watching TV + playing computer games or console ≤2 hr per day.
Breakfast consumption – breakfast consumption 7 days a week.
Sweet beverages consumption – sweet beverages consumption less than two times per week.

Variance inflation factors were less than 1.5, suggesting that the shared variance between the clustering variables was sufficiently small that each variable could contribute to the cluster analysis (Hair, Black, 2000). The highest correlation between the EBRBs was 0.24, and it described the relation between screen time and sweet beverage consumption. Other correlations were non-significant ($p < 0.05$).

Table 2. Inter-correlation between the EBRBs in the sample

	MVPA	screen time	breakfast consumption	sweet beverages consumption
MVPA	1	0.003	0.050	0.015
Screen time	0.003	1	–0.029	0.235
Breakfast consumption	0.050	–0.029	1	–0.025
Sweet beverages consumption	0.015	0.235	-0.025	1

To check the stability of the cluster analysis solution we randomly took subsamples from the dataset, conducted hierarchical and k-means clustering and compared the obtained results with cluster results for the whole sample. Cohen's Kappa κ for 50% of the data was 0.75 which suggested substantial agreement, and for the subsample consisting of 70% of the data κ = 0.95 which suggested almost perfect agreement (Viera, Garrett, 2005).

Cluster solution

Based on the 4 behaviours (MVPA, screen time, breakfast consumption, sugar drinks consumption), a 5-cluster solution seemed the most adequate and reliable representation of this study population. ANOVA with Games-Howell post hoc comparisons were used to test for differences across the clusters.

The first cluster (n = 88) was labelled Sweet Drinks Consumers for the higher results of sweet drinks consumption variable than in the other clusters. The second cluster (n = 45) was named Breakfast Skippers, as the z-scores for breakfast consumption were lower than in the other groups. This cluster also had a low z-score mean (–0.45) for screen time. Third cluster (n = 156) was labelled Healthy Diet Low MVPA. It included the most observations and was not strongly distinct from the other clusters based on a single factor ($p < 0.001$). However, this cluster had higher z-scores for breakfast consumption than 2 clusters ($p < 0.001$). The fourth cluster (n = 40) was labelled Unhealthy Cluster, and was primarily distinguished by very high z-scores regarding screen time. This group agglomerated two other unhealthy behaviours, having breakfast consumption lower than 2 other clusters and sweet drinks consumption higher than 2 other clusters ($p < 0.001$). Finally, the fifth cluster (n = 38) was labelled High MVPA having higher z-scores for MVPA than other clusters ($p < 0.001$). This cluster also had a relatively high mean for breakfast consumption and low mean for screen time.

Table 3. Results of ANOVA with Games-Howell post-hoc comparisons between the clusters (z-scores)

Cluster name	Sweet drinks consumers	Breakfast skippers	Healthy diet low MVPA	Unhealthy cluster	High MVPA	F (ANOVA)	Post-hoc differences between groups
Cluster (N)	88	45	156	40	38		
MVPA	–0.2	–0.31	–0.34	0.21	2.15	107.71*	d, g, i, j
X ± SD (min/day)	56.87 ±37.17	51.25 ±34.19	49.72 ±30.49	79.32 ±46.52	183.16 ±49.61		
Screen time	–0.05	–0.45	–0.36	2.1	–0.45	128.59*	c, f, h, j
X ± SD (min/day)	151.66 ±72.51	104.6 ±70.96	115.65 ±69.93	399.75 ±87.98	105.39 ±84.33		
Breakfast consumption	0.34	–1.99	0.47	–0.31	0.22	179.87*	a, e, f, g, h
X ± SD (days/week)	6.47 ±0.98	2.02 ±1.14	6.72 ±0.62	5.23 ±1.91	6.24 ± 1.42		
Sweet drinks consumption	1.05	–0.29	–0.65	0.32	–0.41	86.69*	a, b, d, h
X ± SD (1–7 – ordered)	4.52 ±0.99	2.73 ±1.07	2.26 ±0.69	3.55 ±1.34	2.58 ± 1.11		

MVPA = Moderate to Vigorous Physical Activity.

* P < 0.001.

a – significant difference between 1st and 2nd cluster; b – significant difference between 1st and 3rd cluster; c – significant difference between 1st and 4th cluster; d – significant difference between 1st and 5th cluster; e – significant difference between 2nd and 3rd cluster; f – significant difference between 2nd and 4th cluster; g – significant difference between 2nd and 5th cluster; h – significant difference between 3rd and 4th cluster; i – significant difference between 3rd and 5th cluster; j – significant difference between 4th and 5th cluster.

Psychosocial Characteristics of Clusters

In Table 4, the associations between the five clusters and the socio-demographic variables (gender, age category, place of living category, mother's education level and father's education level) are presented. For gender, significant differences could be found in the clusters' structures ($\chi^2 = 14.17$, $p = 0.007$). Post-hoc tests showed a higher presence of females in the Breakfast Skippers cluster in comparison to the Unhealthy Cluster and High MVPA cluster. For that reason analysis was carried out for each gender separately. Among males clusters' structures differed according to father's education level ($\chi^2 = 9.94$, $p < 0.05$). For females no significant relationships were

observed ($p < 0.05$). However, we acknowledged an association between same sex parent education levels with the participant's presence in particular cluster. Higher proportions of lower educated parents tended to be observed among the Sweet Drink Consumers and Breakfast Skippers when compared to High MVPA and Unhealthy Cluster, although differences between particular clusters were not significant at $p < 0.05$.

Table 4. Comparison of adolescents in the clusters based on socio-demographical variables

Cluster			Sweet Drinks Consumers	Breakfast Skippers	Healthy Diet Low MVPA	Unhealthy Cluster	High MVPA	Overall	χ^2	p
			%							
Gender	female	180	41	67	55	38	37	49	14.17	0.007
	male	187	59	33	46	63	63	51		
Female										
Age group	12–14	71	39	40	45	33	14	39	4.94	0.294
	15–18	109	61	60	55	67	86	61		
Place of living	village	79	39	43	39	33	36	39	7	0.537
	small city	36	25	10	25	13	7	20		
	average, large city	74	36	47	37	53	57	41		
Education level mother	lower	94	53	70	49	53	29	52	7.22	0.125
	higher	86	47	30	51	47	71	48		
Education level father	lower	116	78	70	59	67	50	64	5.68	0.225
	higher	64	22	30	41	33	50	36		
Male										
Age group	12–14	68	46	40	37	24	25	36	5.23	0.264
	15–18	119	54	60	63	76	75	64		
Place of living	village	64	37	60	34	20	29	34	14.06	0.08
	small city	37	29	13	17	24	8	20		
	average, large city	86	35	27	49	56	63	46		
Education level mother	lower	104	56	60	56	52	54	56	0.29	0.991
	higher	83	44	40	44	48	46	44		
Education level father	lower	112	67	80	62	40	46	60	9.94	0.042
	higher	75	33	20	38	60	54	40		

Discussion

The main aim of the study was to examine clustering of EBRBs among Polish adolescents involved in a large-scale public intervention aimed at increasing physical activity. Based on the comparable indicators, the studied group showed favourable EBRBs over the populational sample in the similar age group (higher frequency of breakfast consumption, lower consumption of sweet beverages) (Mazur, 2015). The cluster solution indicated that merely healthy or unhealthy behaviours seldom coexist together within individuals, yet some established mixed patterns of EBRBs were found.

A mix of healthy and unhealthy behaviours was noted in four clusters, and in one cluster (High MVPA) only healthy behaviours were present. This structure of the groups is coherent with a more general trend, where the

largest clusters represent a mix of healthy and unhealthy behavioural patterns, while a minor number of clusters, constituting small part of a sample, accumulates either healthy or unhealthy behaviours (Jodkowska et al., 2014; Leech et al., 2014).

Cluster solution

The most noticeable clusters in our study were Healthy Diet Low MVPA, Unhealthy Cluster and High MVPA. Healthy Diet Low MVPA was the largest cluster (43%), without a single extreme value regarding one factor, but defined by relatively healthy dietary patterns with low MVPA and screen time. The size of this cluster seems prominent given the group under study – adolescents taking part in the organized PA at least 5 times a week (3 from intervention, 2 from obligatory PE class at school). Clusters with a similar structure were substantial in studies conducted in the other countries (Iannotti, Wang, 2013; Ottevaere et al., 2011; Seghers, Rutten, 2010).

High MVPA cluster accumulated all healthy behaviours. The Unhealthy Cluster included negative scores for three out of the four health indices. However, the Unhealthy Cluster, with remarkably high levels of screen time, was not characterised by a low level of MVPA, which reflects the previous conclusion that sedentary time does not have to displace PA (Pearson, Braithwaite, Biddle, van Sluijs, Atkin, 2014). The lack of consistency regarding relationships between MVPA and sedentary time is continuously found in cluster analysis (Leech et al., 2014). While some have suggested that those who engage in less PA are more likely to watch a lot of TV, in most studies just a weak relationship, if any, is found between MVPA and screen-based sedentary activities. Clusters are instead primarily determined by just one of these variables (Pearson et al., 2014; Pérez-Rodrigo et al., 2015). Furthermore, as mentioned by Ottevaere et al. (2011) people might consciously or unconsciously compensate for unhealthy behaviours (screen time, dietary patterns) with leptogenic behaviours, which may explain relatively high levels of MVPA in the Unhealthy Cluster.

Some similarities with previously obtained cluster solutions were found in our study. The High MVPA cluster concurred with the popular “all-round-healthy” pattern mentioned by Gubbels et al. (2013), where high levels of physical activity is combined with a healthier diet and low levels of sedentary behaviour (Cuenca-García et al., 2013; Gubbels et al., 2013; Iannotti, Wang, 2013; Pérez-Rodrigo et al., 2015). Another universal pattern was found in the study: in the Unhealthy Cluster we identified a “sedentary-snacking” sub-cluster mixing screen time with unhealthy nutrition, which has previous been acknowledged in multiple studies (Gubbels et al., 2013; Iannotti, Wang, 2013). Its structure was also similar to the Unhealthy Diet & Active cluster from the study of Cuenca-García et al. (2013) and “High Activity/High Sedentary” cluster found by Jago et al. (2010).

Socio-demographical variables

In order to identify high-risk groups that could be targeted by preventive interventions, it is important to be able to predict which adolescents are likely to show particular behavioural patterns. Children and adolescents’ gender has been consistently associated with their pattern scores. In this study, we found differences in meeting cut-off values for particular EBRBs based on gender, as well as the association between gender and cluster patterns. Interestingly, we did not find a relationship between gender and meeting established levels for MVPA, which was the case in the study conducted by Jodkowska et al. (2014) and is one of the most steady trends in Polish studies (Mazur, 2015). Other associations between EBRBs and gender were coherent with observations from several studies. The trend of a lower percentage of breakfast skippers among males was consistent with a previous study in

Poland (Jodkowska et al., 2014). On the other hand, girls were less likely to drink sweet beverages, what was noted by Dzielska (2012). Boys also reported more time spent on screen time behaviours, which is a general pattern, as concluded by Bucksch et al. (2016).

One of the more conclusive findings from the review conducted by Leech et al. (2014) was that clusters with lower PA were comprised of older participants, especially females. In our study, the Unhealthy Cluster consisted mainly of older adolescent males, and the High MVPA cluster had very similar gender and age proportions. As we found four clusters to be grounded foremost on the extreme values of a particular EBRB, their structures reflect a factor's association with gender. For example, Breakfast Skippers consisted primarily of females (67%) as this unhealthy pattern was more frequently observed among females in the sample.

Higher proportions of lower educated parents were observed in the clusters with particularly strong single unhealthy dietary habits. This was also the case in other studies, where low quality of diet and levels of PA were associated with lower education of the parents (Fernández-Alvira et al., 2013; Leech et al., 2014). However, this does not imply that there is a reverse linkage between higher education of parents and healthy clusters, since a high education level of parents was noted in both the High MVPA and Unhealthy Cluster, which was not the case in most other studies. Such a contradictory relationship may be explained by the general trend in sedentary time, which reported a positive association of sedentary behaviour with lower socioeconomic status background, as well as living in a household with more access to televisions/computers (Pate, Mitchell, Byun, Dowda, 2011).

Pragmatic summary

From a project management standpoint, cluster analysis provided valuable information about the participants. First, it is crucial to understand the prevalence of unhealthy EBRB in the studied group and the weak, if any, relationship between the levels of MVPA and other EBRB. Second, we found different socio-demographical structures of the clusters, suggesting other risks factors regarding particular EBRBs based on participants' gender and their unclear association with parental education. For girls we noticed a high prevalence of breakfast skipping, while boys recorded a higher amount of screen time and sweet drink consumption. A more general observation is that fraction of girls exceeded boys in the clusters characterised by little energy consumption and little energy expenditure ("not consuming – not moving" pattern). On the other hand, there were much more boys in the clusters with high MVPA and high sweet drink consumption, hence boys fit the "consuming – moving" pattern more often.

Furthermore, it seems essential to acknowledge the structure of cluster in which negative behaviours, except for the levels of MVPA, accumulated. In the group of participants who were in general physically active, we found the same universal "sedentary-snacking" pattern, which has been noted in a few studies in European contexts (Gubbels et al., 2013). This sedentary cluster is formed foremost of males. It is also worth noting that although girls are targeted as a risk group in terms of lowest levels of PA, general health outcomes (obesity prevalence) is significantly higher among boys (according to Mazur (2015)): 18% of 15-years old boys and only 6% girls deal with overweightness and obesity in Poland). If the intervention strategy progresses towards greater interest in healthy lifestyle rather than just increasing MVPA, this group should become a natural target of interest, given that sedentarism is considered a strong predictor of health-risks (Rezende et al., 2014). To sum up, describing adolescents participating in the intervention just as "sporty kids" would be a dangerous oversimplification, given the existence of behavioural patterns similar to those obtained in populational studies.

Conclusions

1. Co-occurrence of EBRBs in the studied group is complicated as EBRBs do not necessary cluster together in a negative or positive ways.

2. Based on four EBRBs, a five cluster solution was found the most compelling. Cluster structures were primarily determined by high results of one variable.

3. The size of the clusters which accumulated most of the negative or positive behaviours, was small.

4. Some patterns of EBRB in adolescents involved in the PA intervention were similar to the results obtained in previous studies conducted on the general population, for example "sedentary-snacking" or "all-round-healthy" clusters.

5. Cluster structures differed based on adolescents' gender and fathers' education level for male participants.

References

Brug, J., Van Stralen, M., te Velde, S., Chinapaw, M., De Bourdeaudhuij, I., Lien, N., Bere, E., Maskini, V., Singh, A., Maes, L., Moreno, L., Jan, N., Kovacs, E., Lobstein, T., Manios, Y. (2012). Differences in Weight Status and Energy-Balance Related Behaviors among Schoolchildren across Europe: The ENERGY-Project. *PLoS ONE*, *7* (4), e34742.

Bucksch, J., Sigmundova, D., Hamrik, Z., Troped, P., Melkevik, O., Ahluwalia, N., Borraccino, A., Tynjälä, J., Kalman, M., Inchley, J. (2016). International Trends in Adolescent Screen-Time Behaviors from 2002 to 2010. *Journal of Adolescent Health*.

Busch, V., Van Stel, HF., Schrijvers, A.J., de Leeuw, J.R. (2013). Clustering of health-related behaviors, health outcomes and demographics in Dutch adolescents: a cross-sectional study. *BMC Public Health*, *13* (1), 1–19.

Charrad, M., Ghazzali, N., Boiteau, V., Niknafs, A., Charrad, M. (2014). Package 'NbClust'. *J. Stat. Soft*, *61*, 1–36.

Chinapaw, M.J., Proper, K.I., Brug, J., Van Mechelen, W., Singh, A.S. (2011). Relationship between young peoples' sedentary behaviour and biomedical health indicators: a systematic review of prospective studies. *Obesity Reviews*, *12* (7), 621–632.

Cuenca-García, M., Huybrechts, I., Ruiz, J.R., Ortega, F.B., Ottevaere, C., González-Gross, M., Moreno, L.A., Vicente-Rodríguez, G., Molnár, D., Polito, A., Manios, Y., Plada M., Vanhelst, J., Widhalm, K., Sjöström, M., Kersting, M., Castillo, M.J., HELENA study group. (2013). Clustering of Multiple Lifestyle Behaviors and Health-Related Fitness in European Adolescents. *Journal of Nutrition Education and Behavior*, *45* (6), 549–557.

Currie, C., (2012). *Social determinants of health and well-being among young people. Health Behaviour in School-aged Children (HBSC) study: international report from the 2009/2010 survey.* Copenhagen: World Health Organization Regional Office for Europe.

De Bourdeaudhuij. I., Verloigne, M., Maes, L., Van Lippevelde, W., Chinapaw, M., Te Velde, S.J., …, Brug., J. (2013). Associations of physical activity and sedentary time with weight and weight status among 10-to 12-year-old boys and girls in Europe: a cluster analysis within the ENERGY project. *Pediatric Obesity*, *8* (5), 367–375.

Douthwaite, W., Summerbell, C., Moore, H. (2012). *Identifying the most important energy balance behaviours among 10–12 year olds, and their parents, that are associated with excessive weight gain and overweight*. Retrieved from http://www.worldobesity.org/site_media/uploads/wp2_-_phase_1_report.pdf.

Dzielska, A. (2012). Zachowania żywieniowe. In: B. Woynarowska, J. Mazur (eds.), *Tendencje zmian zachowań zdrowotnych i wybranych wskaźników zdrowia młodzieży szkolnej w latach 1990–2010* (pp. 53–59). Warszawa: Instytut Matki i Dziecka.

Everitt, B.S., Landau, S., Leese, M., Stahl, D. (2011). *Cluster Analysis* (5th ed.). West Sussex: John Wiley & Sons, Ltd.

Fernández-Alvira, J.M., De Bourdeaudhuij, I., Singh, A.S., Vik, F.N., Manios, Y., Kovacs, E., Moreno, L.A. (2013). Clustering of energy balance-related behaviors and parental education in European children: the ENERGY-project. *Int J Behav Nutr Phys Act*, *10*, 5.

Gubbels, J., Van Assema, P., Kremers, S. (2013). Physical activity, sedentary behavior and dietary patterns among children. *Current Nutrition Reports*, *2* (2), 105–112.

Hair, J.F., Black, W.C. (2000). Cluster analysis. In Grimm L.G., Yarnold, P. R. *Reading and understanding more multivariate statistics*. Washington: American Psychological Association.

Hill, J.O., Wyatt, H.R., Peters, J.C. (2012). Energy balance and obesity. *Circulation*, *126* (1), 126–132.

Iannotti, R., Wang, J. (2013). Trends in physical activity, sedentary behavior, diet, and BMI among US adolescents, 2001–2009. *Pediatrics*, *132* (4), 606–614.

IPAQ Research Committee. (2005). Guidelines for data processing and analysis of the International Physical Activity Questionnaire (IPAQ) – short and long forms. *Retrieved September*, *17*, 2008.

Jago R., Fox, K., Page, A., Brockman, R., Thompson, J. (2010). Physical activity and sedentary behaviour typologies of 10–11 year olds. *Int J Behav Nutr Phys Act*, *7*, 59.

Jodkowska, M., Oblacińska, A., Tabak, I. (2014). How well do Polish teenagers meet health behaviour guidelines? *Przegląd Epidemiologiczny*, *68* (1), 65–70.

Leech, R., McNaughton, S., Timperio, A. (2014). The clustering of diet, physical activity and sedentary behavior in children and adolescents: a review. *Int J Behav Nutr Phys Act*, *11*, 4.

Massougbodji, J., Bodo, Y., Fratu, R., Wals, P. (2014). Reviews examining sugar-sweetened beverages and body weight: correlates of their quality and conclusions. *The American Journal of Clinical Nutrition*, *99* (5), 1096–1104.

Mazur, J. (2015). *Zdrowie i zachowania zdrowotne młodzieży w Polsce na tle wybranych uwarunkowań socjodemograficznych. Wyniki badań HBSC 2014.* Warszawa: Instytut Matki i Dziecka.

Mazur, J., Kowalewska A., Baska, T., Sigmund, E., Nałęcz, H., Nemeth, A., Zawadzka, D. (2014). Patterns of Physical Activity and Multiple Risk Behaviour in Adolescents from Visegrad Countries. *Zeszyty Naukowe Ochrony Zdrowia. Zdrowie Publiczne i Zarzadzanie*, *12* (1), 56–67.

Mazur, J., Małkowska-Szkutnik, A. (2011). *Wyniki badań HBSC 2010: raport techniczny.* Warszawa: Instytut Matki i Dziecka.

Mitchell, J.A., Rodriguez, D., Schmitz, K.H., Audrain-McGovern, J. (2013). Greater screen time is associated with adolescent obesity: A longitudinal study of the BMI distribution from Ages 14 to 18. *Obesity*, *21* (3), 572–575.

Ottevaere, C., Huybrechts, I., Benser, J., De Bourdeaudhuij, I., Cuenca-Garcia, M., Dallongeville, J., …, HELENA Study Group. (2011). Clustering patterns of physical activity, sedentary and dietary behavior among European adolescents: The HELENA study. *BMC Public Health*, *11*, 328.

Pate, R.R., Mitchell, J.A., Byun, W., Dowda, M. (2011). Sedentary behaviour in youth. *British Journal of Sports Medicine*, *45* (11), 906–913.

Pearson, N., Braithwaite, R.E., Biddle, S.J.H., van Sluijs, E.M.F., Atkin, A.J. (2014). Associations between sedentary behaviour and physical activity in children and adolescents: a meta-analysis: Active and sedentary behaviours in youth. *Obesity Reviews*, *15* (8), 666–675.

Pérez-Rodrigo, C., Gil, Á., González-Gross, M., Ortega, R. M., Serra-Majem, L., Varela-Moreiras, G., Aranceta-Bartrina, J. (2015). Clustering of Dietary Patterns, Lifestyles, and Overweight among Spanish Children and Adolescents in the ANIBES Study. *Nutrients*, *8* (1).

Rey-Lopez, J.P., Vicente-Rodríguez, G., Biosca, M., Moreno, L.A. (2008). Sedentary behaviour and obesity development in children and adolescents. *Nutrition, Metabolism and Cardiovascular Diseases*, *18* (3), 242–251.

Rezende, L.F.M. de, Rodrigues Lopes, M., Rey-López, J.P., Matsudo, V.K.R., Luiz, O. do C. (2014). Sedentary Behavior and Health Outcomes: An Overview of Systematic Reviews. *PLoS ONE*, *9* (8), e105620.

Seghers, J., Rutten, C. (2010). Clustering of multiple lifestyle behaviours and its relationship with weight status and cardiorespiratory fitness in a sample of Flemish 11-to 12-year-olds. *Public Health Nutrition*, *13* (11), 1838–1846.

Stierlin, A.S., Lepeleere, S.D., Cardon, G., Dargent-Molina, P., Hoffmann, B., Murphy, M.H., …, DEDIPAC Consortium. (2015). A systematic review of determinants of sedentary behaviour in youth: a DEDIPAC-study. *Int J Behav Nutr Phys Act*, *12* (1), 1–19.

Szajewska, H., Ruszczynski, M. (2010). Systematic review demonstrating that breakfast consumption influences body weight outcomes in children and adolescents in Europe. *Critical Reviews in Food Science and Nutrition*, *50* (2), 113–119.

Tremblay, M.S., LeBlanc, A.G., Kho, M.E., Saunders, T.J., Larouche, R., Colley, R.C., Goldfield, G., Gorber, S.C. (2011). Systematic review of sedentary behaviour and health indicators in school-aged children and youth. *Int J Behav Nutr Phys Act*, *8*, 98.

Viera, A.J., Garrett, J.M. (2005). Understanding interobserver agreement: the kappa statistic. *Fam Med*, *37* (5), 360–363.

Zalewska, M., Genowska, A., Jamiołkowski, J., Nowak, R., Szpak, A., Maciorkowska, E. (2015). The Use of Cluster Analysis for Non-Continuous Variables in the Assessment of Dietary Behaviours and Physical Activities in Primary School Children. *Studies in Logic, Grammar and Rhetoric*, *43* (1), 121–136.

Cite this article as: Zembura, P., Gołdys, A. (2016). Co-Existence of Physical Activity (PA) and other Energy-Balance Related Behaviours among Adolescents Participating in PA Intervention in Poland. *Central European Journal of Sport Sciences and Medicine*, *16* (4), 43–54. DOI: 10.18276/cej.2016.4-05.

COLLEGIATE COACHES' KNOWLEDGE OF THE FEMALE ATHLETE TRIAD IN RELATION TO THEIR CHARACTERISTICS

Jillian E. Frideres,[1, A, B, C, D] Sue G. Mottinger,[2, A, D] José M. Palao[3, A, C, D]

[1] Nutrition education program, University of Wisconsin-Extension, Racine, Wisconsin, United States
[2] Department of Health and Kinesiology, The University of Texas Pan American, Edinburg, Texas, United States (retired)
[3] Department of Health, Exercise Science and Sport Management. University of Wisconsin-Parkside, Kenosha, Wisconsin, United States
[A] Study Design; [B] Data Collection; [C] Statistical Analysis; [D] Manuscript Preparation

Address for correspondence:
Jillian E. Frideres
1220 Mound Ave.
Racine, WI 53404 United States
E-mail: jefrideres@gmail.com

Abstract The purpose of this study was to determine what coaches of female athletes know about the female athlete triad. The sample involved 472 NCAA Division I coaches of female athletes. The variables studied were coaches' knowledge and confidence about the triad and coaches' characteristics (coach's gender, age, type of coach, degree held, years of experience in coaching females, continuing education participation specific to the triad and/or triad components, and sport coached). Coaches' knowledge of the female athlete triad is higher for coaches who have received triad education. No differences regarding knowledge of the female athlete triad were found by gender, degree, experience in coaching female athletes, or coach type. Higher knowledge was found in sports emphasizing low body weight compared to sports that do not emphasize weight. The article discusses the results' implications and the need for future interventions in this population.

Key words sport, women, formation, prevention

Introduction

Coaches play an important role in an athlete's development. They establish the planning and training, create the work environment, and are sources of information as far as training is concerned as well as role models (Field, 1991). It is believed that the coach or staff member that has the best relationship with the athlete may be the best-suited for communicating with the athlete about any struggles (Eagle, Lohman, Jarman, 2013; Joy et al., 1997b; Nattiv et al., 2007).

Coaches' objectives are to increase their athletes' performances, as well as to shape their athletes as people. Therefore, coaches try to get their athletes to improve the different abilities that affect performance. Additionally, coaches try to prevent injuries among their athletes (by monitoring technique, training load, etc.). Their role in

regards to injuries is to prevent the situations that are potentially risky, although in performance sport they try to take their athletes to their limits.

For female athletes, a newer health problem has been detected in the last couple decades: the female athlete triad. It is the simultaneous diagnosis of three conditions: disordered eating, amenorrhea, and osteoporosis (Eagle et al., 2013; Hobart, 2000; Nattiv et al., 2007; Otis et al., 1997; Smith, 1996). The general belief in sport, that there is an ideal weight for competing, may increase the pressure on females to be thin (Beals, Brey, Gonyou, 1999). Furthermore, many sports require their female athletes to closely monitor their weight. This may lead to a conscious or unconscious effort on behalf of the athlete to decrease caloric intake and increase energy expenditure and may trigger the process of disordered eating (Nattiv et al., 2007; Sundgot-Borgen, 1994). As a result of a caloric deficit, for some female athletes, menstrual dysfunction occurs, usually in the form of oligomenorrhea (four to nine menstrual cycles per year) or amenorrhea (absence of three or more consecutive cycles after menarche) (Thein-Nissenbaum, 2013; Otis, Drinkwater, Johnson, Loucks, Wilmore, 1997; Rust, 2002). The absence of normal menses is a serious problem that relates to a reduction in estrogen levels, and, if not attributed to another medical problem, can be a serious consequence of strenuous athletic endeavours. Finally, this decreased estrogen level leads to lower bone mineral density, osteopenia or osteoporosis.

The female athlete triad can involve serious long-term consequences and difficult treatment. Therefore, the importance of early intervention is recognized (Thompson, Gabriel, 2004). However, beyond intervention, prevention is widely regarded as the key to combating the triad (Arendes, Cheung, Barrack, Nattiv, 2012; Beals et al., 1999; Joy, et al., 1997a; Nattiv et al., 2007; Temme , Hoch, 2013; Rust, 2002). Here is where coaches can play an important role. Coaches are a possible key piece in preventive measures, screening, etc. (Eagle et al., 2013; Nattiv et al., 2007; Joy et al., 1997a). The female athlete triad is a relatively new problem; however, many coaches may not be well informed about the triad, though its components are not new. Along these lines, some national governing bodies have considered mandatory education (governing bodies not cited (Joy et al., 1997b)).

The knowledge that coaches have about nutrition and some of the individual components of the triad has been studied, and these studies show that it is not clear whether all coaches are prepared to provide information to their athletes about these topics (Froiland, Koszewski, Hingst, Kopecky, 2004; Jacobson, Sobonya, Ransone, 2001; Juzwiak Ancona-Lopez, 2004; Joy et al., 1997a; Sossin et al., 1997; Pantano, 2006; Troy, Hoch, Stavrakos, 2006). However, few studies have focused on the full triad. Further, most research has focused on specific sports, as this could influence the risk athletes have of suffering the female athlete triad. The effect of a coach's sociodemographic characteristics on this topic is not clear. Pantano (2006) did not find correlations between triad knowledge and gender, coach's education, and/or coaching experience in college coaches.

Sherman et al. (2005), in a study of 2,894 NCAA Division I, II, and III coaches, found that female coaches were more aware of different aspects related to menstruation and talked more with athletes about it than male coaches. Similar results were found by Kroshus et al. (2014) in high school coaches. Women have more positive attitudes and communication behaviours related to eating and menstrual irregularities. No studies have been found about the effect of the years of experience in coaching female athletes, a coach's education (degree), or whether they have received specific training about the triad or the effect of this specific training. The effect of this aspect on the topic is not clear, although, theoretically, with more experience, more education, and specific training, the knowledge of the coaches should be higher.

In order to contribute to the prevention of the female athlete triad, coaches not only need to know about the three disorders of the triad, how to detect them, and their prevention, but it is also necessary for coaches to have confidence in their knowledge. Without this confidence, the jump from knowledge to application of knowledge is more difficult (Wozney, Venkatesh, Abrami, 2006) or even dangerous, when, without proper knowledge, they can create risky situations. Therefore, the purpose of this study was to determine what coaches of female athletes know about the three components of the female athlete triad and what confidence they have in their knowledge with regard to their socio-demographic characteristics.

Method

The sample consisted of 472 NCAA Division I coaches of female athletes in the sports of basketball, bowling, cross-country, diving, fencing, field hockey, golf, gymnastics, ice hockey, lacrosse, rifle, rowing, skiing, soccer, softball, swimming, tennis, track and field, volleyball, and water polo. They had an average age of 36.8 (±10.1) years. Sixty-four percent of participants were female, eighty-nine percent were Caucasian, and fifty-one percent had a master's degree or higher. Forty-eight percent were head coaches, fifty percent were assistant coaches, and two percent were graduate assistants. Participants had 14.5 (±9.3) years of coaching experience and 13.3 (±8.5) years of experience of coaching specifically female athletes. All coaches completed the electronic questionnaire after reading an informed consent form that clearly stated that participation in the study was voluntary and data were confidential. The study was approved by the University of Texas-Pan American Institutional Review Board.

An original, self-report questionnaire including multiple-choice questions, categorical questions, and a 4-point Likert scale to measure confidence in answer was used. Questions were designed to ask about the study's variables and the sample's characteristics. The variables were: a) knowledge of the triad, its components, prevention and intervention; b) confidence of the coach in his or her answers; and c) characteristics of the coach (coach's gender, degree held, years of experience in coaching females, continuing education participation specific to the triad and/or triad components, and sport coached), d) whether coaches provide information and/or educational programming about the female athlete triad; and e) type of continuing education in which they have taken part at least once a year. Finally, questions about the sample's characteristics (ethnicity, number of coaches in their program, etc.) were asked.

From the questions about triad knowledge and confidence of the coaches, an overall knowledge score was calculated which was between 35.00 and -35.00. The weight of the different parts of the knowledge was: a) identification of triad components, ±1 out of 35; b) knowledge of triad, ±25 out of 35; and c) knowledge of prevention and intervention, ±9 out of 35. A correct answer with high confidence obtained a higher score while an incorrect answer with high confidence obtained a lower score.

The process of creating the instrument to measure knowledge of the female athlete triad included three phases. First was the design and development of the instrument, second was the validation of the content, and third was the reliability of the instrument. During instrument design, an expert in online surveys was consulted. The final questionnaire had three parts: a) demographic and experiential questions, b) questions about knowledge of the triad, and c) questions about athletic and team programs.

The design and development of the instrument involved the use of specific literature about the female athlete triad (from World Of Knowledge, SPORTDiscus, Medline, Google Scholar, Sponet, Scielo, and Dialnet databases), questionnaires in the literature that were used as guides (Bradney, 2002; Lassiter, 2002; Martínez-Pecino,

Mulas-Sánchez, Fernández-Palacín, Bayón-Suárez, 1997; Turk, 1995), and literature about creating an original instrument (Hague, Hague, Morgan, 2004; Thomas, 2004).

For the questions related to knowledge of the triad, an evaluation of the level of confidence of the coach was also included with the answer to measure the coach's specific confidence in the knowledge (Turk, 1995), as a low level of self-confidence has been related to lack of application of the knowledge (Bandura, Wood, 1989). Knowledge and confidence level were taken into account to calculate their overall knowledge score. A correct answer with the highest confidence resulted in the highest weighted score for that question, while an incorrect answer with the highest confidence resulted in the lowest weighted score.

Content was validated by sending the instrument to eight experts in fields related to at least one of the components of the triad for their input and approval. The collective suggestions from the experts were considered, and the appropriate changes were made. Experts in the following fields participated: medicine/family practice, nutrition, physical therapy, eating disorder recovery, triad research in athletes, coaching female athletes, and sport psychology.

The validation of the reliability was done by a pilot study. The questionnaire was sent to select college coaches of an NCAA Division II program from a University that did not participate in the study. The test-retest was completed by 12 coaches. A final section allowing for comments took into consideration their understanding of the questionnaire, the time taken to complete the survey, and questions or concerns they had with the instrument. The pilot study also allowed for technical problems to be worked through. The subjects in the pilot study were not included in data collection for the proposed study. Reliability of each item was calculated using the Kappa Index for each of the questions (categorical variables). Then, the total reliability of the questionnaire was determined by using the smallest of these calculations, and an intra-class correlation coefficient of 0.68 was found.

After the design and the validation of the instrument, the following steps were done: a) the information and e-mails of coaches were obtained, b) the survey was sent to the coaches, c) data were collected, and d) data were analysed.

Subjects for the proposed study were located through the NCAA and university websites. The NCAA website listed institutions with Division I teams in each sport. From there, searches were done at the website of the individual institutions to locate email addresses of subjects. With the sports having a relatively small number of athletes and/or programs (fewer than 100 programs), an attempt was made to attain the email addresses of as many of these subjects as possible. Therefore, all institutions with these sports were reviewed for each of these sports. While searching for information on these sports, email addresses for coaches from the rest of the sports that were studied were obtained from these institutions. For the sports with fewer than 200 programs, seventy percent of all institutions with swimming and diving programs were randomly chosen and reviewed. Again, email addresses for coaches from the rest of the sports that were studied were obtained from these institutions. Finally, 50% of remaining institutions (those with more than 300 programs) were randomly chosen and reviewed.

Some institutions did not have athletic information online. Other institutions did not have individual coach contact information available or simply did not provide email addresses. At each institution, all available email addresses of head, assistant, and student coaches in the given sports were collected, though the number that was available varied widely by institution and by sport. Though emails were sent to all coaches whose email addresses were obtained, some emails were rejected by the target server and, therefore, were returned unread. Finally, after questionnaires were completed, data were debugged to remove all incomplete questionnaires. From this process,

the final sample was determined. The questionnaire was distributed by email to 3,620 coaches, a reminder e-mail was sent after one week, and a thank you and final reminder e-mail was sent after two weeks (deadline). The final sample consisted of 472 subjects for a return rate of 13%. Data were gathered from NCAA Division I coaches during the 2005-2006 academic year.

The relatively low response rate may be the result of various factors. Original letters and reminder letters were sent during the last two weeks of August. Some coaches were not yet in the office, while others were busy with pre-season work. Also, new coaches may not have officially started yet. Finally, it is also possible that some emails went directly into a SPAM mailbox and were never read by the subjects.

A descriptive analysis (means, standard deviations, percentages, and frequencies) and an inferential analysis were done. To test normality, the One-Sample Kolmogorov-Smirnov Test was used. To determine whether there were significant differences among subjects' knowledge of the triad, independent samples t-test and ANOVA were utilized with the test of homogeneity of variances using the Levene statistic. A Scheffe post-hoc test was used if a significant difference was determined from the ANOVA. Significance was set at $p<.05$, and two-tailed testing was used. Data analyses were conducted using the SPSS v.15 (Statistical Package for the Social Sciences; Chicago, IL) software package.

Results

No significant differences were found in overall score, in any of the sub scores or the confidence in relation to gender of coach, coaches' age, degree held, number of years that they had coached female athletes, or type of coach. Significant differences were found when coaches had received training on the disordered eating component of the triad (Table 1) in their overall score ($p < 0.001$), in the sub scores ($p < 0.001$), and in their confidence ($p < 0.001$).

Significant differences were found between the score of coaches from rowing and cross country with the score of coaches from basketball, softball, and soccer (Table 2). Significant differences were found between the confidence of coaches from track and field and those of soccer.

With relation to the information coaches give the athletes, results showed that a significantly higher number of male coaches (16% more), coaches who were older (12% more), coaches who held a higher degree (8% more), coaches with more experience coaching females (11% more), and head coaches (11% more) were more likely to provide information than their counterparts. The same tendency, although not significant, was found in relation to providing educational programming about the triad (5–10% more). In all cases, the proportion of coaches that provided information or educational programming about the female athlete triad was less than four out of ten. No significant differences were found in participation in general continuing education for any of the studied variables. Nine out of ten coaches participated in general continuing education. Significantly higher participation in continuing education about the female athlete triad was found by male coaches (11% more), coaches who were older (13% more), coaches holding a higher degree (8% more), coaches with more experience coaching females (13% more), and head coaches (15% more). In all cases, forty percent or less participated in continuing education about the female triad athlete.

The sources of information that were most used by NCAA coaches to complete their general continuing education were athletic department programs, sport/coaching-related magazines, and textbooks (Table 4). The results show that male coaches (>20%), coaches with more experience coaching females (18% more), coaches

holding a higher degree (19% more), coaches who were older (16% more), and head coaches (15% more) read significantly more professional journals. Female coaches attended significantly more professional conferences (10% more). Male coaches and older coaches consulted significantly more professionals. Head coaches attended significantly more professional conferences (10%) and obtained significantly more information from consulting textbooks (10% more) and other professionals (11% more).

In relation to continuing education about the female athlete triad (Table 4), the sources of information that were most used by NCAA coaches were sport/coaching-related magazines, textbooks, online information, and consulting professionals. The results show that the following sources of information were used significantly more by male coaches: athletic department programs, NCAA-sponsored programs, sport/coaching-related magazines, professional conferences, and consulting professionals. Coaches with more years of experience in coaching females are significantly more likely to read sport/coaching-related magazines. Coaches with higher degrees used the following sources of information significantly more: professional journals, sport/coaching-related magazines, professional conferences, textbooks related to coaching, and consulting professionals. Older coaches were significantly more likely to read professional journals, attend professional conferences, and consult professionals. Head coaches were significantly more likely to read sport/coaching-related magazines and to consult professionals.

Table 1. Triad knowledge and confidence in that knowledge in relationship to coaches' characteristics (data expressed as percentages)

	Score						Confidence	
	identify triad (%)	knowledge triad (%)	prevention intervention (%)	overall score[1]	Score (%)	p	%	p
Gender								
Female	58.46 ±36.58	73.75 ±8.35	67.99 ±9.42	15.29 ±5.32	71.84 ±7.60	0.164	71.84 ±7.60	0.523
Male	59.68 ±37.29	72.09 ±7.47	68.61 ±9.03	14.59 ±4.74	70.84 ±6.77		70.85 ±6.77	
Age								
22–34 years	58.61 ±36.25	73.48 ±8.38	73.73 ±8.38	15.22 ±5.38	71.74 ±7.69	0.106	71.09 ±7.69	0.986
>34 years	59.24 ±37.34	72.52 ±7.87	72.52 ±7.87	14.79 ±4.92	71.13 ±7.03		71.11 ±7.03	
Degree held								
Bachelors	55.81 ±35.98	72.82 ±7.62	72.82 ±7.62	14.66 ±4.83	70.94 ±6.90	0.126	70.01 ±6.89	0.163
Graduate	62.66 ±37.14	73.40 ±8.61	73.40 ±8.61	15.36 ±5.45	71.94 ±7.79		72.08 ±7.79	
Years coaching								
0–15 years	55.99 ±36.45	73.21 ±8.29	73.21 ±8.29	14.94 ±5.27	71.34 ±7.53	0.716	70.52 ±7.53	0.250
>15 years	65.58 ±36.67	72.97 ±7.94	72.97 ±7.94	15.16 ±4.96	71.66 ±7.09		72.22 ±7.08	
Type of coach								
Head coach	61.68 ±37.09	73.63 ±7.83	73.63 ±7.83	15.32 ±5.00	71.89 ±7.14	0.182	72.03 ±7.14	0.191
Others	56.17 ±36.34	72.63 ±8.43	72.63 ±8.43	14.68 ±5.30	70.97 ±7.57		70.1 ±7.57	
Triad training[2]								
Yes	60.88 ±37.95	74.65 ±8.16	74.65 ±8.16	17.81 ±5.06*	75.44 ±7.23	<0.001	78.76 ±7.24*	<0.001
No	56.62 ±35.25	71.34 ±7.77	71.34 ±7.77	13.94 ±4.99*	69.91 ±7.13		68.27 ±7.12*	

Scores for identifying the triad, knowledge of the triad, and prevention and intervention are expressed in percentages; p = level of significance.

[1] Scores obtained for the overall score of female athlete triad knowledge had a range of values between –35.00 and +35.00.

[2] Training in triad or at least two components of the triad.

Table 2. Triad knowledge and confidence in that knowledge in relationship to coaches' sport

Sport	n	Overall score[1]		Confidence[2]	
		M	%	M	%
Basketball	63	12.93 ±5.31*	68.48 ±7.59	2.68 ±0.66	67.12 ±16.51
Cross-country	45	18.24 ±3.20*	76.07 ±4.57	3.28 ±0.49	81.97 ±12.25
Diving	13	15.83 ±3.75	72.63 ±5.36	2.97 ±0.42	74.17 ±10.44
Golf	23	15.11 ±5.11	71.58 ±7.30	2.78 ±0.71	69.38 ±17.83
Gymnastics	15	15.43 ±5.19	72.04 ±7.41	3.02 ±0.56	75.62 ±13.92
Lacrosse	24	14.77 ±3.79	71.10 ±5.41	2.72 ±0.53	67.96 ±13.25
Rowing	39	18.62 ±5.98*	76.59 ±8.54	3.02 ±0.69	75.42 ±17.35
Soccer	53	13.27 ±4.47*	68.96 ±6.39	2.63 ±0.63 ‡	65.62 ±15.78
Softball	38	13.73 ±4.51*	69.62 ±6.44	2.74 ±0.57	68.57 ±14.22
Swimming	43	15.71 ±4.62	72.45 ±6.60	2.88 ±0.55	71.90 ±13.78
Tennis	17	12.34 ±3.65*	67.63 ±5.21	2.68 ±0.67	66.99 ±16.72
Track & Field	75	16.70 ±4.67	73.85 ±6.67	3.06 ±0.60 ‡	76.48 ±14.95
Volleyball	41	14.88 ±5.86	71.26 ±8.37	2.88 ±0.59	71.97 ±14.65

* $p < 0.011$; ‡ $p < 0.009$.
[1] Scale from –35 to 35.
[2] Scale from 0 to 4.

Table 3. Providing triad information to athletes and participating in general and triad-specific continuing education in relationship to oaches' characteristics (data expressed as percentages)

	Gender		Age		Degree held	
	female	male	22–34 yrs	35–67 yrs	bachelors	graduate
provide information	18.21*	34.38*	17.17*	30.40*	19.63+	27.97+
Provide educational prog.	30.66	39.10	28.70$	38.74$	31.46	36.32
General continuing education	93.27	96.34	93.70	94.02	92.53	97.65
Triad continuing education	31.31+	42.68+	28.57$	41.88$	41.08$	49.80$

[1] Triad or at least two components of the triad.
Provide information – coach personally provided information about triad; Provide education – provided educational programming about triad; Continuing ed (gen) – participated at least once per year in general continuing education; Continuing ed (triad) – participated at least once per year in triad-specific continuing education.
* – level of significance $p < 0.001$; + – level of significance $p < 0.005$; $ – level of significance $p < 0.05$.

Table 4. Providing triad information to athletes and participating in general and triad continuing education in relationship to coaches' characteristics (data expressed as percentages).

	Years coaching		Type of coach		Triad training[1]	
	0–15 yrs	> 15yrs	head coach	other	yes	no
Provide information	19.54+	32.00+	29.33+	18.38+	28.24	18.14
Provide educational prog.	30.69	39.73	38.01	29.57	39.44	26.50
General continuing education	94.29	93.51	95.22	92.53	97.65	95.10
Triad continuing education	31.75+	44.81+	43.48+	27.39+	–	–

[1] Triad or at least two components of the triad.
Provide info – coach personally provided information about triad; Provide education – provided educational programming about triad; Continuing ed (gen) – participated at least once per year in general continuing education; Continuing ed (triad) – participated at least once per year in triad-specific continuing education.
* – level of significance $p < 0.000$; + – level of significance $p < 0.005$; $ – level of significance $p < 0.05$.

Table 5. Sources of information used by coaches for their general continuing education and triad-specific education in relationship to coaches' characteristics (data expressed as percentages)

	Gender		Age		Degree held	
	female	male	22–34 yrs	35–67 yrs	bachelors	graduate
General continuing ed.						
Athletic Department	77.78	84.15	78.15	81.62	80.97	79.25
NCAA-sponsored	54.88	58.54	55.46	56.41	57.52	54.36
Journals	39.73*	61.59*	39.08*	55.98*	42.04&	51.87&
Magazines	74.07	79.88	77.73	74.79	78.32	73.86
Prof. conferences	70.71+	60.37+	65.55	68.38	68.14	65.56
Textbooks	66.33	72.56	66.81	69.66	65.04	72.20
Consult professional	56.23+	67.07+	55.46&	64.53&	60.18	59.75
Information online	58.59	56.10	61.76	53.42	58.41	56.85
Other	3.70	5.49	3.78	4.70	3.98	4.56
Triad-specific continuing ed.[1]						
Athletic Department	26.67+	35.71+	25.00	34.69	36.23	25.25
NCAA-sponsored	6.67+	14.29+	8.82	10.20	7.25	11.11
Journals	33.33	32.86	27.94	35.71	24.64&	37.37&
Magazines	41.11$	52.86$	30.88*	58.16*	37.68$	52.53$
Prof. conferences	8.89+	17.14+	2.94$	18.37$	2.90*	18.18*
Textbooks	44.44	42.86	38.24	50.00	37.68+	48.48+
Consult professional	60.0&	61.43&	51.47&	67.35&	55.07+	62.63+
Information online	44.44	41.43	50.00	38.78	47.83	39.39
Other	5.56	5.71	2.94	7.14	4.35	9.09

[1] Triad or at least two components of the triad.

Continuing ed. (gen) – general continuing education; Continuing ed. (triad) – triad continuing education; Athletic Department – Athletic department programs; NCAA-sponsored – NCAA-sponsored programs; Journals – Professional journals; sport/coaching-related magazines; Prof. conferences – professional conferences; Textbooks – textbooks related to coaching, physiology, nutrition, etc.; Consult prof – Consult professionals; Info online – Information online.

* – level of significance $p < 0.001$; $ – level of significance $p < 0.005$; & – level of significance $p < 0.05$; + – level of significance $p < 0.025$.

Table 6. Sources of information used by coaches for their general continuing education and triad-specific education in relationship to coaches' characteristics (data expressed as percentages)

	Years coaching		Type of coach		Triad training[1]	
	0–15 yrs	>15 yrs	head coach	other	yes	no
1	2	3	4	5	6	7
General continuing ed.						
Ath. department prog.	79.68	79.87	81.74	78.01	83.14	80.39
NCAA-sponsored prog.	54.92	57.79	59.57	52.70	57.25	57.84
Professional journals	41.27*	59.09*	55.65*	39.83*	54.51$	41.67$
Magazines	74.92	78.57	76.09	76.35	77.65	79.41
Prof. conferences	65.40	70.13	72.17+	61.83+	68.24	69.12
Textbooks	66.67	70.78	73.48+	63.07+	72.55	66.67
Consult professional	56.83	65.58	65.22+	54.77+	67.06$	54.90$
Information online	59.68	53.25	56.09	58.92	58.82	59.31
Other	3.81	4.55	3.91	4.56	4.71	3.92

1	2	3	4	5	6	7
Triad continuing ed. [1]						
Ath. department prog.	25.51	38.24	32.00	28.79	–	–
NCAA-sponsored prog.	9.18	10.29	10.00	9.09	–	–
Professional journals	30.61	35.29	33.00	31.82	–	–
Magazines	38.78*	58.82*	53.00&	37.88&	–	–
Prof. conferences	11.22	13.24	16.00	6.06	–	–
Textbooks	42.86+	48.53+	49.00	39.39	–	–
Consult professional	56.12*	67.65*	67.00&	51.52&	–	–
Information online	47.96	36.76	40.00	48.48	–	–
Other	4.08	7.35	4.00	7.58	–	–

[1] Triad or at least two components of the triad.

Continuing ed. (gen) – General continuing education; Continuing ed. (triad) – Triad continuing education; Ath. department prog. –Athletic department programs; NCAA-sponsored prog. – NCAA-sponsored programs; Magazines – sport/coaching-related magazines; Prof. conferences – professional conferences; Textbooks – Textbooks related to coaching, physiology, nutrition, etc.

* – level of significance $p < 0.001$; $ – level of significance $p < 0.005$; & – level of significance $p < 0.05$; + – level of significance $p < 0.025$.

Discussion

The purpose of this study was to determine what coaches of female athletes know about the female athlete triad with regard to their socio-demographic characteristics. For overall scores regarding knowledge of the female athlete triad, gender, degree, years of experience in coaching female athletes, and type of coach did not significantly affect the score. However, having training in disordered eating did significantly affect knowledge of the triad.

Specifically, regarding gender, these results show that having more knowledge about menstruation and/or women's health (Sherman et al., 2005; Kroshus, et al., 2014), which theoretically women have, does not result in more knowledge about the triad. Thus, specific training about the triad is needed. These data confirm the results found by Pantano (2006) in college coaches. The same tendency was found in relation to the degree and years of experience, also showing that this type of knowledge is not included in formal education or acquired through experience. The fact that the female athlete triad is a specific issue and relatively new (identified in 1992) may be the cause of this. These data also confirm the results found by Pantano (2006) in college coaches related to degree and years of experience. The reasoning for these results may be that the education of coaches is varied and/or the formation about the female athlete triad is not included in coaches training. These results are different from the tendency of knowledge related to nutrition found by previous studies, which showed a correlation in years of study and coaches' training (Juzwiak, Ancona-Lopez, 2004). The reason is that nutrition is included in coaches' training.

The aspect that correlates with knowledge and confidence in this knowledge is the participation in specific training related to the triad and/or one of its components. These results confirm the importance of coaches' education on having an active role in triad prevention (Eagle et al., 2013; Nattiv et al., 2007). This also shows that without this type of training, coaches lack the knowledge related to prevention and knowing how to act in regard to this health issue. These results showed that specific training is a key aspect in reducing the difference between coaches and medical professionals (Troy et al., 2006). The data that were found reinforce the importance of continuing education for coaches so they can be part of the multidisciplinary team needed to defeat the triad (Nattiv et al., 2007; Temme Hoch, 2013).

Regarding the specific sport (following the sport classification of Rust (2002)), knowledge differences were found between sports that emphasize low body weight (cross-country and rowing) and sports that do not emphasize

weight (basketball, soccer, and softball). The results show that the type of sport affects the coach's knowledge. The causes may be that coaches are more aware of this problem in their sport, they receive more training, and/or they search for more information. Every sport has its own characteristics, traditions, risks, etc. The female athlete triad is a problem that can affect all female athletes, regardless of their sport, although for some the risk is higher. The results can serve as a reference for designing specific an education program for coaches of the different sports.

Male coaches, head coaches, and coaches who coached females longer have provided athletes with more information. This result could be correlated with the fact that these groups of coaches more likely to participate in continuing education on the subject of the triad. However, the results showed that a low percentage of coaches provide information to their athletes (<40%). More studies are needed to know the causes of this low involvement. A possible cause is that coaches do not know or believe the importance of their role in the prevention of the triad or their influence over athletes. This hypothesis is supported partially by the fact that coaches that have a training knowledge provide more information to the athletes, but in a low percentage of cases. The reasoning for this result could be a reduction in confidence because coaches are working with other medical professionals, and they believe that they have different knowledge and skills (Troy et al., 2006). More studies are needed to clarify the reason for the low percentage of communication about this topic and its relation to coaches' knowledge and confidence.

Differences are found in the source of information used by coaches for continuing education in general and for triad education. These differences may be due to the large number of aspects that affect performance and health in sport performance. These differences were found for all the sources of information, except consulting professionals. The differences found related to gender, years of experience, degree, type of coach, and age can serve as a reference for designing and planning coaches' continuing education for athletic departments and/or the NCAA. Specifically, related to female athlete triad education, the most utilized sources by coaches were sport/coaching-related magazines, textbooks, online information, and consulting professionals.

In general, receiving triad specific education is the aspect that most correlates with knowledge and confidence among NCAA Division I coaches. Specific training and involvement seems to be the key (e.g. coaches of certain types of high-risk sports demonstrate greater knowledge of the triad as well as more confidence in this knowledge). These findings have been suggested previously by other researchers as key for college coaches in relation to managing the triad issue (Heffner et al., 2003; Pantano, 2006; Sherman et al., 2005; Kroshus, et al., 2014). However, inadequate levels of knowledge and information provided to athletes were found.

The female athlete triad is a relatively new issue in coaching. The knowledge of this topic and the aspects that affect it are still unclear. The response rate demonstrated that these coaches may be interested in this topic, which could bias the result (e.g. only coaches interested in this topic answered the survey). The present article provides reference values by type of sport and coaches' characteristics (gender, age, degree held, years coaching, and type of coach) to guide the design and planning of educational training for coaches with regard to coaches' characteristics. The article takes into consideration both knowledge and confidence as criteria for measuring the coaches' knowledge and their possibility of applying it.

Conclusions

Data found show that coaches' knowledge of the female athlete triad is higher for coaches that have received triad education. No differences regarding knowledge of the female athlete triad were found by gender, degree, years of experience in coaching female athletes, or type of coach. Different triad knowledge was found by different

type of sport. Higher knowledge was found in sports that emphasize low body weight compared to sports that do not emphasize weight. The data support the idea that specific training about this topic is necessary and useful to increase the knowledge about the female athlete triad, and the sensitization of the coaches about this topic varied according to the type of sport and the emphasis that they place on weight control. Future studies are needed to determine the relationship between coaches' knowledge and coaches' attitudes, communication, and management decisions (Coppola, Ward, Freysinger, 2014; Kroshus, et al., 2014).

Acknowledgements

We would like to thank all the coaches who completed the survey. Without them, this study would not have been possible.

References

Arends, J.C., Cheung, M.Y.C., Barrack, M.T., Nattiv, A. (2012). Restoration of menses with non-pharmacologic therapy in college athletes with menstrual disturbances: A 5-year retrospective study. *International Journal of Sport Nutrition and Exercise Metabolism*, *22* (2), 98–108.

Bandura, A., Wood, R.E. (1989). Effects of perceived controllability and performance standards on self-regulation of complex decision-making. *Journal of Personality and Social Psychology*, *56*, 805–814.

Beals, K.A., Brey, R.A., Gonyou, J.B. (1999). Understanding the female athlete triad: Eating disorders, amenorrhea, and osteoporosis. *The Journal of School Health*, *69* (8), 337–340.

Bradney, D. (2002). *Attitudes of coaches regarding eating disorders.* Unpublished doctoral dissertation, Springfield College, Springfield, MA.

Coppola, A.M., Ward, R.M., Freysinger, V.J. (2014). Coaches' communication of sport body image: Experiences of female athletes. *Journal of Applied Sport Psychology*, *26* (1), 1–16.

Eagle, S.R., Lohman, C., Jarman, N. (2013). Enhancing knowledge of nutrition and prevention in medical professionals and coaches; the key to defeating the Female Athlete Triad. *Journal of Athletic Medicine*, *1* (1), 23–36.

Field, R.W. (1991). Coach as a role model: What are his salient roles and how do others perceive them? *Track Technique*, *117*, 3730–3733.

Froiland, K., Koszewski, W., Hingst, J., Kopecky, L. (2004). Nutritional supplement use among college athletes and their sources of information. *International Journal of Sport Nutrition and Exercise Metabolism*, *14*, 104–120.

Hague, P., Hague, N., Morgan, C. (2004). *Market research in practice: A guide to the basics.* London, GB: Kogan Page.

Heffner, J.L., Ogles, B.M., Gold, E., Marsden, K., Johnson, M. (2003). Nutrition and eating in female college athletes: A survey of coaches. *Eating Disorders*, *11*, 209–220.

Hobart, J.A. (2000). The female athlete triad. *American Family Physician*, *61* (11), 3357–3364.

Jacobson, B.H., Sobonya, C., Ransone, J. (2001). Nutrition practice and knowledge of college varsity athletes: A follow-up. *Journal of Strength and Conditioning Research*, *15*, 63–68.

Joy, E., Clark, N., Ireland, M.L., Martire, J., Nattiv, A., Varechok, S. (1997a). Team management of the female athlete triad: Part 1: What to look for, what to ask. *The Physician and Sportsmedicine*, *25* (3), 94–102.

Joy, E., Clark, N., Ireland, M. L., Martire, J., Nattiv, A., Varechok, S. (1997b). Team management of the female athlete triad: Part 2: Optimal treatment and prevention tactics. *The Physician and Sportsmedicine*, *25* (4), 55–64.

Juzwiak, C.R., Ancona-Lopez, F. (2004). Evaluation of nutrition knowledge and dietary recommendations by coaches of adolescent Brazilian athletes. *Journal of Sport Nutrition and Exercise Metabolism*, *14*, 222–235.

Kroshus, E., Sherman, R.T., Thompson, R.A., Sossin, K. Austin, S.B. (2014). Gender differences in high school coaches' knowledge, attitudes, and communication about the female athlete triad. *Eating Disorders*, *22* (3), 1–16.

Lassiter, J.W. (2002). *A survey of student coaches' knowledge, attitudes, skills, and behaviors regarding the female athlete triad.* Unpublished master's thesis, State University of New York College at Brockport.

Martínez-Pecino, M., Mulas-Sánchez, M.Y., Fernández-Palacín, F., Bayón-Suárez, F. (1997). Encuesta a los médicos internos residentes de rehabilitación sobre su formación. [Survey to medical residents of rehabilitation about their formation]. *Rehabilitación*, *31*, 17–22.

Nattiv, A., Loucks, A.B., Manore, M.M., Sanborn, C.F., Sundgot-Borgen, J., Warren, M.P. (2007). American College of Sports Medicine position stand. The female athlete triad. *Medicine and Science in Sports and Exercise*, *39* (10), 1867–1882.

Otis, C.L., Drinkwater, B., Johnson, M., Loucks, A., Wilmore, J. (1997, May). ACSM position stand: The female athlete triad. *Medicine and Science in Sports and Exercise*, *29* (5), 1–9.

Pantano, K.J. (2006) Current knowledge, perceptions, and interventions used by collegiate coaches in the US regarding the prevention and treatment of the female athlete triad. *North American journal of sports physical therapy: NAJSPT*, *1* (4), 195.

Rust, D.M. (2002). The female athlete triad: Disordered eating, amenorrhea, and osteoporosis. *The Clearing House*, *75* (6), 301–305.

Sherman, R.T., Thompson, R.A., Dehass, D., Wilfert, M. (2005). NCAA coaches survey: The role of the coach in identifying and managing athletes with disordered eating. *Eating Disorders*, *13*, 447–466.

Smith, A.D. (1996). The female athlete triad: Causes, diagnosis, and treatment. *The Physician and Sportsmedicine*, *24* (7), 67–73.

Sossin, K., Gizis, F., Marquart, L.F., Sobal, J. (1997). Nutrition beliefs, attitudes, and resource use of high school wrestling coaches. *International Journal of Sport Nutrition*, *7*, 219–228.

Sundgot-Borgen, J. (1994). Risk and trigger factors for the development of eating disorders in female elite athletes. *Medicine and Science in Sports and Exercise*, *26* (4), 414–419.

Temme, K.E., Hoch, A.Z. (2013). Recognition and rehabilitation of the female athlete triad/tetrad: A multidisciplinary approach. *Current Sports Medicine Reports*, *12* (3), 190–199.

Thein-Nissenbaum, J. (2013). Long term consequences of the female athlete triad. *Maturitas*, *75* (2), 107–112.

Thomas, S.J. (2004). *Using web and paper questionnaires for data-based decision making: From design to interpretation of the results*. Thousand Oaks, CA: Corwin Press.

Thompson, S.H., Gabriel, M. (2004). Risk factors for the female athlete triad among female collegiate and noncollegiate athletes. *Physical Educator*, *61* (4), 200–212.

Troy, K., Hoch, A.Z., Stavrakos, J. (2006). Awareness and comfort in treating the female athlete triad: are we failing our athletes? *WMJ-MADISON*, *105* (7), 21.

Turk, J.C., Prentice, W.E., Chappell, S., Shields, E.W. (1999). Collegiate coaches' knowledge of eating disorders. *Journal of Athletic Training*, *34* (1), 19–24.

Wozney, L., Venkatesh, V., Abrami, P. (2006). Implementing computer technologies: Teachers' perceptions and practices. *Journal of Technology and teacher education*, *14* (1), 173–207.

Cite this article as: Frideres, J.E., Mottinger, S.G., Palao J.M. (2016). Collegiate Coaches' Knowledge of the Female Athlete Triad in Relation to Their Characteristics. *Central European Journal of Sport Sciences and Medicine*, *16* (4), 55–66. DOI: 10.18276/cej.2016.4-06.

REVIEW OF TRADITIONAL AND NATURAL METHODS OF TREATING ALZHEIMER'S DISEASE

Maurycy Mieczkowski,[A, B, D] Krzysztof Sieja,[A, D] Marta Stępień-Słodkowska[D, E]

University of Szczecin, Faculty of Physical Culture and Health Promotion, Szczecin, Poland
[A] Study Design; [B] Data Collection; [C] Statistical Analysis; [D] Manuscript Preparation; [E] Funds Collection

Address for correspondence:
Marta Stępień-Słodkowska
University of Szczecin, Faculty of Physical Culture and Health Promotion, Poland
Al. Piastów 40B building 6, 71-065 Szczecin, Poland
E-mail: marta.slodkowska1@wp.pl

Abstract The most common form of dementia in the elderly population is Alzheimer's disease (AD). World Health Organization (WHO) thus defines Alzheimer's disease: "a set of neurodegenerative brain symptoms, resulting in progressive impairment of memory, thinking, cognition, counting, language, ability to learn and assessing situations, which disturb everyday life". It usually develops in 65+-year-olds, and the risk of AD in 85+-year-olds is as high as 50%. It has become a considerable threat to the society, given the longer life expectancy and an increase in the retirement-aged population. AD prevention and treatment methods described in this paper are still being developed and perfected. Studies on genesis of the disease aim at comprehensive understanding of its causes. New, alternative treatment methods are still sough. Researchers develop and test biomarkers that could facilitate early diagnosis.

Key words Alzheimer disease, Pharmacological Treatment, Nutrition, Physical Activity, Herbal Medicine

Introduction. The Nature of the Disease

The most common form of dementia in the elderly population is Alzheimer's disease (AD). It usually develops in 65+-year-olds, and the risk of AD in 85+-year-olds is as high as 50% (Duthey, 2013). As reported Pąchalska (2009) the disease develops in 10% of people over 65 years old and in 30% of people aged above 85 years old. It is estimated that in the world suffers from 12 to 15 million people, while in Poland 200–250 thousand people (Gustaw et al., 2008; Pąchalska et al., 2009). It has become a considerable threat to the society, given the longer life expectancy and an increase in the retirement-aged population. In its initial stage, AD is often taken for dementia, which is a natural result of the aging process. It is not a consequence of neurodegenerative changes, and therefore the disease is diagnosed too late. This, in turn, limits the possibility of slowing down the development of AD and increasing patient's overall state.

World Health Organization (WHO) thus defines Alzheimer's disease: "a set of neurodegenerative brain symptoms, resulting in progressive impairment of memory, thinking, cognition, counting, language, ability to learn

and assessing situations, which disturb everyday life" (Kaliszan, Macur, 2010). Despite still unknown pathogenesis mechanisms, AD is classified as tauopathy, i.e. a disease related to tau protein pathology, which leads to aggregation of neurofibrillary tangles, beta-amyloid formations (senile plaques) (Ling et al., 2011), as well as oxidative stress (Szwed, Miłowska, 2012).

AD results in significant costs of treatment, due to increased population of the elderly. In the US, approximately 5.4 million people suffer from AD, and the cost of treatment is estimated at 200 billion USD (Anderson, 2013). According to the WHO, costs of treatment and care for dementia patients all over the world amount to 604 billion USD. In 2012, WHO estimated that there were 35.6 million people worldwide who suffered from dementia. WHO predicts that by 2030 this number will have doubled, and by 2050 it will have tripled (Duthey, 2013). The increased number of patients will generate higher costs. According to demographic forecasts, in Poland in 2030 there will be 9.1 million of 60+-year-olds; 10% of them will suffer from dementia.

Attempts to identify and analyze AD biomarkers are still ongoing. Possibly, beta-amyloid (Aβ) build-up might be detected even 15 years before the onset of the disease, based on blood and cerebrospinal fluid tests. Aβ level one of isoforms decreases approx. 25 years before the onset of the disease (Anderson, 2013). Assessing the level of total Aβ in patients with AD in CSF using ELISA method, showed no changes compared to those without dementia (Blennow, 2004). However, further studies have shown the existence of two isoforms of Aβ: containing 40 amino acids of Aβ40 and 2 containing 42 amino acids, Aβ4 which is the dominant form of brain streaks and more toxic. Different methods (ELISA, Western blot, UREA SDS-PAGE – Western blot) showed reduced by approx. 50% Aβ42 in the CSF of patients with AD. This reduction was caused probably by storing it in senile plaques. Should this revelation be confirmed, it might become a very effective method of diagnosing high-risk groups.

Another potential method of identifying AD's onset might be MRI to measure atrophy in the hippocampus as a biomarker of AD development (Greene, Killiany, 2012). Researchers from Boston found different changes in various parts of the hippocampus in the aging process, as well as changes in glucose metabolism in some parts of the brain of the AD patients. Relation between atrophy and beta-amyloid build-up in AD is still being researched, but it has already been found (Chételat et al., 2010) that there is a strong correlation between these two processes in the early stage of AD. The research revealed general and specific atrophy in patients with subjective cognitive disorders resulting from beta-amyloid build-up, while it was not revealed in patients with medium cognitive disorders or AD. AD-related atrophy results in neuron and synapse loss, mostly in hippocampus, which leads to impaired cognitive skills. The most popular hypothesis is the impact of production and build-up of beta-amyloid on gray matter loss. Nevertheless, the relation between these two pathological processes is still unknown. Research on the relation between beta-amyloid and atrophy does not assume direct and total impact of beta-amyloids on AD. It rather focuses on their neurodegenerative nature in the build-up areas, as well as indirect impact on other areas such as hippocampus. In-depth research is important, as – potentially – anti-amyloid therapy might be used in the early stages to slow down atrophy and decrease the loss of cognitive functions. One of promising method of treating AD in the future is photothermal therapy (Meng, 2012). Tested on mice, it showed very optimistic results and effectively bypassed the physical barrier between blood and brain.

Pharmacological Treatment

In the pharmacological treatment of AD, acetylcholinesterase inhibitors are used. In Poland, donepezil, rivastigmine, galantamine and taurine are used (Kijena et al., 2008). They affect cholinergic transmission, increasing

the activity level of the cholinergic system (Gabryelewicz, Mandacka, 2013). The treatment usually involves the maximum tolerated dosage. The drugs are prescribed to patients with diagnosed, quick progress of the dementia symptoms. Drugs stop the progress of the disease for 2 years for a small proportion (approx. 20%) of patients (Leszek, 2013). They stimulate cognitive functions, orientation, visual and spatial functions, alertness, attention and learning. They also affect other functions, such as memory and language functions, but with weaker effects (Kijena et al., 2008). Neuroprotective effect of the treatment is reported, especially of donepezil in cholinergic neurons of rats (Leszek, 2013), but donepezil's mechanism has not been fully discovered yet. A literature review made by Briggs (2006) demonstrated the effect of the use of inhibitors. However, no detailed data on their impact on the social aspects of the disease. There is also no possibility of identifying persons before treatment which obtains a positive therapeutic response inhibitors. There is also no basis to determine which one is more effective despite the differing mechanisms of action.

Memantine, NMDA receptor antagonists, is used in medium and late dementia. It may also be used for early dementia, based on NMDA receptors' role and glutamate effects (Sobów, 2014). It needs to be noted, however, that there is still no research which would prove its effectiveness in the early stage of cognitive impairment, Meanwhile, memantine helps with many neurodegenerative problems. It is also recommended by the FDA to treat AD (Leszek, 2013). As a consequence, only acetylcholinesterase inhibitors and NMDA antagonists are currently approved in AD treatments. There are few randomized studies, which compared mementine to other therapies, mostly acetylcholinesterase inhibitor, that have shown to slow progression of disorders (Gauthier et al., 2007).

Kinase-inhibitors are also used in AD treatment, despite lack of detailed research on kinase's impact on AD. There are, however, reasons to believe that they combat key symptoms of neurodegeneration, or to be more precise: neurotoxic functions, neuroinflammation and phosphorylation of tau protein (Savage, Gingrich, 2009). Use of kinase seems promising due to its impact on regulations of various biological processes. It is, however, challenging to carry out detailed studies on their properties, especially *in vivo* tests. Striving for selectiveness (to limit potential toxic effects) lets us mention kinase only as potential, alternative method which might become AD treatment in the future.

Ibuprofen and glutathione are used in AD treatment (Pinnen et al., 2011), based on the belief that nonsteroidal anti-inflammatory drugs and anti-oxidation therapy may limit the development of AD. They fight inflammation and oxidative stress in AD-affected cells. Glutathione neutralizes various oxidants. Italian researchers created a molecular combination of ibuprofen and glutathione with amide binding. They based their study on an assumption that according to epidemiologic studies, NSAIDs decrease incidence of AD amongst patients (Tendera, Kruk, Biała, 2010) and slows down the onset and development of the disease, as well as decreases the loss of cognitive functions. Ibuprofen and glutathione were also tested in rats in order to determine harmfulness of beta-amyloids to cognitive structures and functions. Study results revealed better long-term spatial memory in rats that were treated with ibuprofen + glutathione.

Studies of relation between biology and genesis of AD recommend the use of medical methyl blue (Tęgowska, Wosińska, 2011). According to a study which involved 300 persons, the 30, 60 and 100 mg dosage 3 times per day resulted in slowing down AD development after one year. Numerous benefits of methyl blue are highlighted: reduced number of free radicals, lowering the sensitivity threshold to adrenaline, noradrenaline and dopamine. The research also revealed a decrease of NOS gene expansion, which occurs at the early stage of the disease. Given these properties, it is fair to say that there is a significant potential of improving metabolic functions of brain of AD patients.

Another example of pharmacological treatment is immunotherapy with beta-amyloids (Tendera et al., 2010). It is based on a study with mice. First active immunization was carried out with QS-21 and CAD-106 antibodies (Seeman, Seeman, 2011); the second one, passive with anti-beta-amyloid antibodies (Kwieciński, 2010), was considered to be safer. Studies highlight benefits of both methods: restoring synapse and neuron functions, reducing amyloids and improving patients' behaviors. Immunotherapy needs further research to eliminate risks of auto-immune diseases and encephalitis.

Impact of insulin in AD treatment should also be discussed. Brain metabolism studies and related to it reduced glucose consumption point to the fact that glucose concentration is accompanied by increased (improved) memory of patients. Perhaps it resulted not only from glucose, but also insulin. Type 2 diabetes is seen as one of risk factors of AD, due to resistance of insulin receptors. Among many scientific revelations, de Felice et al. proposed that AD might be a form of diabetes that occurs only in the brain (Tęgowska, Wosińska, 2011).

Non-Pharmacological Treatments

AD patients are treated with reality orientation therapy, i.e. giving information about current time and place. It should help patients with understanding their whereabouts. To improve patients' orientation, calendars, watches, newspapers and news programs are recommended. These measures prevent loss of sense of time and help train memory (Długosz-Mazur, Bojar, Gustaw, 2013). Another method is validation therapy, which ensures comfort and acceptance of people around the patient. In the validation therapy, patients' remarks are accepted, even if they are not realistic. It serves to stimulate appropriate social behaviors, improving well-being and decreasing anxiety and fear. It is recommended to avoid confrontation with patients and stir up conversation on another topic. Third method is a reminiscence therapy, based on memories and recollections of patients. It involves talking about actions or events from patient's past, using some objects to help access old memories. Effectiveness of these therapies is still verified; some studies suggest only temporary improvements. Method descriptions also highlight negative effects, such as sense of frustration. Analysis of validation therapy report improvement, as well as apathy, agitation and irritability. These therapies are meant to maintain patient' cognitive functions and comfort of life. It is important, as it significantly affects dementia patients' behavior.

AD, being a type of dementia, results in behavioral changes. These are called BPSD (behavioral and psychological symptoms of dementia) (Ponichtera-Kasprzykowska, Pękala, Sobów, 2013). It is important, as studies revealed a relation between BPSD and negative effect on cognitive function and self-reliance loss, as well as higher risk of falling and injuries. Pharmacological treatment is not effective enough and it increases the risk of complications, such as cerebral stroke or heart attack. The literature distinguishes four approaches to development mechanisms of these behaviors: genetic/biological approach; behavioral approach; oversensitivity to stress; unfulfilled needs. These approaches do not exclude each other; therefore, it is possible that patients display a couple of them.

Non-pharmacological treatment involves various forms of interventions: sensory methods, e.g. music therapy, multi-sensory therapy, massages, music and aromatherapy. Aromatherapy with essential oils is used both in palliative care, as well as in case of dementia. The most recommended oils are: lavender, boswellia, ylang ylang – they are relaxing and help decrease to some extent anxiety and fear (Walden-Gałuszko, Gaworska-Krzemińska, 2012). Another group of methods involve contact with animals, such as therapy dogs. There are also methods based on activities which help patients give structure to their lives, mostly by means of occupational therapy. They are

recommended due to their preventive nature for patients with behavior disorders (Ponichtera-Kasprzykowska et al., 2013).

Nutrition

Nutrition is an important aspect, as it is indispensable part of our lives and affects human development on every stage of ontogenesis, therefore it may treat and prevent AD. Most of all, unhealthy eating habits may lead to various diseases: excessive consumption, unhealthy diet, food contaminated with heavy metals and highly processed food with a large number of colorants. As long-term effects are not fully known, it is assumed that some of these risk factors may lead to diseases (Gawędzki, Roszkowski, 2013). Healthy diet may be an alternative in AD prevention. Shops do not offer food tailored to the needs of 65+-year-olds. Thoughtfully designed and popularized diet might improve seniors' health and prevent many diseases (Gawęcki, Roszkowski, 2013). One should also remember the impact of advanced age on the bodies of the elderly: decrease in muscle mass, increase of fatty tissue lead to higher risk of lipid disorders, hypertension and diabetes. At the old age, absorption and metabolic processes are weak, which leads to micro and micro element deficit. Another threat to seniors' health is malnutrition (Dudkowiak, Gryglas, Poniewierka, Poniewierka, 2013), which results in cognitive function impairment and excessively limited physical activity.

One of dietary ingredients important in AD are antioxidants (Tendera et al., 2010) as well as vitamin C and E. They help remove free radicals from the body. Low level of antioxidants increases oxidative stress and accelerates the aging process, as well as contributes to inflammations (Dudkowiak et al., 2013). It has not been confirmed scientifically that vitamin E limits the development of AD (Jaworski, 2010). It is, however, noted that insufficient consumption of vitamin E may lead to worse results in cognitive function tests (Dudkowiak et al., 2013). One study revealed that vitamin C increases activity of acetylcholinesterase in tests on mice. Another study showed a positive effect of vitamin C and E on cognitive functions in old mice (Tendera et al., 2010). Vitamin B12 and B6, as well as folic acid, may reduce the risk of developing AD (Jaworski, 2010). It is supported by the fact that these vitamins correlate with correct reactions with homocysteine, which is believed to be an independent factor in atherosclerosis; when increased, it may also impact the speed of anti-amyloid build-up (Dudkowiak et al., 2013).

Ketogenic diet (Liśkiewicz, Jędrzejowska-Szypułka, Lewin-Kowalik, 2012) is a high-fat and low-carbohydrate diet, used therapeutically in epilepsy. It delivers 80% of fat, 15% of protein and only 5% of carbohydrates from the food, at a 4 : 1 ratio. The fat ratio may also be 3 : 1 or 2 : 1. The main source of fat are medium- and long-chain triglycerides. Ketogenic diet was developed in 1971 by Peter R. Huttencholer. Research confirmed its neuroprotective effects. Ketogenic diet affects the insulin level in blood and insulin receptors in cerebral cortex and hippocampus, which impacts memory and ability to learn (effect of insulin in beta-amyloid secretion, leading to their build-up).

The Mediterranean diet is promoted as one of the most effective diets in AD prevention (Dudkowiak et al., 2013). Numerous epidemiologic studies reveal lower incidence of dementia, resulting from frequent consumption of fish and sea food. This diet is based on fish, vegetable oils (incl. olive oil), fruit and vegetable and reduces the consumption of red meat. Diet rich in omega-3 and omega-6 fats is a desirable form of AD prevention. Mediterranean diet is also used in treatment of diabetes and hypertension.

Caffeine, a known stimulant of the central nervous system, increases levels of serotine and acetylcholine – neurotransmitters related to memory. Its consumption increased adenosine receptors in animal brain (Tendera et al., 2010). Studies showed a correlation between cognitive functions of humans and regular consumption of caffeine;

they also pointed to other benefits of small dosage of caffeine, due to its neuroprotective effects. However, this type of research was only carried on experimental models, therefore it is difficult to prove actual effect of caffeine.

Nicotine and nicotine receptor antagonists may affect the cognitive functions in AD. Its neuroprotective effects are based on stimulation of neural nicotine acetylcholine receptors (Kaliszan, Macur, 2010). Direct stimulation results in dopamine, serotonin and glutamate release, which are related to learning and memory in presynaptic receptors. Beneficial effects were discovered in studies devoted to effects of smoking on Parkinson disease and improved cognitive functions in humans, which suggest a positive effect of nicotine in AD treatment. This form of treatment, however, needs to be approached cautiously, given the negative effect of smoking on human health, which is still a controversial and undiscovered issue (Dudkowiak et al., 2013).

Cannabinoids may reduce neuropathies, according to research in 2007 (Tkaczyk, Florek, Piekoszewski, 2012) and have neuroprotective effect. Studies suggest that using cannabinol tracts may help treat AD more effectively, but there are still no comprehensive studies. Hopefully, more studies will follow, as the issue of cannabinoids and therapeutic marihuana raises significant interest among researchers.

Physical Activity

There are no proved correlations between physical activity and AD (Dudkowiak et al., 2013). Physical activity improves level of fitness and agility in the old age, as well as impacts other diseases, such as diabetes and hypertension. As diabetes seems to increase the risk of AD, National Institute of Aging is currently conducting studies on physical activity and prevention of AD (https://clinicaltrials.gov/ct2/show/NCT02000583, 2015). The research will conclude in January 2018 with conclusions about impact of physical activity on reduced AD risk. In May 2016 another study is scheduled to finish; it focuses on different forms of physical activity on thought processes. The study involves subjects with medium cognitive impairment (https://clinicaltrials.gov/ct2/show/ NCT02237560, 2015). As far as the elderly are concerned, the emphasis should be put on increasing muscle flexibility, as its loss is a natural consequence of the aging process. Exercise is also recommended to increase the limited motion range of joints and balance – as falling down is common among the elderly. It is often a consequence of metabolic disorders, such as hypoglycemia, dehydration and neurological disorders: strokes, neuropathy or dementia (Niechwiadowicz, Klimczyk, 2010). For example, Wielkopolskie Stowarzyszenie Alzheimerowskie (AD Association in the Wielkopolskie region in Poland) recommends physical activity, mostly isometric exercises to patients with light dementia. Preferably, exercise should be done in groups. In case of advanced dementia, it is better to use individual exercises: a short walk or workout on a mattress and relaxation techniques. Beneficial effect of physical activity of the brain was showed in studies on animals (Jaworski, 2010). Physical activity promoted neurogenesis and lengthened the longevity of nerve cells in tests on animals; it also increased plasticity of synapses.

Herbal Medicine

Studies revealed therapeutic effect of neuroactive substances in Lamiaceae plants (Ożarkowski et al., 2009). They were proved to stop enzymes which affect the central nervous system in development of AD. The studies focused on effectiveness of substances in rosemary, melissa and *Salvia Miltiorrhiza* (red sage). As for rosemary, rosmarinic acid has antioxidant, anti-inflammatory and antimicrobial properties (Kubis, Janusz, 2008). Authors of studies on rosemary wrote: '(...) that most of extracts from these plants inhibited activity of acetylcholinesterase *in vitro'.* It was also revealed that some active ingredients of the polyphenol group, including flavonoid from

Lamiaceae plants, inhibited aggregation of beta-amyloid *in vitro* (Ożarkowski et al., 2009). However, as there are no studies on animals, this form of treatment is only potentially more beneficial than pharmacological treatments.

Another substance that might help with AD treatment comes from *Morus Alba* (white mulberry). Leaves of this plant contain large proportion of vitamin C, B, D and E (Krzemińska, 2011). They are used in Korea, Japan and Chile to make anti-diabetic tea. A study on rats revealed lowered level of glucose after 5 weeks. Extract from leaves of *Morus Alba* was also reported to inhibit and lower neurotoxicity of beta-amyloids; it is also believed to have anti-oxidation properties, due to high concentration of quercetin and rutin. Given the antioxidant properties, vitamin C and E and its effect on beta-amyloids, *Morus Alba* might be another method of preventive AD treatment. Using *Morus Alba* in treatment of AD requires further in-depth studies.

Conclusion

AD prevention and treatment methods described in this paper are still developed and perfected. Studies on genesis of the disease aim at comprehensive understanding of its causes. New, alternative treatment methods are still sough. Researchers develop and test biomarkers that could facilitate early diagnosis. Using ibuprofen and glutathione, immunotherapy, methyl blue and kinase inhibitors to slow down the onset of the disease give increasingly promising results. All of these therapies rely primarily on the action of symptomatic and bring only limited clinical results and used drugs do not affect the mechanism of the disease process (Bilikiewicz, Bidzian, 2007). However, currently in clinical trials are measures that can affect the disease process.

At the same times, other, non-pharmacological methods are researched, which could be available to majority of those suffering from AD. Ketogenic diet is recommended, as it is used in epilepsy and potentially has neuroprotective properties. Mediterranean diet is also popularized, as its beneficial effects are becoming commonly known. Antioxidants' effect has already been proved; vitamin C and E relieve oxidative stress, while caffeine (used in small dosage) has neuroprotective properties. Healthy nutrition and diet seem to have long-lasting effects on maintaining good physical and mental state on every stage of life. Hopefully, it will help combat AD more effectively in the future.

Studies are carried out to determine pro-health benefits of physical activity; however, there is no explicit confirmation of relation between physical activity and development of the disease. On the other hand, positive effect of physical activity on the general improvement of quality of life and reduced risk of many diseases is well known. Researchers also study potential impact of psychoactive substances on the development of AD. It is, however, limited by their known negative effect on many functions of the organism. Searching for new treatments leads to creating new hypothesis, e.g. relation between insulin/diabetes and AD.

It seems justified to look for new herbal substances that would effectively treat AD as well as prevent it. The existing methods and new solutions give hope for successful combat with Alzheimer's disease.

References

Anderson, D.C. (2013). Alzheimer's Disease Biomarkers: More Than Molecular Diagnostics. *Drug Development Research*, *74*.

Bilikiewicz, A., Bidzan, L. (2007). Current trends in Alzheimer's Disease pharmacotherapy. *Farmakoterapia w psychiatrii i neurologii*, *2*, 69–74.

Blennow, K. (2004). Cerebrospinal fluid protein biomarkers for Alzheimer's disease. *The Journal of the Society for Experiment NeuroTherapeutics*, *1* (4), 213–225.

Chételat, G., Villemagne, V.L., Bourgeat, P., Pike, K.E., Jones, G., Ames, D., Ellis, K.A., Szoeke, C., Martins, R.N., O'Keefe, G.,J., Salvado, O., Masters, C.L., Rowe, C.C. (2010). Relationship between Atrophy and Beta-Amyloid Deposition in Alzheimer Disease. *Annals of Neurology*, *67* (3).

Długosz-Mazur, E., Bojar, I., Gustaw, K. (2013). Niefarmakologiczne metody postępowania u chorych z otępieniem. *Medycyna Ogólna i Nauki o Zdrowiu*, *19* (4).

Dudkowiak, R., Gryglas, A., Poniewierka, A., Poniewierka, E. (2013). Rola wybranych czynników ryzyka w etiopatogenezie i przebiegu choroby Alzheimera. *Aktualności Neurologiczne*, *13* (2).

Duthey, B. (2013). Alzheimer Disease and other Dementias, Priority Medicines for Europe and the World. *A Public Health Approach to Innovation*, Background Paper 6.11.

Gabryelewicz, T., Mandecka, M. (2013). Wyzwania terapii otępienia w chorobie Alzheimera. *Aktualności Neurologiczne*, *13* (2).

Gauthier, S., Wirth, Y., Möbius, H.J. (2005). Effects of memantine on behavioural symptoms in Alzheimer's disease patients: an analysis of the Neuropsychiatric Inventory (NPI) data of two randomised, controlled studies. *Int. J. Geriatr. Psychiatry*, *20*, 459–464.

Gawęcki, J., Roszkowski, W. (2013). *Żywienie u progu i schyłku życia*. Poznań: Wydawnictwo Uniwersytetu Przyrodniczego.

Greene, S.J., Killiany, R.J. (2012). Hippocampal Subregions Are Differentially Affected in the Progression to Alzheimer's Disease. *The Anatomical Record*, *295*.

Gustaw, K., Bełtowska, K., Makara-Studzińska, M. (2008). Reakcje emocjonalne opiekunów z demencją – potrzeba pomocy społecznej. *Przegląd Lekarski*, *65* (6), 304–307.

Jaworski, M. (2010). Łagodzenie objawów poznawczych poprzez stosowanie odpowiedniej diety u osób z chorobą Alzheimera, *Neuropsychiatria i Neuropsychologia*, *5* (3–4).

Kaliszan, R., Macur, K. (2010). Na tropie środków przydatnych w terapii lub profilaktyce choroby Alzheimera. *Forum Medycyny Rodziny*, *4* (1).

Kiejna, A., Pacan, P., Trypka, E., Sobów, T., Parnowski, T., Kłoszewska, I., Bidzan, L., Borzym, A., Antoniak, D., Cieślak, U., Paszkowska, E., Jarema, M. (2008). Standardy leczenia otępień. *Psychogeriatria Polska*, *5* (2).

Krzemińska, S. (2011). Morwa biała-niedoceniony skarb. *Świat Farmacji*, *6*.

Kubis, A.M., Janusz, M. (2008). Choroba Alzheimera – nowe możliwości terapeutyczne oraz stosowane modele eksperymentalne. *Postępy Higieny i Medycyny Doświadczalnej*, *62*.

Kwieciński, H. (2010). Nowości w diagnostyce i terapii schorzeń neurologicznych. *Przewodnik Lekarza*, *4*.

Leszek, J. (2013). Leczenie farmakologiczne choroby Alzheimera, *Farmakoterapia w Psychiatrii i Neurologii*, *3–4*.

Ling, S., Zhou, J., Rudd, J.A., Hu, Z., Fang, M. (2011). The Recent Updates of Therapeutic Approaches Against Ab for the Treatment of Alzheimer's Disease. *The Anatomical Record*, *294*.

Liśkiewicz, A., Jędrzejowska-Szypułka, H., Lewin-Kowalik, J. (2012). Characteristics of ketogenic diet and its therapeutic properties in central nervous system disorders. *Annales Academiae Medicae Silesiensis*, *66* (6).

Meng, L., Xinjian, Y., Jinsong, R., Konggang, Q., Xiaogang, Q. (2012). Using Graphene Oxide High Near-Infrared Absorbance for Photothermal Treatment of Alzheimer`s Disease. *Advanced Materials*, *24* (13).

National Institute of Aging, Effect of Aerobic Exercise on Pathophysiology of PreClinical Alzheimer's Disease, ClinicalTrials.gov ID:NCT02000583. Retrieved from: https://clinicaltrials.gov/ct2/show/NCT02000583.

National Institute of Aging, The Cognitive Benefits of Interactive Mental and Physical Exercise for Mild Cognitive Impairment (MCI), ClinicalTrials.gov ID:NCT02237560. Retrieved from: https://clinicaltrials.gov/ct2/show/ NCT02237560.

Niechwiadowicz, T., Klimczyk, A. (2010). *Wybrane zagadnienia z pielęgniarstwa geriatrycznego*. Wrocław: Continuo.

Ożarkowski, M., Mikołajczak, P., Bobkiewicz-Kozłowska, T., Kujawski, R., Mrozikiewicz P. (2009). Neuroaktywne związki roślin leczniczych rodziny Lamiaceae wykazujące potencjalne korzystne działanie w leczeniu choroby Alzheimera. *Herba Polonica*, *55* (4).

Pąchalska, M., Bidzan, L., Pufal, A., Bidzan, M., Łukaszewska, B. (2009). Dynamika zaburzeń zachowania w otępieniu typu Alzheimera. *PsyhoGeriatria Polska*, *6* (2), 43–58.

Pinnen, F., Sozio, P., Cacciatore, I., Cornacchia, C., Mollica, A., Iannitelli, A., D'Aurizio, E., Cataldi, A., Zara, S., Nasuti, C., Di Stefano, A. (2011). Ibuprofen and Glutathione Conjugate as Potential Therapeutic Agent for Treating Alzheimer`s Disease. *Archiv der Pharmazie – Chemistry in Life Sciences*, *11*.

Ponichtera-Kasprzykowska, M., Pękala, K., Sobów, T. (2013). Niefarmakologiczne strategie postępowania w zaburzeniach zachowania towarzyszących otępieniu. *Aktualności Neurologiczne*, *13* (4).

Savage, M.J., Gingrich, D.E. (2009). Advances in the Development of Kinase Inhibitor Therapeutic for Alzheimer`s Disease. *Drug Development Research*, *70*.

Seeman, P., Seeman, N. (2011). Alzheimer's Disease: b-Amyloid Plaque Formation in Human Brain. *Synapse*, *65*.

Sobów, T. (2014). Memantyna w łagodnych zaburzeniach poznawczych i otępieniu alzheimerowskim o nasileniu lekkim: przesłanki teoretyczne, badania kliniczne i rekomendacje stosowane. *Aktualności Neurologiczne*, *14* (1).

Szwed, A., Miłowska, K. (2012). Rola białek w chorobach neurodegeneracyjnych. *Postępy Higieny i Medycyny Doświadczalnej*, *66*.

Tęgowska, E., Wosińska, A. (2011). Rola nauk biologicznych w zrozumieniu genezy i nowego podejścia terapeutycznego do choroby Alzheimera. *Postępy Higieny i Medycyny Doświadczalnej, 65.*

Tendera, K., Kruk, M., Biała, G. (2010). Alzheimer disease: causes, symptoms and pharmacotherapy. *Annales UMCS, Sectio DDD, Pharmacia, XXIII* (3), 13.

Tkaczyk, M., Florek, E., Piekoszewski, W. (2012). Marihuana i kanabinoidy jako leki. *Przegląd Lekarski*, *69* (10).

Walden-Gałuszko, K., Gaworska-Krzemińska, A. (2012). *Opieka paliatywna.* Wrocław: Wydawnictwo Elsevier Urban & Partner.

Cite this article as: Mieczkowski, M., Sieja, K., Stępień-Słodkowska, M. (2016). Review of Traditional and Natural Methods of Treating Alzheimer's Disease. *Central European Journal of Sport Sciences and Medicine*, *16* (4), 67–75. DOI: 10.18276/cej.2016.4-07.

EFFECTS OF ENERGY BOOST AND SPRINGBLADE FOOTWEAR ON RUNNING ECONOMY AND SUBSTRATE OXIDATION

Jonathan Sinclair,[1, A, B, C, D] Stephanie Dillon[2, C, D]

[1] Centre for Applied Sport and Exercise Sciences, School of Sport and Wellbeing, College of Health and Wellbeing, University of Central Lancashire, Preston, Lancashire, UK
[2] International Institute of Nutritional Sciences and Applied Food Safety Studies, School of Sport and Wellbeing, College of Health and Wellbeing, University of Central Lancashire, Preston, Lancashire, UK
[A] Study Design; [B] Data Collection; [C] Statistical Analysis; [D] Manuscript Preparation; [E] Funds Collection

Address for correspondence:
Jonathan Sinclair
Centre for Applied Sport Exercise and Nutritional Sciences
School of Sport and Wellbeing, College of Health and Wellbeing
University of Central Lancashire
Preston, Lancashire, UK, PR1 2HE
E-mail: jksinclair@uclan.ac.uk

Abstract The current study aimed to investigate the influence of energy boost, spring and conventional footwear on running economy and substrate usage. Ten male runners completed 5 min steady state runs in energy boost, spring and conventional footwear. Running economy and percent contribution of carbohydrate to total calorie expenditure were assessed. Participants also subjectively indicated which shoe condition they preferred for running. Differences between footwear were examined using repeated measures ANOVA. The results showed firstly that running economy was significantly improved in the energy return (33.36 ml.kg.min^{-1}) compared to spring (34.83 ml.kg.min^{-1}) and conventional footwear (34.65 ml.kg.min^{-1}). In addition, percent carbohydrate was significantly lower in the energy return (74.51%) in comparison to the spring (78.56%) and conventional (78.52%) footwear. As running economy was improved and carbohydrate utilization reduced in the energy return footwear, this study indicates that they may be associated with improvements in running performance.

Key words Running, economy, VO_2, footwear

Introduction

Endurance capacity in runners relates to the ability to maintain a given velocity (Jones, 2006). Aerobic exercise requires the re-synthesis of ATP via oxidative phosphorylation in order to provide energy, and necessitates both the delivery of oxygen and also the availability of carbohydrates and fats. The economy of running represents the amount of inspired oxygen that is required to maintain a given steady state running speed (Saunders et al., 2004). Importantly running economy is strongly linked with running performance (Williams, Cavanagh, 1987), and has been demonstrated as a better predictor of performance that indices of maximum oxygen uptake (Hanson et al.,

2010). Superior running economy indicates that a runner is able to exercise at the same velocity, whilst functioning at a lower percentage of their maximum work output. given its proposed relationship with running performance, economy is of substantial interest to both runners and researchers alike.

Running footwear has been advocated as a mechanism by which running economy may be influenced. The results from previous work has provided conflicting results, with some showing that footwear can mediate alterations in running economy and others indicating that footwear is not influential. Both Bosco, Rusco (1983) and Frederick et al. (1986) demonstrated that running in footwear with viscoelastic cushioning properties significantly enhanced running economy. Similarly, the observations provided by Woboret et al. (2014) demonstrated that a footwear with the softest midsole improved running economy in relation to a control shoe during overground and treadmill running. Some research has however shown that running footwear does not influence the economy of running. Nigg et al. (2003) examined footwear with distinct midsole cushioning properties and showed that the did not significantly affect the oxygen requirements of steady state running. Similarly, Sinclair et al. (2014) examined footwear with different shock attenuating properties which did not have any effect of running economy.

The concept footwear energy return is now a novel subject area in the field of biomechanics. The energy boost concept designed by Adidas were the first to commercialize the energy return principle, using a polyurethane thermoplastic midsole designed to reduce energy loss relation to traditional ethylene-vinyl acetate materials. There has been only limited research into the effects of these footwear. Sinclair et al. (2014) investigated the effects of conventional and energy boost footwear on the kinetics and kinematics of running. Their results showed that the conventional running footwear were associated with significantly reduced tibial accelerations and peak eversion angles in comparison to energy boost. Sinclair et al. (2015) demonstrated that the energy return footwear significantly improved running economy in comparison to a conventional running shoe. In addition, Sinclair et al. (2016) showed that energy return shoes improved running economy and reduced the bodies reliance on carbohydrate as an energy source in comparison to minimalist and maximalist footwear of equal mass.

In addition to the energy boost shoes, a further footwear design, the springblade has been introduced more recently by Adidas which similarly is designed to increase the energy returned from the midsole. These footwear feature 16 curved blades which are designed to store and release energy. Currently there is only one investigation which has examined the biomechanics of running in the springblade footwear. Sinclair and Dillon (2016) examined the kinetics and kinematics of running in the spring footwear in relation to conventional footwear. Their observations showed that spring footwear were associated with significant increases in peak eversion and tibial internal rotation. To date there has still yet to be any published work which has investigated the effects of spring footwear on running economy, given the importance of running economy research of this nature would be of both practical and clinical significance.

The aim of the current study was to explore the effects of energy return, spring and conventional footwear on running economy and substrate oxidation during steady state running. A study of this nature may provide additional information that will help to understand the mechanisms by which different footwear may influence running economy.

Methods

Participants

Ten male runners volunteered for this work. The mean characteristics of the participants were: age 22.11 ±2.14 years, height 177.44 ±4.27 cm and body mass 73.47 ±5.24 kg. All participants were free from lower extremity

injury and were not taking any prescribed medication at the time of data collection. Written informed consent was obtained from all runners in accordance with the declaration of Helsinki. The procedure utilized for this work was approved by the University of Central Lancashire, Science, Technology, Engineering and Mathematics, ethical committee (Ref: 422).

Procedure

Participants ran in each footwear at 12.5 $km.h^{-1}$ on a laboratory treadmill (HP Cosmos, Nussdorf-Traunstein) with maintained at a gradient of 0% (Sinclair et al., 2015). The velocity of the treadmill belt has been validated previously (Sinclair et al., 2014). The order that the experimental footwear were worn was randomized (Frederick et al., 1986). Breath by breath gas analysis was undertaken via an ergospirometry system (MetaLyser 3B system, Cortex Biophysic, Leipzig, Germany). Participants were asked to continue their customary dietary intake in the 48 hours before data collection testing and undertook data collection 4 hours postprandial.

Data collection firstly required baseline data to be obtained this involved 10 minutes of quiet sitting whilst the volume of inspired oxygen (VO_2) was measured (Gruber et al., 2013). Participants were also required to undertake a 3 min habituation period in all footwear conditions, during which they ran at the required velocity prior to the commencement of data collection (Hanson et al., 2010). Participants then completed 6 min steady state runs in accordance with the protocol used by Nigg et al. (2003). All metabolic data was collected within the same testing session with rest in between. The subsequent footwear condition was not examined until VO_2 returned to within 0.025 $l.min^{-1}$ of baseline measurements.

Data reduction

The second five minutes of the baseline data were averaged to obtain a resting VO_2 measurement. This value was subtracted from the mean VO_2 obtained during the running trials to provide a net value of oxygen consumption ($ml.kg.min^{-1}$). The metabolic substrates in grams per minute that were used during exercise were determined using the amounts of inspired oxygen (VO_2) and expired carbon dioxide (VCO_2) in accordance with the below (McArdle et al., 2010).

$$\text{Carbohydrate} = 4.58 \times VCO_2 - 3.23 \times VO_2,$$
$$\text{Fat} = 1.70 \times VO_2 - 1.69 \times VCO_2.$$

To calculate the energy expended in kilocalories during each run the amount of carbohydrate and fat in grams utilized during the trials were multiplied by 4 for carbohydrate and by 9 for fats and then adding together the contribution from the two substrates. To quantify the relative contribution of carbohydrates to total kilocalories (percent carbohydrate) the number of kilocalories derived exclusively from carbohydrate by the total kilocalories was divided by the total number of kilocalories.

Finally, following each run participants were asked to provide their rating of the comfort of each shoe. This involved a 100 mm visual analogue scale with the extreme left side being indicative of 'not comfortable at all' and the extreme right of the scale labelled as 'most comfortable condition imaginable' (Mündermann, et al., 2002).

Experimental footwear

The footwear used during this study consisted of conventional footwear (New Balance 1260 v2), energy boost (Adidas energy boost) and spring (Adidas springblade drive 2) footwear, (shoe size 8–10 in UK men's sizes) (Figure 1).

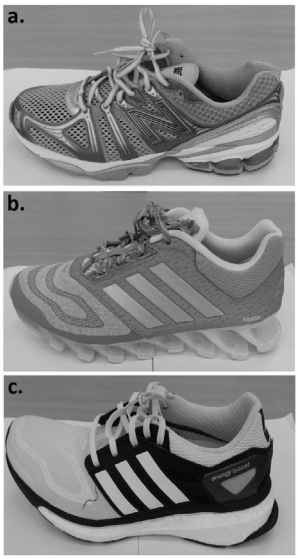


Figure 1: Experimental footwear (a. conventional, b. spring, c. energy boost).

Statistical analysis

Means, standard deviations and 95% confidence intervals were calculated for each outcome measure for each footwear condition. Differences in between footwear were examined using one-way repeated measures ANOVAs, with significance accepted at the $P \leq 0.05$ level (Sinclair et al., 2013). Effect sizes were calculated using partial eta^2 ($p\eta^2$). Post-hoc pairwise comparisons were conducted on all significant main effects. In addition to this percentage differences were also calculated for all statistically significant effects. All statistical actions were conducted using SPSS v22.0 (SPSS Inc., Chicago, USA).

Results

Table 1. Mean, standard deviation and 95% confidence interval, metabolic and shoe comfort parameters for each footwear condition

	Energy return			Spring			Conventional		
	mean	SD	95% CI	mean	SD	95% CI	mean	SD	95% CI
Net VO_2 (ml.kg.min^{-1})	33.36	2.47	31.29–35.42	34.83	2.79	32.49–37.17	34.65	2.68	32.41–36.90
% CHO	74.51	7.46	68.27–80.75	78.56	6.86	72.82–84.29	78.52	7.08	72.60–84.44

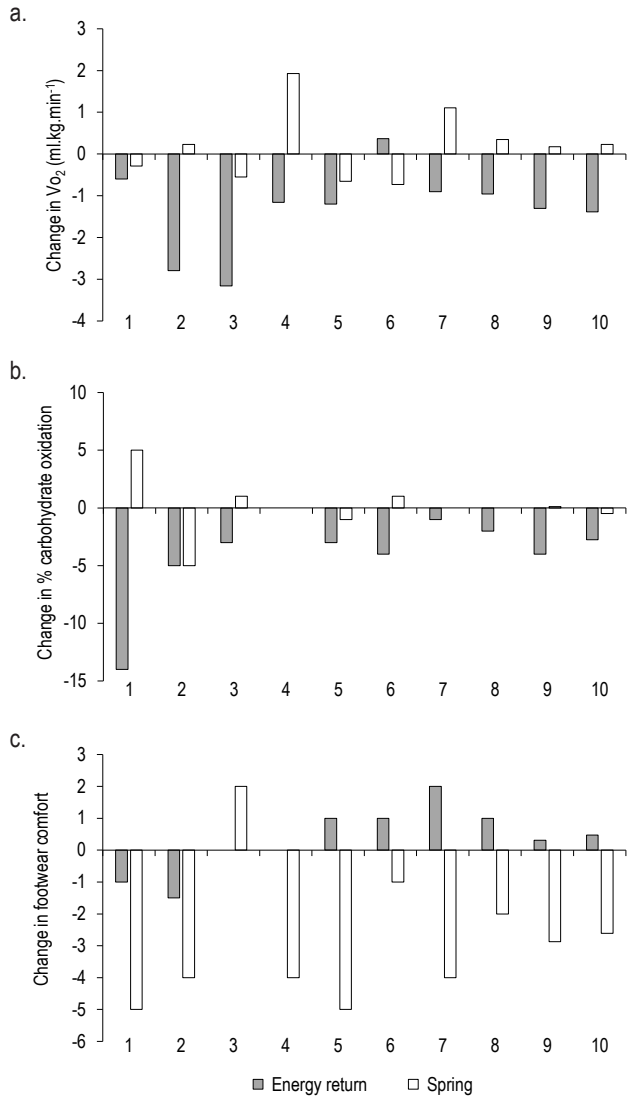


Figure 2. Differences in a. – net VO_2, b. – percent carbohydrate oxidation and c. – footwear comfort between the energy return/spring footwear in relation to conventional running shoes. Positive indices indicate that values were greater the energy return/spring footwear

Net VO_2

A significant main effect ($P < 0.05$, $p\eta^2 = 0.50$) was shown for net VO_2. Post-hoc analyses showed that net VO_2 was significantly lower in the energy return footwear in comparison to the spring ($P = 0.026$) and conventional ($P = 0.015$) conditions.

Substrate usage

A significant main effect ($P < 0.05$, $p\eta^2 = 0.35$) was shown for percent carbohydrate. Post-hoc analyses showed that percent carbohydrate was significantly lower in the energy return footwear in comparison to the conventional ($P = 0.034$) condition.

Shoe comfort

A significant main effect ($P < 0.05$, $p\eta^2 = 0.61$) was shown for shoe comfort. Post-hoc analyses showed that shoe comfort was rated as being significantly lower in the spring footwear in comparison to the energy return ($P = 0.010$) and conventional ($P = 0.012$) condition.

Discussion

The aim of the current investigation was to study the influence of energy boost, spring and conventional footwear on running economy and substrate oxidation during steady state treadmill running. To our knowledge this work represents the first examination of the effects of spring footwear on running economy and a study of this nature may give important information to runners regarding appropriate footwear selection and also improve our understanding of the manner by which different footwear may influence running economy and the substrates that are used to fuel exercise metabolism.

The current study showed firstly that the energy return shoes were associated with significantly reduced net VO_2 in comparison to the conventional and spring footwear, indicating that economy was enhanced in this condition. This observation supports the findings of Sinclair et al. (2015) and Sinclair et al. (2016) who showed that the energy boost footwear were most economical in relation to conventional, minimalist and maximalist shoe conditions. Given the proposed association between running economy and performance, this indicates that the energy return footwear may be associated with increased performance in relation to the conventional and spring footwear. Ultimately the mechanisms that mediated this improvement in economy is impossible to determine accurately, however Sinclair et al. (2015) suggested that the potential increase in returned energy from the shoe midsole could be responsible. The effects of the energy return footwear on running performance in relation to the spring and conventional conditions can be appraised by taking into account the observations of Burkett et al. (1985) who showed that every 1.0% increase in steady-state VO_2 mediated a subsequent 0.17 $km.h^{-1}$ reduction in running velocity. As such application of the reductions in net VO_2 observed in the energy boost footwear indicates that this condition would translate into a 13 min and 11 min reductions in marathon times in relation to the spring and conventional footwear respectively.

A further important finding from this work is that carbohydrate oxidation was shown to be significantly lower in the energy return footwear in relation to the spring and conventional shoe conditions. This result is also in agreement with the findings of Sinclair et al. (2015) and Sinclair et al. (2016) who also showed that energy return footwear reduced the bodies' reliance on carbohydrate. This result may be similarly important as distance running is known to rely heavily on carbohydrate metabolism as an energy source a (Rapoport et al., 2010). Therefore, a reduced contribution of carbohydrate to energy expenditure during running may be significant in long distance events, as it may prevent the onset of glycogen depletion, which is known to be a limiting factor in prolonged aerobic performance (Rapoport et al., 2010).

Finally, a further key observation from this investigation is that the energy return and conventional footwear were rated as being subjectively more comfortable in relation to the spring shoe condition. Luo et al. (2009) showed that running economy was greatest in footwear rated as being the most comfortable, an observation supported by the observations of Sinclair et al. (2015) and Sinclair et al. (2016). The results from the current investigation provide only partial support for these findings as both energy return and conventional and footwear were rated as being most comfortable in the current investigation, although the energy return condition was shown to be the most economical. The improved footwear comfort noted by Sinclair et al. (2015) and Sinclair et al. (2016) was used to explain the increases in running economy in these studies, however this study shows that the association between comfort and running economy may be more complex than previously anticipated. Therefore, further work investigating the relationship between footwear comfort and running economy is still required.

The results from the current study highlight the complexities of the interaction between biomechanical and physiological data. This study confirms the findings of previous work in that the energy return footwear may be associated with performance benefits in relation to other footwear conditions. However, the study of Sinclair et al. (2014) who examined the kinetics and kinematics of running in energy return and conventional footwear, showed that energy return footwear were associated with increased tibial acceleration and peak eversion parameters that have been linked to the aetiology of injury (R). As such it appears that whilst the energy return footwear may be able to mediate performance benefits, they may place runners at increased risk from chronic injuries.

In conclusion whilst the effects of energy return footwear on running economy have been investigated previously there has yet to be an examination of running economy and substrate utilization when running in spring footwear. This study therefore gives new information regarding the effects of spring footwear on running performance in relation to energy return and conventional footwear. As both net VO_2 and carbohydrate utilization were lower when running in the energy return footwear in relation to conventional and spring shoes, this investigation indicates that the energy return footwear may be associated with improvements in running performance.

References

Bosco, C., Rusko, H. (1983). The effect of prolonged skeletal muscle stretch-shortening cycle on recoil of elastic energy and on energy expenditure. *Acta Physiologica Scandinavica*, *119*, 219–224.

Frederick, E.C., Howley, E.T., Powers, S.K. (1986). Lower oxygen demands of running in soft-soled shoes. *Research Quarterly for Exercise & Sport*, *57*, 174–177.

Gruber, A.H., Umberger, B.R., Braun, B., Hamill, J. (2013). Economy and rate of carbohydrate oxidation during running with rearfoot and forefoot strike patterns. *Journal of Applied Physiology*, *115*, 194–201.

Hanson, N.J., Berg, K., Deka, P., Meendering, J.R., Ryan, C. (2010). Oxygen Cost of Running Barefoot vs. Running Shod. *International Journal of Sports Medicine*, *32*, 401–406.

Jones, A. (2006). The physiology of the world record holder for the women's marathon. *International Journal of Sports Science & Coaching*, *1*, 101–116.

Luo, G., Stergiou, P., Worobets, J., Nigg, B., Stefanyshyn, D. (2009). Improved footwear comfort reduces oxygen consumption during running. *Footwear Science*, *1*, 25–29.

McArdle, W.D., Katch, F.I., Katch, V.L. (2010). *Exercise physiology: nutrition, energy, and human performance*. Philadelphia PA: Lippincott Williams & Wilkins.

Mündermann, A., Nigg, B.M., Stefanyshyn, D.J., Humble, R.N. (2002). Development of a reliable method to assess footwear comfort during running. *Gait & Posture*, *16*, 38–45.

Nigg, B.M., Stefanyshyn, D., Cole, G., Stergiou, P., Miller, J. (2003). The effect of material characteristics of shoe soles on muscle activation and energy aspects during running. *Journal of Biomechanics*, *36*, 569–575.

Rapoport, B.I. (2010). Metabolic factors limiting performance in marathon runners. *PLoS One Computational Biology*, *6*, 1–13.

Sinclair, J., Taylor, P.J., Hobbs, S.J. (2013). Alpha level adjustments for multiple dependent variable analyses and their applicability – a review. *International Journal of Sports Science & Engineering*, *7*, 17–20.

Sinclair, J., Taylor, P.J., Edmundson, C.J., Brooks, D., Hobbs, S.J. (2014). The influence of footwear kinetic, kinematic and electromyographical parameters on the energy requirements of steady state running. *Movement & Sports Sciences*, *80*, 39–49.

Sinclair, J., Franks, C., Goodwin, J.F., Naemi, R., Chockalingam, N. (2014). Influence of footwear designed to boost energy return on the kinetics and kinematics of running compared to conventional running shoes. *Comparative Exercise Physiology*, *10*, 199–206.

Sinclair, J., Mcgrath, R., Brook, O., Taylor, P. J., Dillon, S. (2015). Influence of footwear designed to boost energy return on running economy in comparison to a conventional running shoe. *Journal of Sports Sciences*, *34*, 1094–1098.

Sinclair, J., Shore, H., Dillon, S. (2016). The effect of minimalist, maximalist and energy return footwear of equal mass on running economy and substrate utilisation. *Comparative Exercise Physiology*, *12*, 49–54.

Sinclair, J., Dillon, S. The influence of energy return and spring footwear on the kinetics and kinematics of running. *Human Movement* (in press).

Williams, K.R., Cavanagh, P.R. (1987). Relationship between distance running mechanics, running economy, and performance. *Journal of Applied Physiology*, *63*, 1236–1245.

Worobets, J., Wannop, J.W., Tomaras, E., Stefanyshyn, D. (2014). Softer and more resilient running shoe cushioning properties enhance running economy. *Footwear Science*, *6*, 147–153.

Cite this article as: Sinclair, J., Dillon, S. (2016). Effects of Energy Boost and Springblade Footwear on Running Economy and Substrate Oxidation. *Central European Journal of Sport Sciences and Medicine*, *16* (4), 77–84. DOI: 10.18276/cej.2016.4-08.

ASSESSMENT OF SHOULDER JOINT STRENGTH DISPROPORTION OF MASTERS SWIMMERS

Aleksander Wiażewicz,[A, B, C, D] Jerzy Eider[A, D]

Faculty of Physical Culture and Health Promotion, University of Szczecin, Poland
[A] Study Design; [B] Data Collection; [C] Statistical Analysis; [D] Manuscript Preparation

Address for correspondence:
Aleksander Wiażewicz
Faculty of Physical Culture and Health Promotion, University of Szczecin
Al. Piastów 40 B, building 6, 71-065 Szczecin, Poland
E-mail: Aleksander.Wiazewicz@usz.edu.pl

Abstract The aim of this study was to find out whether Masters class swimming affects strength disproportion and if there is a correlation between the length of sport swimming training in Masters swimmer's past (SST) and strength parameter's deficits? Eighteen Masters category swimmers affiliated in Szczecin Masters Team (178.3 ±2.28 m; 77.9 ±2.86 kg) participated in the study. Isokinetic strength measurement was made on Biodex S4 dynamometer. Subjects performed shoulder flexion/extension moves: 3 repetitions – 60 deg/sec and 20 repetitions – 180 deg/sec. Following values were used: peak torque (PT), maximal repetition work (MRW), coefficient of variation (COV), total work (TW), average power (AP), agonist to antagonist ratio (AG:AN). None of the investigated variables were statistically significant in side to side comparison. All of the parameters were higher in extension. Also, no statistically significant difference between sides in AG:AN. Moderate positive correlation was found between SST and PT deficit in extension movement (0.420). Also low positive correlation between SST and PT deficit in flexion (0.396), and MRW deficit in extension (0.352). Masters class swimming did not affect side strength disproportion or agonist to antagonist differences. However, it is possible that swimming training in other categories does.

Key words shoulder joint, strength, Masters swimmers, Biodex

Introduction

The number of masters athletes is increasing. They spend more time working out, playing sport and have better health then other people (Rittwager, di Prampero, Maffulli, Narici, 2009). Masters athletes are active, full of power and vital forces. They want to live a healthy, fulfilled life (Dionigi, 2006). The effects of regular Masters trainings provide that the older athletes perform much better than younger people that lead sedentary lives (Ransdell, Vener, Huberty, 2009). Researchers Young and Medic (2011) were also examining social influences on the sport commitment of Masters swimmers. Hodge, Allen, Smellie (2008) studied the relationships amongst achievement goals, social goals and motivational correlates in Masters sport. Others Petrescu, Piţigoi, Păunescu (2014) are highlighting the role and influence of Masters swimming on mental condition.

However, the question arises whether Masters sport swimming is certainly good for older athletes strength and health? Abrahin's et al. (2016) results showed that swimming has no positive influence on bone mineral density. Banias and Rasadean (2011) highlighted the reduction of swimming speed in relation to age, in freestyle men events. Muscle area decreases by 40% in the ages section between 20 and 80 years. Decreased power, lower force production and less efficient agonist-antagonist muscle group coordination is observed (Lemmer et al., 2003). Nevertheless the strength abilities are very important element that has an impact on the final swimming result (Crowe, Babington, Tanner, Stager, 1999; Dopsaj, Matković, Thanopoulos, Okičić, 2004; Kjendlie, Thorsvald, 2006; Morouco et al., 2011). Numerous repeats can cause an imbalance in muscle strength of the shoulder girdle (Bak, 1996). Batalha, Marmeleira, Garrido, Silva (2014), Batalha, Raimundo, Tomas-Carus, Barbosa, Silva (2013), Ramsi, Swanik, Swanik, Straub, Mattacola (2004) and Walker, Gabbe, Wajswelner, Blanch, Bennell (2012) indicate that swimming technique can cause a lack of balance in shoulder muscle strength. Olivier, Quintin, Rogez (2008) formulated a conclusion that sport swimming at the highest level weakens the shoulder joint and interferes muscle balance. Havriluk (2009) identified three factors limiting the effectiveness of swimming: the differences between the right and left shoulder, loss of strength and unnecessary movements. These factors may affect all swimmers.

The main aim of this study was to find out whether Masters class swimming affects side strength disproportion or agonist to antagonist differences?

The purpose was to find statistically significant differences in: peak torque, work done in maximal repetition, repeatability of movements, total work done and average power between the right and the left arm in flexion and extension in Masters swimmers. Furthermore it was to find out significant differences in agonist to antagonist strength ratios of their right and left shoulder and a correlation between the length of sport swimming training in Masters swimmer's past and strength parameter's deficits.

Methods

Eighteen subjects (178.3 ±2.28 m; 77.9 ±2.86 kg) participated in the study. They were all Masters category swimmers affiliated in Szczecin Masters Team. Participants gave written consent to the test. Bioethics Committee at the Regional Medical Chamber in Szczecin has expressed a positive opinion about the research project in the following range (resolution No. 15/KB/V/2013 dated 10.12.2013). At first, subjects performed 5-minute warm up on the cross trainer device, then 5-minute warm up focused on the shoulder joint. The isokinetic strength measurement was made on the Biodex S4 dynamometer (Biodex Corp., Shirley, NY, USA). During the test, subjects done 3 shoulder flexion/extension repetitions with the 60 deg/sec angular speed (protocol 1). After 2-minute break they performed 20 shoulder flexion/extension repetitions with the 180 deg/sec angular speed (protocol 2). There was a 4-minute rest between right and left limb measurement. Preparation part and the measurement were made in accordance with instructions (Biodex Medical Systems, Inc. *Biodex Multi-Joint System – Pro. Setup/Operation Manual*.).

The following values were used: peak torque (PT), maximal repetition work (MRW) from protocol 1 and coefficient of variation (COV), total work (TW), average power (AP), agonist to antagonist ratio (AG:AN) form protocol 2 (for both – flexion and extension).

For statistical data analyzing a Statistica 12.5 and descriptive statistics tools were used. To check whether samples came from a normally distributed population, researchers used a Shapiro-Wilk test. If the result of Shapiro-Wilk's test was significant (significance level 0.05) in at least one of the two compared variables, a nonparametric

Mann-Whitney U test was used. Otherwise a t-Test: two-sample assuming equal variances data analysis tool (significance level 0.05) was used. Pearson correlation coefficients were computed between the length of sport swimming training (SST) in the subjects' past and PT, MRW, TW and AP side deficits.

Results

Only one parameter difference – COV, was close to statistically significant. PT and COV were higher in right shoulder in both moves. MRW, TW and AP were higher in the left arm in both directions. But none of the investigated variables were statistically significant in side to side comparison. All of the parameters were higher in extension moves (Table 1). Left shoulder had higher agonist to antagonist strength ratio, but also there was no statistically significant difference between sides (Table 2).

Table 1. Differences in right and left shoulder joint strength in Masters swimmers

Variable		Flexion		Extension	
		Average ± SD	P	Average ± SD	P
PT (Nm)	right shoulder	56.39 ±4.18	0.9152	65.25 ±5.80	0.8615
	left shoulder	55.77 ±4.02		63.85 ±5.45	
MRW (J)	right shoulder	154.88 ±11.85	0.9502	174.68 ±16.04	0.9248
	left shoulder	155.88 ±10.59		176.72 ±14.23	
COV (%)	right shoulder*	15.76 ±2.02	0.0556	20.92 ±3.31	0.5166
	left shoulder*	10.97 ±0.91		16.39 ±2.23	
TW (J)	right shoulder	1,663.82 ±150.63	0.8955	1,803.26 ±261.71	0.7036
	left shoulder	1,691.79 ±148.22		1,934.58 ±220.59	
AP (W)	right shoulder	53.04 ±5.55	0.7205	59.17 ±9.33	0.6962
	left shoulder	55.86 ±5.49		64.06 ±8.19	

* A nonparametric Mann-Whitney U test was used.

Table 2. Differences of agonist to antagonist strength ratio in Masters swimmers shoulder joint

Variable		Average ± SD	P
AG:AN (%)	right shoulder*	87.92 ±16.52	0.937
	left shoulder*	89.21 ±18.48	

* A nonparametric Mann-Whitney U test was used.

The length of sport swimming training (SST) in the subjects' past was compared with PT, MRW, TW and AP side deficits. Moderate positive correlation was found between SST and PT deficit in extension movement (0.420). Low positive correlation was found between SST and PT deficit in flexion (0.396), also MRW deficit in extension (0.352) (Table 3).

Table 3. Correlations between length of sport swimming training (SST) in the subjects' past and measured variables deficits

Variables	Flexion				Extension			
	PT def.	MRW def.	TW def.	AP def.	PT def.	MRW def.	TW def.	AP def.
SST	0.396	0.008	–0.164	–0.146	0.420	0.352	0.057	0.097

Discussion

There are no statistically significant differences in: peak torque, work done in maximal repetition, total work done and average power between the right and the left arm in flexion and extension in Masters swimmers. Also, no difference in dominant and non-dominant shoulder motor function was seen in either the younger or older untrained men in Gallagher, Zuckerman, Cuomo, Ortiz (1996) research. Subjects in this studies had higher PT scores than untrained persons results: extension 53.9 Nm and flexion 43.5 Nm (Ivey, 1985). Study was carried out on Cybex. As well as PT was higher than average presented by Mayer (2001) 48 Nm in flexion, 62 Nm in extension, both measured in 60 deg/sec.

All isokinetic variables were higher in the extension movements, for both sides. This is consistent with the Alonso-Cortés Fradejas et al. (2006) results. Also Ivey (1985) results indicates that in untrained persons shoulder strength extension results were higher than in flexion in 60 deg/s test. In individual analysis of subjects results, there were notable differences and large variables deficits. Masters athletes should accept that they will not achieve the same level as they did when they were younger. Aging will cause changes in the body as well as in their ability to compete. Weight training prevention program should be applied to avoid the lean body mass loss and strength decline (Ransdell et al., 2009). According to Alonso-Cortés Fradejas et al. (2006) sport swimming participants should seek for a harmonious development of both sides of the body.

The repeatability of movements – coefficient of variances was high, but also no statistically significant difference was noticed between the right and left shoulder. Acceptable COV is less than or equal to 15% (Isokinetic testing and data interpretation) as in the extension in subjects results. COV of shoulder flexion was just above this limit. Ransdell et al. (2009) indicates that the quantity of training can't be more important than its quality.

The agonist to antagonist strength ratios of Masters swimmers are higher than suggested by Biodex – 83% (Isokinetic testing and data interpretation), but there is no significant difference between right and left shoulder. The AG:AN ratio is important information in pathological states, and its normalization must be the main goal of rehabilitation (Codine, Bernard, Pocholle, Herisson, 2005). Misalignment of AG:AN ratio can lead to injuries (Isokinetic testing and data interpretation). Many authors (Batalha et al., 2014; Batalha et al., 2013; Ramsi et al., 2004; Walker et al., 2012; Wiażewicz, 2015) postulates enforcement of compensatory programs, because of the agonist to antagonist ratio disorder.

There were moderate and low positive correlations between length of sport swimming training in the subjects' past and measured variables deficits. Although swimming is symmetrical sports, long-term and intensive water training, causes asymmetry targeted to the stronger arm (Olivier et al., 2008). The results of Batalha et al. (2014) also suggests that swimming training macrocycles lead to an increase of the shoulder rotator muscles imbalance in younger swimmers.

Conclusion

Masters class swimming did not affect side strength disproportion or agonist to antagonist differences. However, it is possible that swimming training in other categories does. It should be considered to perform a similar study with sport swimmers from other categories with high training experience.

References

Abrahin, O., Rodrigues, R.P., Marçal, A.C., Alves, E.A.C., Figueiredo, R.C., de Sousa, E.C. (2016). Swimming and cycling do not cause positive effects on bone mineral density: a systematic review. *Revista Brasileira de Reumatologia (English Edition)*, *56* (4), 345–351.

Alonso-Cortés Fradejas, B., Alvear-Órdenes, I., Ramírez-García, C., García-Isla, F.J., González-Gallego, J., Seco Calvo, J. (2006). Valoración isocinética del hombro en jóvenes nadadores mediante un patrón diagonal. *Fisioterapia*, 28 (6), 298–307.

Bak, K. (1996). Nontraumatic glenohumeral instability and coracoacromial impingement in swimmers. *Scandinavian Journal of Medicine and Science in Sports*, *6* (3), 132–144.

Banias, P., Rasadean, M. (2011). Study on reduction of swimming speed in relation to age, in freestyle men events, in masters swimming. *Procedia – Social and Behavioral Sciences*, *15*, 2684–2688.

Batalha, N., Marmeleira, J., Garrido, N., Silva, A.J. (2014). Does a water-training macrocycle really create imbalances in swimmers' shoulder rotator muscles? *European Journal of Sport Science*, *23*, 1–6.

Batalha, N.M., Raimundo, A.M., Tomas-Carus, P., Barbosa, T.M., Silva, A.J. (2013). Shoulder rotator cuff balance, strength, and endurance in young swimmers during a competitive season. *Journal of Strength and Conditioning Research*, *27* (9), 2562–2568.

Biodex Medical Systems, Inc. *Biodex Multi-Joint System – Pro. Setup/Operation Manual*. New York: Biodex Medical Systems, Inc.

Biodex Medical Systems, Inc. *Isokinetic testing and data interpretation*. New York: Biodex Medical Systems, Inc.

Codine, P., Bernard, P.L., Pocholle, M., Herisson, C. (2005). Évaluation et rééducation des muscles de l'épaule en isocinétisme: méthodologie, résultats et applications. *Annales de Réadaptation et de Médecine Physique*, *48* (2), 80–92.

Crowe, S., Babington, J., Tanner, D., Stager, J. (1999). The relationship of strength to dryland power, swimming power, and swimming performance. *Med Sci Sports Exerc*, *31* (5), *S255.*

Dionigi, R. (2006). Competitive sport as leisure in later life: negotiations, discourse, and aging. *Leis Sci, 28*, 181–196.

Dopsaj, M., Matković, I., Thanopoulos, V., Okičić, T. (2004). Reliability and validity of basic kinematics and mechanical characteristics of pulling force in swimmers measured by method of tethered swimming with maximum intensity of 60 seconds. *Physical Education and Sport*, *1* (10), 11–22.

Gallagher, M.A., Zuckerman, J.D., Cuomo, F., Ortiz J. (1996). The effect of age, speed, and arm dominance on shoulder function in untrained men. *Journal of Shoulder and Elbow Surgery*, *5* (1), 25–31.

Havriluk, R. (2009). Analyzing Hand Force in Swimming. Three Typical Limiting Factors. *ASCA Newsletter, 5*, 22–26.

Hodge, K., Allen, J.B., Smellie, L. (2008). Motivation in Masters sport: Achievement and social goals. *Psychology of Sport and Exercise*, *9* (2), 157–176.

Ivey, F.M., Calhoum, J.H., Rusche, K., Bierschenk, J. (1985). Isokinetic testing of shoulder strength/normal values. *Arch Phys Med Rehabil, 66*, 384–386.

Kjendlie, P.-L., Thorsvald, K. (2006). A tethered swimming power test is highly reliable. *Port J Sport Sci*, *6* (S2), 231–233.

Lemmer, J.T., Hurlbut, D.E., Martel, T.B.L., Ivey, F.M., Metter, E.J., Fozard, J.L., Fleg, J.L., Hurley B.F. (2003). Age and gender responses to strength training and detraining. *Med Sci Sports Exerc*, *32*, 1505–1512.

Mayer, F., Horstman, T. (2001). Diagnostics with isokinetic devices in shoulder measurements – potentials and limits. *Isokinet Exerc Sci*, *9*, 19–25.

Morouco, P., Neiva, H., Gonzalez-Badillo, J., Garrido, N., Marinho, D., Marques, M. (2011). Associations Between Dry Land Strength and Power Measurements with Swimming Performance in Elite Athletes: a Pilot Study. *J Hum Kinet*, *29A*, 105–112.

Olivier, N., Quintin, G., Rogez, J. (2008). The high level swimmer articular shoulder complex. Annales de Readaptation et de Medecine Physique, *51* (5), 342–347.

Petrescu, S., Piţigoi, G., Păunescu, M. (2014). The Effects of Practicing Swimming on the Psychological Tone in Adulthood. *Procedia – Social and Behavioral Sciences*, *159*, 74–77.

Ramsi, M., Swanik, K.A., Swanik, C., Straub, S., Mattacola, C. (2004). Shoulder-Rotator Strength of High School Swimmers over the Course of a Competitive Season. *Journal of Sport Rehabilitation, 13* (1), 9–18.

Ransdell, L.B., Vener, J., Huberty J. (2009). Masters Athletes: An Analysis of Running, Swimming and Cycling Performance by Age and Gender. *Journal of Exercise Science & Fitness*, *7* (2), S61–S73.

Rittwager, J., di Prampero, P.E., Maffulli, N., Narici, M.V. (2009). Sprint and endurance power and aging: an analysis of master athletic world records. *Proc R Soc B*, *276*, 683–689.

Walker, H., Gabbe, B., Wajswelner, H., Blanch, P., Bennell, K. (2012). Shoulder pain in swimmers: A 12-month prospective cohort study of incidence and risk factors. *Physical Therapy in Sport*, *13* (4), 243–249.

Wiażewicz, A. (2015). Izokinetyczna ocena parametrów siłowych u zawodników w Ośrodku Szkolenia Pływackiego w Szczecinie. In: J. Eider (ed.), *Wybrane zagadnienia olimpijskie w teorii i praktyce* (pp. 197–213). Szczecin: Wydawnictwo Naukowe Uniwersytetu Szczecińskiego.

Young, B.W., Medic, N. (2011). Examining social influences on the sport commitment of Masters swimmers. *Psychology of Sport and Exercise*, 12 (2), 168–175.

Cite this article as: Wiażewicz, A., Eider, J. (2016). Assessment of Shoulder Joint Strength Disproportion of Masters Swimmers. *Central European Journal of Sport Sciences and Medicine*, *16* (4), 85–90. DOI: 10.18276/cej.2016.4-09.

DETERMINATION OF CAPACITY AND RULES OF THE VARIABILITY OF MAXIMUM FORCE USING NONLINEAR MATHEMATICAL MODELS: A CASE STUDY

Milenko B. Milosevic,[1, A, B, C, D] Vesna J. Nemec,[1, A, B, C, D] Morteza Jourkesh,[2, A, B, C, D] Predrag M. Nemec,[1, A, B, C, D] Milos M. Milosevic,[3, A, B, C, D] Behm G. David[4, A, B, C, D]

[1] Faculty of Management in Sport, Alpha University, Belgrade, Serbia
[2] Department of Physical Education and Sports Science, Shabestar Branch, Islamic Azad University, Shabestar, Iran
[3] Faculty of Sport, University Union-Nikola Tesla, Belgrade, Serbia
[4] School of Human Kinetics and Recreation, Memorial University of Newfoundland, Canada
[A] Study Design; [B] Data Collection; [C] Statistical Analysis; [D] Manuscript Preparation

Address for correspondence:
Milenko B. Milosevic
Alpha University
Faculty of Management in Sport
3 Palmira Toljatija Street, 11000 Belgrade Serbia
E-mail: mlsvc2010@gmail.com

Abstract The aim of this study is to determine the capacity and the variability of maximum force rules measured 1 RM for eight muscle groups (back-hip extensors, legs extensors, arm extensors, back extensors, shoulder and arms extensors, shoulder joint flexors, hip and knee extensors, trunk flexors). The determination was performed on the experimental results of the top basketball center player using repeated measurements and nonlinear mathematical models methods. Changes in maximum force were induced with 8 months of weight lifting training and analised with nonlinear regression analysis within 95% confidence interval. The results indicate that from all the models applied only the Asymptotic Regression, Michaelis-Menten and Gompertz Growth models had satisfactory performance and provided solid solutions to the given problem. This means that the models developed in this study properly and reliably determine the capacity and predicted changes in the maximum force (1 RM) for all eight monitored muscle groups.

Key words additive model, interactive model, nonlinear models, 1 repetion maximum prediction, resistnce training

Introduction

For proper training programming and selection of athletes, it is necessary to know the capacity and the variability of performances. To determine the capacity and variability of athletes' performances, two models (theory) are commonly used, additive and interactive (Tucker, Collins, 2011). With the additive model, capacity and volatility are determined by the sum of the genetic and training variance. This model assumes that both parts of the total variability are additive, which may not be entirely valid. One of the extremes of the additive model is the Galton

model (Galton, 1869, quoted in Ericsson, Nandagopal, Roring, 2009) by which training contributes to developing of the performances, but capacity (upper limit of development) is determined solely by a genetic component. The other extreme is the Ericsson model (Ericsson, Krampe, 1996; Ericsson, Nandagopal, Roring 2009) where capacity is determined exclusively by a training component. An interactive model in addition to the genetic and training component introduces the component that indicates the interaction between genetic and simulation components, as well (Schneider, 1997; Vaeyens, Güllich, Warr, Philippaerts, 2009). This model implies that the volatility of performance and thus the capacities and the top sports achievements, in addition to these two components, are determined by result of interaction between genetic and training component..In this paper, the problem of determining the capacity and variability of maximum force in particular muscle groups has been resolved in an elite basketball center player.

The problem of modern training is the fact that average values, obtained from practice and scientific research, are used as reference values for training programming in order to produce elite athletes and champions. In contrast, in this paper a methodology is presented, that allows for assessment of the development dynamics of maximum force, quantification of training goals and the selection of the each individual based on the estimated potential rather than their current state. This methodology also allows for individual programming and control of the training work as well as training effects and changes by the use of modern hardware and software equipment. Proposed methodology can be used in any sport in order to produce elite athletes and champions.

It was presumed that the problem could be solved using the method of repeated measurements and nonlinear mathematical models (Motulsky, Christopouls, 2003; Schumaker, Solieman, Chen, 2010; Watts, Bates, 2007). The choice of mathematical models was based on assumption that a basketball player, after the initial measurements, over time, with individually programmed training would rapidly improve performance under the influence of all three components (Tucker, Collins, 2011), However with prolonged training, improvements would still continue, but at a somewhat slower pace. This slowdown should become increasingly obvious as the basketball player approaches the limits of his capacity. Once the influence all three components are exhaustand, it would not be possible to improve performance, regardless of the type and time of the future training application (Milosevic, Milosevic, 2013a; Milosevic, Milosevic, 2013b; Milosevic, 2010; Tucker, Collins, 2011). That moment and level of force achieved represent a measurement of the participant's capacity in the maximum force (1 RM) of the monitored muscle groups (Milosevic, Milosevic, 2013a, b; Milosevic, Blagojevic, Pilipovic, Tosic, 2000; Milosevic, Dopsaj, Blagojevic, Mudric, 2012).

In according to the hypothesis, using the method of repeated measurements and nonlinear mathematical models, the aim of this study was to determine the capacity and the rules of the variability of 8 muscle groups (back-waist extensors, legs extensors, arm extensors, back extensors, shoulder and arms extensors, shoulder joint flexors, hip and knee extensors, trunk flexors) maximum force that are relevant for achieving optimal basketball performance (Milosevic, Milosevic, 2013a, b; Milosevic, 2010; Motulsky, Christopouls, 2003; Schumaker Solieman, Chen, 2010; Watts, Bates, 2007).

Materials and Methods

Participants

Experiment data that were used for developing a methodology for assessing the variability rules and limit value (capacity) of maximum force were obtained from a basketball player (center position) (BH = 2.12 m; BW = 125 kg before treatment, 118 kg after treatment; Age = 22 years). The participant was a member of Serbian National

team in a full multi-year training process. Participant gave his informed consent to the procedures of the study. The conditions of the study were approved by the university's ethics committee.

Testing and training

The development of maximal force was performed through the development of the following neuromuscular qualities: (i) the maximal rate of the force development, (ii) synchronization and speed of recruitment of motor units, (iii) the maximal force of certain motor unit groups level, (iv) overall muscle density, (v) intramuscular coordination, (vi) intermuscular coordination. Testing, programming and control of the development of maximal force as well as chosen neuromuscular qualities was done using a new modeling approach (to be explained in detail later), standardized procedures and certified hardware and software system (VAC Bioengineering). At the beginning of the training process (one initial and 8 transition tests) the maximal force of the following muscle groups by using the one repetition maximum (1 RM) test method: power clean (an integral indicator of back-hip extensors), bench press (arm extensors), half-squat (legs extensors), behind-the-neck press (shoulder and arms extensors), dead lift (back extensors), "good morning" (back extensors), pull-over (shoulder joint flexors), sit-ups (trunk flexors) and step-up (step test - hip and knee extensors) was tested.These neuromuscular qualities, as well as weight and weight lifting speed were tested at the beginning of each month (beginning of the training cycle) for each muscle group (VAC Bioengineering). Testing results were used for calculating status, models of the variability of maximum force, potential value of maximum lifted weight, training time in which a potential maximum were achieved, increase of weights for monitored muscle groups (Tables 1 and 2). After each test (every month) a new training program (VAC Bioengineering) was designed. Training sessions were conducted twice a week (Mondays and Fridays) and took one hour each. At each training session, 6 muscle groups were treated (3 exercise pairs), in five sets with 1–5 repetitions, with 3 minutes rest period (Milosevic, Milosevic, Nemec, Zivotic, Radjo, 2014a; Milosevic, Milosevic, 2013a, b; Milosevic, 2010). Free weights were used as a basic means of force development. During the month, three weeks were used for training, and the last week was for test and rest (Bosquet, Montpetit, Mujika, 2007; Milosevic et al., 2014a; Milosevic, Milosevic, 2013a; Milosevic, 2010). Monthly training sessions were designed in such a way that on Mondays in the first week of training, the speed of recruitment for motor units would be developed, while on Fridays the rate of force development would be developed (Aagaard et al., 2002; Milosevic, Dzoljic, Milosevic, Jourkesh, Behm, 2014b; Milosevic, Milosevic, 2013a, b; Milosevic, 2010). To develop motor unit speed of recruitment for the chosen muscle groups a weight of 70% of 1 RM was used. This weight was lifted at the maximum lifting speed for the particular weight chosen according to the particular participant for 5 sets of 5 repetitions each (Blagojevic, Milosevic, Aleksic, Papadimitrioiu, Dopsaj, 1998; Milosevic et al., 2014; Milosevic, Milosevic, 2013a; Milosevic, 2010; Milosevic, Stefanovic, Dopsaj, Blagojevic, 1998a; Milosevic, Cirkovic, Mihajlovic, Blagojevic, Dopsaj, 1998b; Milosevic et al., 2002). For the development of the maximal rate of force development the weight of 80% of 1 RM was used in 5 sets of 5 reps each, and for muscle density the weight of 90% of 1 RM, in 5 sets, each comprised of 3 repetitions (Blagojevic et al., 1998; Furandžijev, Abadžijev, 2003; Milosevic et al., 2014a, b; Milosevic, Milosevic, 2013a; Milosevic, 2010; Milosevic et al., 1998a, b, 2000, 2002). Lifting was performed at maximum speed in both cases. During the second week of training the maximal force of certain motor units groups would be developed on Mondays, while on Fridays intramuscular coordination in combination with motor unit synchronization would be developed (Milosevic et al., 2014a, b; Milosevic, Milosevic, 2013a, b; Milosevic, Mudric, Mudric, Milosevic, 2012; Milosevic, 2010). The development of the maximal force of certain motor units groups, intramuscular coordination

and intermuscular coordination was accomplished by varying the resistance of weights and lifting speed (maximal, submaximal and large (80% of maximal). The weights of 30, 40, 50, 70, 75, 80, 85, 90, 95, 100, 130 and 150% of 1 RM were employed, and exercises carried out in 5 sets of 1–5 repetitions each (Milosevic et al., 2014; Milosevic, Milosevic, 2013a, b; Milosevic et al., 2012; Milosevic, 2010). During the third week of training the muscle density would be developed on Mondays, whereas on Fridays intermuscular coordination would be developed (Furandžijev, Abadžijev, 2003; Milosevic et al., 2014a, b; Milosevic, Milosevic, 2013a, b; Milosevic et al., 2000, 2012; Milosevic, 2010). Motor unit synchronization development was based on exercises employing the weight of 95% and 100% of 1 RM, in 5 sets of 1 to 2 repetitions each, done at the maximum speed of lifting of the particular weight for the particular participant (Milosevic et al., 2014; Milosevic, Milosevic, 2013a; Milosevic, 2010). The intramuscular coordinations in combination with the motor units synchronization was done by combining weight lifting 70, 75, 80, 85, 90, 95 and 100% of 1 RM. The following exercise pairs were performed on Mondays: power clean and sit-ups, half-squat and bench press, dead lift and torso rotation (Barbell with disc weights – 40 kg) (Milosevic et al., 2014a, b; Milosevic, Milosevic, 2013a, b; Milosevic, 2010). The following exercise pairs were performed on Fridays: power clean and sit-ups, step-up and behind-the-neck press, “good morning” and pull-over (Milosevic et al., 2014; Milosevic, Milosevic, 2013a, b; Milosevic, 2010). Training session was designed in such way that one performs all the sets and all the repetitions of the first pair at the beginning, then the second pair and at the end the third pair (Milosevic et al., 2014; Milosevic, Milosevic, 2013a, b; Milosevic, 2010). Five sets of 1 to 5 repetitions each were performed for each muscle group. Each of the five sets for each muscle group was done with each of the different weights mentioned above. Immediately following the last repetition of the fifth set, 2 additional series of repetitions were performed for each muscle group with a weight of 60% of 1 RM with a five second break between repetitions. Each series was continued until the point at which the participant was unable to lift the weight (Milosevic et al., 2014; Milosevic, Milosevic, 2013a; Milosevic, 2010). The lifting speed was maximal. The total amount of work was 48 training sessions (48 hours of training work of which the pure time of weight lifting was from 10 to 12 minutes per session, and on the eight-month level from 8 up to 9.6 hours).

Data Analysis

To determine the capacity values and the variability maximum force of 8 muscle group rules the following nonlinear regression models were used (Ivancevic, Ivancevic, 2006; Motulsky, Christopouls, 2003; Watts, Bates, 2007): (i) Asymptotic Regression (concave), (ii). Michaelis-Menten, (iii). Gompertz Growth, (iv) Logistic Growth, (v) Loglogistic Growth, (vi) Weibull Growth, (vii) 1-parameter Sigmoid, (viii) 2-parameter Sigmoid 1, (ix) 2-parameter Sigmoid 2. For each model the flow of nonlinear regression was determined, the maximum force capacity of the subject was estimated by increasing the 1 RM (parameter Theta 1), time point at which the concavity of the function/curve changes sign, ie. changes from plus to minus (parameter Theta 2 or in the case of Michaelis-Menten it would be 50% of Theta 1), 95% confidence interval, the standard errors of the model parameters evaluation and summary statistics from which mean square error (MSE) was chosen between two or more regressions. The lower value of MSE, bolded in Table 1, suggests that the model according to this criterion had better performance, and was elected to evaluate the capacity of the subject and the training time, for which the capacity value can be achieved.

Results

Table 1 shows nonlinear mathematical models of the variability of maximum force for all screened/tested muscle groups and exercises.

Table 1. Models of the variability of maximum force measured using one-repetition maximum (1 RM) test

	Equation	MSE
Power clean (kg)		
Asymptotic Regression	PC = 113.613 – 31.1808 × exp(–0.344942 × Month)	**5.21000**
Michaelis-Menten	PC = 114.173 × Month / (0.279141 + Month)	6.13529
Gompertz Growth	PC= 113.37 × exp[–exp(–1.17504 – 0.372801 × Month)]	7.67756
Half-squat (kg)		
Michaelis-Menten	HS = 314.086 × Month / (1.16544 + Month)	**29.0581**
Gompertz Growth	HS = 284.896 × exp[–exp(–0.0688132 – 0.427014 × Month)]	34.7278
Bench press (kg)		
Michaelis-Menten	BP = 127.836 × Month / (0.499298 + Month)	26.4913
Gompertz Growth	BP = 147.821 × exp[–exp(–0.574319 – 0.157755 * Month)]	**6.93020**
Dead lift (kg)		
Michaelis-Menten	DL = 207.815 × Month / (0.480778 + Month)	**9.89002**
Gompertz Growth	DL = 195.921 × exp[–exp(–0.526638 – 0.614665 × Month)]	21.6435
Behind-the-neck press (kg)		
Michaelis-Menten	BNP = 85.9301 × Month / (1.41143 + Month)	10.6047
Gompertz Growth	BNP = 85.9848 × exp[–exp(–0.0395771 – 0.255884 × Month)]	**1.78360**
Pull-over (kg)		
Michaelis-Menten	PL = 125.457 × Month / (1.10068 + Month)	67.5278
Gompertz Growth	PL= 174.404 × exp[–exp(0.0439944 – 0.123983 × Month)]	**14.0954**
Step-up (kg)		
Michaelis-Menten	ST = 151.403 × Month / (1.20534 + Month)	**18.9145**
Gompertz Growth	ST= 125.248 × exp[–exp(0.760158 – 1.08348 × Month)]	35.3003
Sit-ups (kg)		
Michaelis-Menten	SU= 60.4435 × Month / (1.74436 + Month)	**4.28548**
Gompertz Growth	SU= 49.0218 × exp[–exp(0.370396 – 0.597066 × Month))	8.21129

Based on the model evaluation it could be said that thay have satisfactory validity and reliability; PC – power clean, HS – half-squat, BP – bench press, DL – dead lift, BNP – behind-the-neck press, PL – pull-over, ST – step-up, SU – sit-ups

Figures 1–8 shows nonlinear mathematical models of the variability of maximum force for all screened/tested muscle groups and exercises.

Table 2 contains the following results for all participant muscle groups and exercises: one-repetition maximum (1 RM) measured initially and after 8 monthly training cycles. Estimated potential one-repetition maximum (1 RM) and the number of months needed to reach the value. Table 2 also shows the differences between estimated potential values and the values measured initially and after 8 monthly training cycles for all muscle groups and exercises. Finally, Table 2 shows the reached increase after 8 monthly training cycles for all muscle groups and exercises.

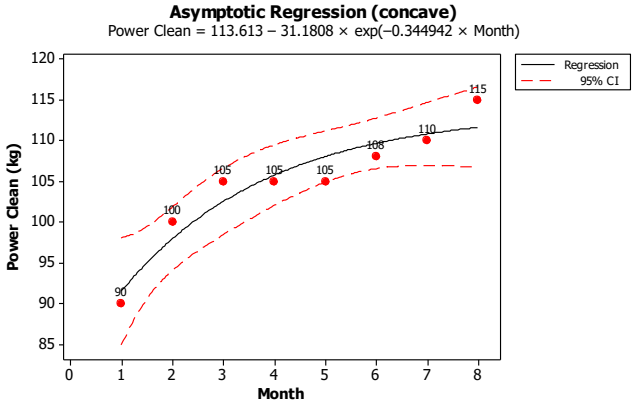


Figure 1. Asymptotic Regression model of the variability of maximum force of back-waist extensors

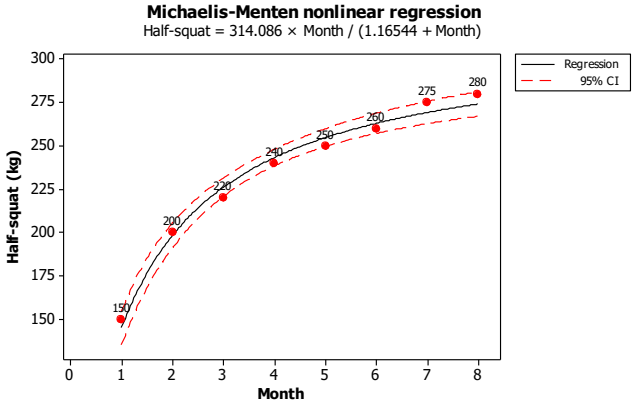


Figure 2. Michaelis-Menten model of the variability of maximum force of legs extensors

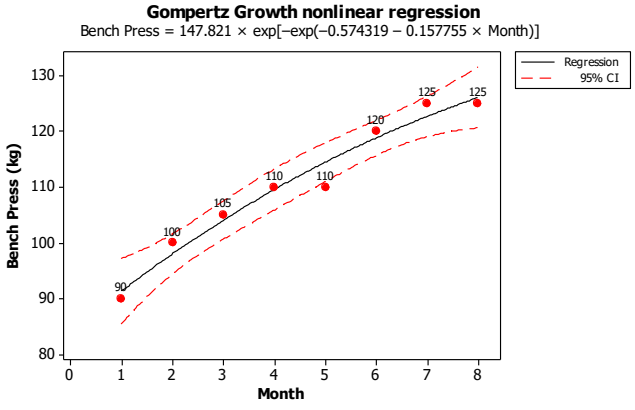


Figure 3. Gompertz Growth model of the variability of maximum force of arm extensors

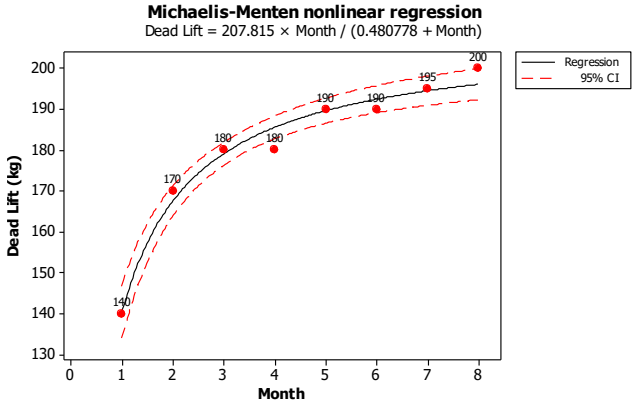


Figure 4. Michaelis-Menten model of the variability of maximum force of back extensors

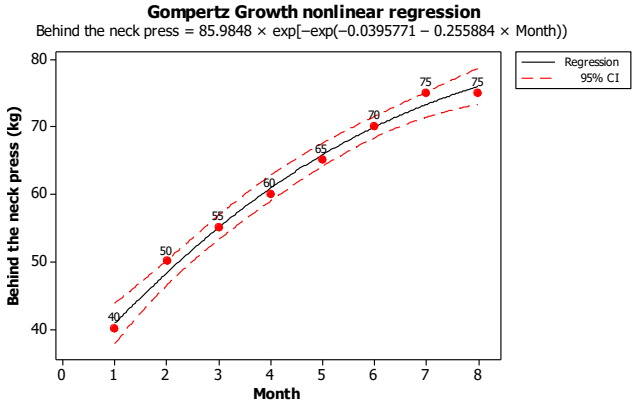


Figure 5. Gompertz Growth model of the variability of maximum force of shoulder and arms extensors

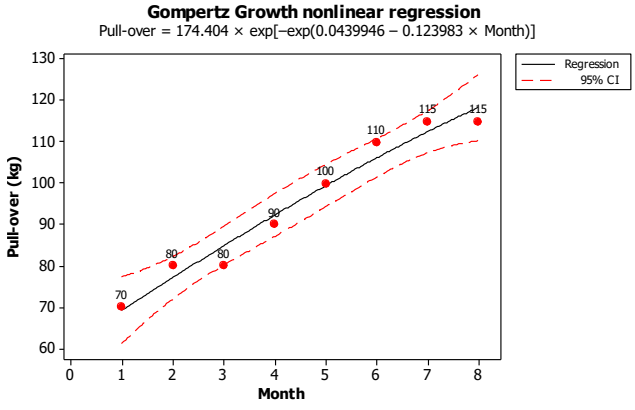


Figure 6. Gompertz Growth model of the variability of maximum force of shoulder joint flexors

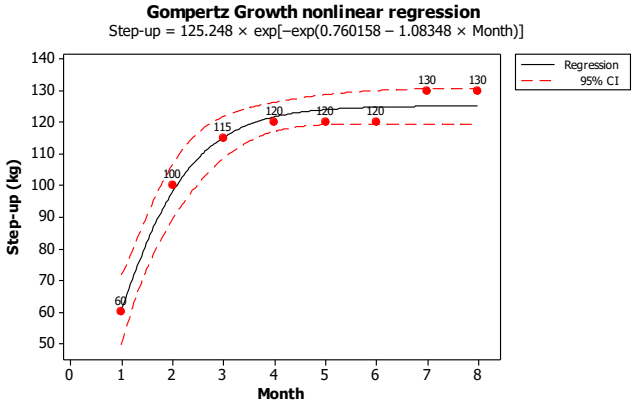


Figure 7. Gompertz Growth model of the variability of maximum force of hip and knee extensors

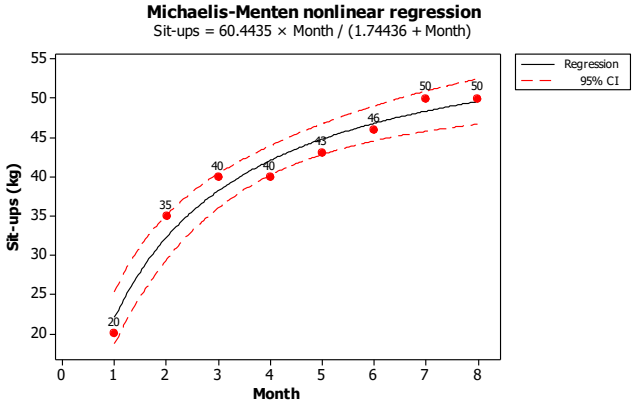


Figure 8. Michaelis-Menten model of the variability of maximum force of trunk flexors

Therefore, the paper presents the results only for Asymptotic Regression model, Michaelis-Menten model and Gompertz Growth model (Tables 1–2 and Figures 1–8) as they have satisfactory reliability and validity. Applying the selected models (Motulsky, Christopouls, 2003; Watts, Bates, 2007) enabled the assessment of capacity and determination of the variability of 8 muscle groups' maximum force rules for the participant (Tables 1–2 and Figures 1–8). To assess the capacity and the variability maximum force rules with the power clean, the best performance was associated the Asymptotic Regression model (Table 1 and Figure 1). In the half-squat, dead lift, step-up and sit-ups the best performance was achieved with the Michaelis-Menten model (Table 1 and Figures 2, 4, 8). While with the bench press, behind-the-neck press and pull-over, the best performance was found with the Gompertz Growth model (Table 1 and Figures 3, 5, 6, 7).

Table 2. State, anticipated capacity and lifted weight changes of 1 RM

Variables /muscle Groups and exercises	Power clean	Sit-ups	Half-squat	Bench Press	Dead lift	Behind the neck press	Puul-over	Step-up
Initial state (kg)	90	20	150	90	140	40	70	60
Estimated capacity (kg)	115[1]	53.3[2]	288.2[2]	137.5[3]	200.4[2]	83.1[3]	144[3]	139[2]
In time (month)	11	13	13	13	13	13	13	13
Starting level based on capacity (%)	78	37.5	52	65.4	69.8	48.1	48.6	43.2
State after 8 monthly training cycles (kg)	115	50	280	120	200	75	110	130
Increase after 8 monthly training cycles (kg)	25	30	130	30	60	35	40	70
Rached level based on capacity (%)	100	93.8	97.1	87.2	99.8	90.2	76.3	93.5

Prediction by [1] Asymptotic Regression model, [2] Michaelis-Menten model, [3] Gompertz Growth model.

The participant reduced his body weight 6% from 125 to 118 kg. At the same time, he increased the 1 RM from 25 kg to 130 kg (Table 2). The capacity values were calculated for each muscle group, as well as the time for which it could be reached (Table 2). Afther 48 training sessions the participant increased from 76.3 to 100% of his capacity. Results (Table 2) showed that the basketball player needed 11 to 13 months of training for each muscle group to achieve the necessary capacity values.

Discussion

Applying regression models (Ivancevic, Ivancevic, 2006; Motulsky, Christopouls, 2003; Watts, Bates, 2007) to determine the capacity and time to achieve sports performance illustrated the problem of short series. This problem led to an iterative process in the evaluation of the function parameters (iv-ix) that did not fulfill the convergence criteria. The applied regression models (Table 1 and Figures 1–8) provided a proper maximal force change prediction for all muscle groups in the period of 1–13 months. The capacity and variability data on monitored performances allowed the improvement of early selection, programming and training control in basketball. The early selection of future champions or top basketball players would be done by comparing the capacity value of each individual with the champion basketball requirements and their performances level (Milosevic, Milosevic, 2013a, b; Milosevic et al., 2012, 2014a, b; Milosevic, 2010; Tucker, Collins, 2011). From this relationship the ability to reach the requirements of the game and champions performance could be predicted. The knowledge of the athlete's capacity and current state (Table 2) would allow the prediction of potential capacity and future performance changes (Table 1). With this predictive power, it should be possible to directly quantify the training objectives, training effects, changes and training work required for one or more training sessions within one or more months (Aagaard et al., 2002; Furandžijev, Abadžijev, 2003; Milosevic, Milosevic, 2013a, b; Milosevic, 2010; Milosevic et al., 2002, 2012, 2014a, b).

Conclusions

Based on the results the mathematical model developed in this study demonstrated satisfactory validity and reliability for providing an accurate estimation of the maximum force capacity (1 RM) for eight muscle groups relevant for achieving top results in basketball. In addition to determine capacities, models provided a reliable maximal force in the prediction of training process changes. To assess the capacity and the maximum force by weight lifting rules

variability (1 RM) for the power clean, the best performance was with the Asymptotic Regression model. With the half-squat, dead lift, step-up, and sit-ups the best performances was achieved with the Michaelis-Menten model. While for the bench press, behind-the-neck press and pull-over the best performance was associated with the Gompertz Growth model. It can be concluded that the capacity and rules of variability of maximum force can be determined, separately for each individual basketball player, using nonlinear mathematical models. For future research of this type it is recommended to use a series with a larger number of observations.

Acknowledgments

The paper was realized as a part of the project I-34 sponsored by Faculty of Management in Sport, Alpha University, Belgrade, Serbia.

References

Aagaard, P., Simonsen, E.B, Andersen, J.L., Magnusson, P., Halkjaer-Kristensen, J., Dyhre Poulsen, P. (2002). Increased rate of force development and neural drive of human skeletal muscle following resistance training. *Journal of Applied Physiology*, *93* (4), 1318–1326.

Blagojevic, M., Milosevic, B.M., Aleksic, V., Papadimitrioiu, A., Dopsaj, M. (1998). The comparative analysis of force generation velocity and its dimensions at maximal voluntary contractions in isometric and dynamic muscle work regime. In: K. Hakkinen (ed.), *Proceedings of the International Conference on Weightlifting and Strength Training* (pp. 273–274). Lahti, Finland: Juvaskyla.

Bosquet, L.J., Montpetit, D.A, Mujika, I. (2007). Effects of tapering on performance: A meta-analysis. *Medicine and Science in Sports and Exercise*, *39* (8), 1358–1365.

Carpinelli, N.R., (2008). The size principle and a critical analysis of the unsubstantiated heavier-is-better recommendation for resistance training**.** *Journal of* Exercise *Science and Fitness, 6* (2), 67–86.

Ericsson, K.A., Krampe, R. (1993). The role of deliberate practice in the acquisition of expert performance. *Psychological Review*, *100* (3), 363–406.

Ericsson, K.A., Nandagopal, K., Roring, R.W. (2009). Toward a science ofexceptionalachievement: Attaining superior performance through deliberate practice. *Annals of the New York Academy of Sciences*, *1172*, 199–217. DOI: 10.1196/annals.1393.001.

Furandzijev, V., Abadzijev, I. (2003). Osnovi na podgotovkata na elitni i podrastvasci sportisti: Adaptacija na kletčno i molekuljarno nivo. [Basis of preparation of elite and young athletes: The adptacija of cell and molecular level]. Sofija, Bulgaria: Tip-top pres.

Ivancevic, V., Ivancevic, T. (2006). Natural biodynamics. Singapore: *World Scientific.*

Milosevic, B.M., Stefanovic, D., Dopsaj, M., Blagojevic, M. (1998a). The change in leg extensor muscle involvement velocity at weightlifting from deep squat, at different weights and maximal velocity. In: K. Hakkinen (ed.), *Proceedings of the International Conference on Weightlifting and Strength Training* (pp. 271–272). Lahti, Finland: Juvaskyla.

Milosevic, B.M., Cirkovic, Z., Mihajlovic, M., Blagojevic, M., Dopsaj, M. (1998b). The analysis of changes in the parameters of velocity, force and its dimensions at lifting different weights from deep squat at different velocities**.** In: K. Hakkinen (ed.), *Proceedings of the International Conference on Weightlifting and Strength Training* (pp. 268–270). Lahti, Finland: Jyvaskyla.

Milosevic, B.M., Blagojevic, M., Pilipovic, S., Tosic, B. (2000). The muscle contraction and the force production. In: H. Youlian, P.J. David (eds.), *Proceedings of the XVIII International Symposium of Biomechanics in Sport* (pp. 183–186). Hong Kong.

Milosevic, M., Dopsaj, M., Blagojevic, M., Mudric, R. (2002). Changes in force and motor unit involvement velocity (MUIV) induced by plyometric training and the method of incomplete eccentric muscle response. In: K. Hakkinen, W.J. Kraemer, J. Tihanyi (eds.), *Proceedings of the 3rd International Conference on Strength Training* (pp. 99–100). Budapest, Hungary.

Milosevic, M. (2010). *Physical Preparation of Elite Athletes: Standardization of Management Processes*. Belgrade: APP.

Milosevic, B.M., Mudric, M., Mudric, R., Milosevic, M.M. (2012). Using the mind in reprogramming the limits of muscle force in the process of creating champions. *Sport Science & Practice*, *2* (5), 39–58.

Milosevic, B.M., Milosevic, M.M. (2013a). *Special physical education: Scientific basis. Belgrade.* Serbia: CEDIP.

Milosevic, B.M., Milosevic, M.M. (2013b). Model for assessing the physical status, as well as prediction and programming of training and sports performance of a soccer player. *Journal of Physical Education and Sport*, *13* (4), 479–488. DOI: 10.7752/jpes.2013.04076.

Milosevic, B.M., Milosevic, M.M., Nemec, P., Zivotic, D., Radjo, I. (2014a). A new approach to development of human maximal muscular force. *Journal of Exercise Physiologyonline*, *17* (5), 70–80.

Milosevic, B.M., Dzoljic, E., Milosevic, M.M., Jourkesh, M., Behm, D. (2014b). The Analysis of Muscle Force Development with Trained and Elite Athletes. *Fiziologia-Physiology*, *24*, *1* (81), 5–12.

Motulsky, J.H., Christopouls, A. (2003). *Fitting models to biological data using linear and nonlinear regression. A practical guide to curve fitting.* San Diego: GraphPad Softwere.

Schneider, W. (1997). The impact of expertise on performance: Illustrations fromdevelopmental research on memory and sports. *High Ability Studies*, *8* (1), 7–18. DOI**:** 10.1080/1359813970080102.

Schumaker, P.R., Solieman, K.O., Chen, H. (2010). *Sports data mining.* New York, NY: Springer.

Tucker, R., Collins, M. (2012). What makes champions? A review of the relative contribution of genes and training to sporting success. *British Journal of Sports Medicine*, *46* (8), 555–561. DOI: 10.1136/bjsports-2011-090548.

Vaeyens, R., Güllich, A., Warr, C.R., Philippaerts, R. (2009). Talent identifi cation and promotion programmes of Olympic athletes. *Journal of* Sports *Sciences*, *27* (13), 1367–1380. DOI: 10.1080/02640410903110974.

Watts, G.D., Bates, M.D. (2007). *Nonlinear regression analysis and its applications.* New York, NY: Wiley.

Cite this article as: Milosevic, M.B., Nemec, V.J., Jourkesh, M., Nemec, P.M., Milosevic, M.M., David, B.G. (2016). Determination of Capacity and Rules of the Variability of Maximum Force Using Nonlinear Mathematical Models: a Case Study. *Central European Journal of Sport Sciences and Medicine*, *16* (4), 91–101. DOI: 10.18276/cej.2016.4-10.

MAXIMUM LOCOMOTOR SPEED OF THE BEST FOOTBALL PLAYERS AT THE FIFA WORLD CUP IN BRAZIL

Łukasz Bojkowski,[1, A, B, C, D] Robert Śliwowski,[2, D, E] Andrzej Wieczorek[2, D, E]

[1] Division of Physical Activity and Health Promotion Science, University School of Physical Education, Poznań, Poland
[2] Division of Theory and Methodology of Team Sport Games, University School of Physical Education, Poznań, Poland
[A] Study Design; [B] Data Collection; [C] Statistical Analysis, [D] Manuscript Preparation; [E] Funds Collection

Address for correspondence:
Łukasz Bojkowski
Division of Physical Activity and Health Promotion Science
University School of Physical Education
Królowej Jadwigi 27/39, 61-871 Poznań, Poland
E-mail: bojkowski@awf.poznan.pl

Abstract In comprehensive preparation of a player to football competition special attention is paid to his predispositions in terms of speed abilities. Therefore, the authors' objective was to analyse maximum locomotor speed of players of the four best national teams competing during the FIFA World Cup in Brazil, including specifying the differences in terms of speeds of these national teams and players in corresponding playing positions of individual teams.

The analysis used data obtained using the Castrol Performance Index, a kinematic method and in order to present significance of differences between the studied teams and playing positions one-way analysis of variance (ANOVA) was performed.

The study showed that the mean maximum running speed of the players of the four best teams of the World Cup was 8.34 metres/second. The mean maximum locomotive speed of the defenders in semi-finalist teams of the tournament was 8.29 m/s, while the midfielders' speed was – 8.16 m/s, the forwards' – 8.48 m/s and the goalkeepers' – 7.40 m/s. The players who had a maximum speed of 9 m/s or more were the Dutchman Ron Vlaar (9.16 m/s) and the Argentines José María Basanta (9.09 m/s) and Ángel Di Maria (9.17 m/s). There is no significant difference between the world's best teams, including between their corresponding playing positions, in the level of maximum running speeds determining the dynamics of the game.

Key words football, speed, World Cup

Introduction

Locomotor activity is related to athlete's moving around (Soroka, 2011). The profile of forms of locomotion during a football match includes such activities as walk, jog, slow run, backward run, moderate run, high speed run and sprint (Bangsbo, 1999; Mohr et al., 2003; Bradley et al., 2009). During a sprint the maximum speed of motion an athlete can reach is approximately 9 m/s. On average a player performs 46 sprints during a football game (30 to 40 according to Soroka, 2011), which last from 2 to 4 seconds (Bangsbo et al., 1991; Soroka, 2011). They are performed in situations when a player tries to run away from an actively attacking or defending opponent or to run into a free

space to make a shot or perform a so called "key pass" (Faude et al., 2012). The studies have shown that during a match a player covers in total 200 to 350 metres (from 215 to 446 metres according to Di Salvo et al. (2007)), from 179 to 334 metres according to Lago et al. (2010) from 199 to 290 metres according to Dellal et al. (2011), from 167 to 345 metres according to Bompa et al. (2013) by sprinting.

The study of Bradley et al. (2009) carried out on 370 players of the English Premier League competing in the 2005/2006 season showed that on average sprinting takes 0.6% of the whole play time of a highly effective player during a football game. On the basis of their analysis Mohr et al. (2003) established that this time accounts for 1.4% of total playing time. Nevertheless, the ability to perform short fast runs, so called sprints, and their quality may be very important for the final success in a situation of direct sport competition (Cometti et al., 2001). Chmura (2001) wrote that a player who "is a few centimetres closer to a ball, a few milliseconds faster at the ball then his opponent, may score the decisive goal, or stop the opposition from scoring one".

In this study the authors took up the problem of maximum speeds which are some of the elementary "indicators" showing the dynamics of play of a team (Chmura et al., 2010), reached by the players of the four best teams at the 2014 World Cup in Brazil. Like other championship tournaments, the World Cup provided an opportunity to watch changes taking place in the game using the example of professional players. The analysis of the teams characterised by the top level of sports advancement is to help in determining the speed requirements in terms of locomotor speed in a football game played by world class players.

Methodology of study

The aim of this study was the analysis of maximum locomotor speeds of players of the four best teams of the 2014 World Cup, i.e. national teams of Germany (the current world champions), Argentina (vice champions), Netherlands (bronze medallists) and Brazil. Moreover, the aim was to specify the differences in results of the teams and players in corresponding playing positions of individual teams. The following research questions were used to achieve the aim of the study:

1. What was the mean maximum speed of the first four teams of the 2014 World Cup during the tournament?
2. What were the mean maximum speeds of the individual playing positions of the four best teams of the World Cup finals in Brazil during the tournament?
3. Were there any players in the four best teams of the 2014 World Cup whose maximum locomotor speed was 9 m/s or more?
4. Were there significant differences in the mean maximum locomotor speeds between the teams and the corresponding playing positions of these teams?

The study covered football players representing the best teams of the FIFA World Cup in Brazil, that is the finalists of the tournament and the teams which competed for the third position. Only players who played for at least 90 minutes during the whole tournament were taken into consideration. What is important, the analysis included also the data obtained during so called "extra times". During the World Cup, from 12th of June to 13th of July 2014, all analysed teams played seven games (three in the group stage, 1/8th of the final, quarter finals, semi-final and the game for the 3rd place or the final). In total the results obtained by 68 players in 24 championship games were analysed.

In the analysis statistical data prepared on the basis of the *Castrol Performace Index* (*fifa.com/castrolindex*, access on 20.07.2014), using a kinematic method, an objective system of game analysis, were used. The method uses semi-automatic cameras in order to monitor events in each sector of the pitch during a sport competition. The data obtained using this system are commonly used in many scientific studies.

Thanks to a database of available data, mean maximum speeds were calculated for:

1. Teams, where the total of maximum speeds of all players of a given team was divided by the number of players of the team included in the analysis.
2. Players in individual playing positions, where the total of maximum speeds of players in certain playing position of a given team was divided by the number of players of the team included in the analysis.
3. Individual players, where the maximum locomotor speed of a player in each game was established and the highest value of the indicator in the tournament was used for the analysis.

Then the results presented in reports in km/h were translated into m/s (both values were presented in the description of the results). For a mathematical analysis of results descriptive statistics was used and in order to demonstrate significance of differences between the studied teams and corresponding playing positions one-way analysis of variance (ANOVA) was performed. The descriptive statistics and calculations were performed in STATISTICS 10.0 PL, StatSoft Polska.

Results

The analysis of the four best teams of the tournament showed that the mean maximum running speed of the representatives of Germany (n = 14), Argentina (n = 17), the Netherlands (n = 15) and Brazil (n = 18) in the studied 24 games was 8.34 metres/second (30.04 kilometres/hour). The Argentine players had the mean speed of 8.42 m/s (30.32 km/h), the Brazilian players – 8.31 m/s (29.90 km/h), the German players – 8.25 m/s (29.70 km/h) and the Dutch players – 8.20 m/s (29.51 km/h). In the calculation of the mean maximum speeds of individual teams, the speeds of goalkeepers were not taken into consideration. Standard deviation for all results was 1.61.

Among the analysed players three players, i.e. two defenders and one offensive midfielder, had maximum speeds of 9 m/s or more. The defenders included the Argentine José María Basanta – 9.09 m/s (32.72 km/h) and the Dutchman Ron Vlaar whose maximum running speed in the tournament was 9.16 m/s (32.98 km/h). The midfielder was the Argentine Ángel Di Maria who had the maximum speed of 9.17 m/s (33.01 km/h).

The mean result of defenders of the best "four" of the tournament was 8.29 m/s (29.86 km/h). The analysis of the top running speeds of individual defenders indicated that the Argentine players had the mean maximum speed of 8.58 m/s (30.87 km/h), the Dutch players – 8.29 m/s (29.85 km/h), the German players – 8.18 m/s (29.50 km/h) and the representatives of Brazil – 8.16 m/s (29.38 km/h). Standard deviation for the results in this group was 2.07.

The midfielders of the four top teams of the tournament had the mean speed of 8.16 m/s (29.37 km/h). Standard deviation for the presented results in the group of midfielders was 2.09. The analysis of the results of midfielders from the best teams competing during the World Cup showed that the midfielders of the Brazilian team had the speed of 8.33 m/s (30 km/h), the midfielders from Germany had the mean speed of 8.30 m/s (29.88 km/h), the midfielders from Argentina – 8.18 m/s (29.43 km/h) and the Dutch midfielders – 7.78 m/s (28.01 km/h).

Table 1. Mean maximum speeds of the four best teams of the tournament during the matches of the 2014 World Cup

Team	1. Argentina		2. Brazil		3. Germany		4. Netherlands	
	player	speed (m/s)	player	speed (m/s)	player	speed (m/s)	player	speed (m/s)
Results	Di Maria*	9.17	Neymar	8.83	Hummels	8.97	Vlaar*	9.16
	Basanta*	9.09	Bernard	8.83	Öezil	8.88	Robben	8.93
	Rojo	8.83	Silva	8.78	Boateng	8.63	Depay	8.53
	Lavezzi	8.78	Gustavo	8.73	Müller	8.47	Lens	8.48
	Garay	8.72	Ramires	8.63	Hoewedes	8.47	Indi	8.48
	Palacio	8.72	Willan	8.63	Schurrle	8.38	Van Persie	8.38
	Perez	8.68	Jô	8.57	Khedira	8.27	Sneijder	8.38
	Agüero	8.63	Maicon	8.48	Kross	8.27	Kuyt	8,32
	Higuain	8.53	Marcelo	8.47	Götze	8.12	Janmaat	8,32
	Gago	8.43	Fernandinho	8.47	Schweinsteinger	8.11	Wijnaldum	7,97
	Mascherano	8.43	Hulk	8.43	Klose	8.06	De Guzman	7,96
	Messi	8.43	Maxwell	8.32	Lahm	7.97	De Vrij	7,92
	Zabaleta	8.22	Luiz	8.07	Mertesacker	7.82	De Jong	7,91
	Demichelis	8.02	Alves	8.02	Mustafi	7.09	Blind	7,63
	Fernandez	7.97	Paulinho	7.82			Clasie	6,68
	Biglia	7.60	Oscar	7.72				
	Rodriguez	6.94	Fred	7.72				
			Dante	6.99				
M (m/s)	8,42		8.31		8.25		8.20	
M (m/s) for teams	8.34 (SD = 1.61)							

M – mean, SD – standard deviation, * – players who had speeds of 9 m/s or more.

Table 2. Mean maximum speeds of the defenders of the four best teams of the tournament during the matches of the 2014 World Cup

Team	1. Argentina		2. Netherlands		3. Germany		4. Brazil	
	player	speed (m/s)	player	speed (m/s)	player	speed (m/s)	player	speed (m/s)
Results	Basanta*	9.09	Vlaar*	9.16	Hummels	8.97	Silva	8.78
	Rojo	8.83	Indi	8.48	Boateng	8.63	Maicon	8.48
	Garay	8.72	Janmaat	8.32	Hoewedes	8.47	Marcelo	8.47
	Zabaleta	8.22	De Vrij	7.92	Mertesacker	7.82	Maxwell	8.32
	Demichelis	8.02	Blind	7.63	Mustafi	7.09	Luiz	8.07
							Alves	8.02
							Dante	6.99
M (m/s)	8.58		8.29		8.19		8.16	
M (m/s) for teams	8.29 (SD = 2.07)							

M – mean, SD – standard deviation, * – players who had speeds of 9 m/s or more.

The mean result for the group of forwards was 8.48 m/s (30.52 km/h) with standard deviation of 1.06. Among the players in the most offensive playing positions the representatives of Argentina had the mean maximum speed of 8.62 m/s (31.03 km/h). The Dutch forwards had the maximum speed of 8.52 m/s (30.67 km/h), the Brazilian forwards – 8.48 m/s (30.51 km/h), and the German forwards 8.26 m/s (29.73 km/h).

Table 3. Mean maximum speeds of the midfielders of the four best teams of the tournament during the games of the 2014 World Cup

Team	1. Brazil		2. Germany		3. Argentina		4. Netherlands	
	player	speed (m/s)	player	speed (m/s)	player	speed (m/s)	player	speed (m/s)
Results	Gustavo	8.73	Öezil	8.88	Di Maria*	9.17	Sneijder	8.38
	Ramires	8.63	Khedira	8.27	Perez	8.68	Wijnaldum	7.97
	Willan	8.63	Kross	8.27	Gago	8.43	De Guzman	7.96
	Fernandinho	8.47	Schweinsteinger	8.11	Mascherano	8.43	De Jong	7.91
	Paulinho	7.82	Lahm	7.97	Fernandez	7.97	Clasie	6.68
	Oscar	7.72			Biglia	7.60		
					Rodriguez	6.94		
M (m/s)	8.33		8.30		8.18		7.78	
M (m/s) for teams	8.16 (SD = 2.09)							

M – mean, SD – standard deviation, * – players who had the speed of 9 m/s or more.

Table 4. Mean maximum speeds of forwards of the four best teams during the games of the 2014 World Cup

Team	1. Argentina		2. Netherlands		3. Brazil		4. Germany	
	player	speed (m/s)	player	speed (m/s)	player	speed (m/s)	player	speed (m/s)
Results	Lavezzi	8.78	Robben	8.93	Neymar	8.83	Müller	8.47
	Palacio	8.72	Depay	8.53	Bernard	8.83	Schurrle	8.38
	Agüero	8.63	Lens	8.48	Jô	8.57	Götze	8.12
	Higuain	8.53	Van Persie	8.38	Hulk	8.43	Klose	8.06
	Messi	8.43	Kuyt	8.32	Fred	7.72		
M (m/s)	8.62		8.52		8.48		8.26	
M (m/s) for teams	8.48 (SD = 1.06)							

M – mean.

The mean maximum running speed of goalkeepers was 7.40 m/s (26.65 km/h). Among them Manuel Neuer (Germany) had the maximum speed of 8.57 m/s (30.85 km/h), followed by an Argentine Romero – 8.01 m/s (28.84 km/h), Cesar (Brazil) – 6.85 m/s (24.66 km/h) and Cillassen (Netherlands) – 6.18 m/s (22.25 km/h).

Table 5. Maximum running speeds of the goalkeepers of the four best teams of the 2014 World Cup during the games of the tournament

Team	1. Germany		2. Argentina		3. Brazil		4. Netherlands	
Results	player	speed (m/s)	player	speed (m/s)	player	speed (m/s)	player	speed (m/s)
	Neuer	8.57	Romero	8.01	Cesar	6.85	Cillasen	6.18
M (m/s) for players	7.40							

M – mean.

One-way analysis of variance (ANOVA) did not show a statistically significant differences between the studied teams (F = 0.54; df = 3.60; p = 0.654) or between corresponding playing positions of various teams (defenders –

F = 0.54; df = 3.18; p = 0.664; midfielders – F = 0.99; df = 3.19; p = 0.420; forwards – F = 1.19; df = 3.15; p = 0.349) in terms of mean maximum running speeds.

This means that the teams as well as groups of players in the corresponding playing positions of the best national teams competing during a world championship tournament do not differ significantly in terms of motor preparation including the level of speed abilities which determine, among other things, the dynamics of team's play.

Discussion

Motor preparation of football players to competition-related physical effort is one of the most important elements of long-term periodised training process. The above applies also to speed abilities including locomotor speed which according to the authors of this study may comprehensively predispose certain players to sport competition, and then differentiate their level of preparation. As a consequence it may affect the success of realisation of tactical activities of the whole team in a certain sport discipline and be an indicator of the team's dynamics of play (Chmura et al., 2010). Short, intensive runs, i.e. sprints, are performed in many sports, in particular in contact team sports such as football, basketball and hockey (Ferro et al., 2014).

The analysis of maximum locomotor speed of the four best teams of the 2014 World Cup showed that mean maximum running speed of the players from national teams of Germany, Argentina, Netherlands and Brazil was 8.34 m/s (in these groups the results of goalkeepers were not included in the calculations). Among the analysed team the Argentines had the speed of 8.42 m/s, the Brazilians – 8.31 m/s, the Germans – 8.25 m/s and the Dutch – 8.20 m/s.

The mean speed for the four best goalkeepers of the 2014 FIFA World Cup was 7.40 m/s, while it was 8.29 m/s for the defenders. Among the defenders the mean values were 8.58 m/s for the Argentines, 8.29 m/s for the Dutch, 8.19 m/s for the Germans. The speed of 8.16 m/s indicates an average level of speed preparation of Brazilian defenders, who conceded most goals among the analysed teams – 14 (Germany, Argentina and Netherlands conceded 4 goals each). The midfielders from the four top teams of the tournament has a mean maximum speed of 8.16 m/s, while for the Brazilian team midfielders it was 8.33 m/s, for the German team midfielders 8.30 m/s, for the Argentine midfielders 8.18 m/s and for the Dutch midfielders 7.78 m/s. On the other hand, the mean maximum speed in the group of forwards was 8.48 m/s (Argentina – 8.62 m/s, Netherlands – 8.52 m/s, Brazil – 8.48 m/s, Germany – 8.26 m/s). It should be noted here that in the comparison of the four national teams the German team was characterised by the highest level of shooting effectiveness. In seven games the *DFB* players scored in total 18 goals (while the Argentine scored 8, the Dutch 15 and the Brazilians 11).

Out of all studied players only three had maximum running speed exceeding 9 m/s. They were José María Basanta (Argentina), Ron Vlaar (Netherlands) and Ángel Di Maria (Argentina). In reference to these data Chmura et al. (2010, p. 86) commented the presented level of speed abilities of the best footballers of the World Cup falling below expectations by writing: "the reasons for this can be seen, among other things, in a long and exhausting season, a large numbers of played games, and too short a recovery time after the season".

As we demonstrated in our analysis, among seventeen defenders of the four top teams of the tournament who had speed of 8 m/s, as many as twelve were nominally classified by their managers as central midfielders (Vlaar, Basanta, Hummels, Rojo, Silva, Garay, Boateng, Maicon, Hoewedes, Indi, Luiz and Demichelis). This may indicate the significance of the motor ability of speed and dynamics of motion in the effective action of players in playing positions 4 and 5. On the other hand, among thirteen fastest midfielders of the teams from Germany, Argentina,

Netherlands and Brazil who had speeds of at least 8 m/s, there is a significant difference, if we analyse them in terms of their nominal playing positions in midfield. For example, Ángel Di Maria is a player who usually plays in the national team on right wing or as a central offensive midfielder (position 7 or 10), Öezil, Willan and Sneijder are nominally central offensive midfielders (position 10), Perez, Fernandinho, Kroos and Schweinsteinger are central midfielders (position 8), whereas Luis Gustavo, Ramirez, Gago, Mascherano and Khedira are defensive midfielders (usually playing in position 6). This may indicate the fact that in modern football competition the differences is the level of speed predipositions become blurred between individual playing positions in the midfield. On the other hand, in the group of forwards, eighteen out of nineteen players (all forwards except for Brazilian Fred) "exceeded" the limit of locomotor speed of minimum 8 m/s. They were (in a decreasing order of maximum speeds) Robben, Neymar, Bernard, Lavezzi, Palacio, Agüero, Jô, Higuain, Depay, Müller, Lens, Messi, Hulk, Van Persie, Schuerrle, Kuyt, Götze and Klose. Perhaps this variable was the one that made the Brazil World Cup one of the most attractive in terms of the number of scored goals.

Conclusions

On the basis of the presented analysis of the four best teams of the FIFA World Cup in Brazil, the following final conclusions can be made corresponding to the research questions:

1. The mean maximum running speed of the four teams of the Mundial in Brazil was 8.34 m/s.
2. The mean maximum speed of the goalkeepers of the best four of the tournament was 7.40 m/s, while for defenders it was 8.29 m/s, for midfielders – 8.16 m/s, for forwards – 8.48 m/s.

Only three players at the 2014 World Cup had speeds of 9 m/s or more. They were defenders Ron Vlaar (9.16 m/s) and José María Basanta (9,09 m/s) and a midfielder Ángel Di Maria (9,17 m/s).

There are no significant differences in the level of maximum running speeds determining the dynamics of the game between the world's best teams and between their corresponding playing positions.

References

Bangsbo, J., Lorregaard, L., Thorsoe, F. (1991). Activity profile of competition soccer. *Can J Sports Sci.*, *16* (2), 110–116.

Bangsbo, J. (1999). *Sprawność fizyczna piłkarza: naukowe podstawy treningu*. Warszawa: COS.

Bompa, T., Zając A., Waśkiewicz, Z., Chmura, J. (2013). *Przygotowanie sprawnościowe w zespołowych grach sportowych*. Katowice: AWF.

Bradley, P.S., Sheldon, W., Wooster, B. Olsen, P., Boanas, P., Krustrup, P. (2009). High-intensity running in English FA Premier League soccer matches. *Journal of Sports Sciences*, *27* (2), 159–168.

Chmura, J. (2001). *Szybkość w piłce nożnej*. Katowice: AWF.

Chmura, P., Chmura, J., Kawczyński, A., Mroczek, D. (2010). Szybkościowe formy aktywności ruchowej piłkarzy na Mistrzostwach Świata w Piłce Nożnej 2010. *Sport Wyczynowy*, *4* (536), 80–87.

Chmura, P., Goliński, D., Andrzejewski, M., Mroczek, D., Kawczyński, A., Rokita, A., Chmura, J. (2014). Endurance capacity and selected technical-tactical skills of soccer players participating in the group stage of the 2014 FIFA World Cup. *Trends in Sport Sciences*, *3* (21), 153–160.

Cometti, G., Maffiuletti, N.A., Pousson, M., Chatard, J.C., Maffulli, N. (2001). Isokinetic Strength and Anaerobic Power of Elite, Subelite and Amateur French Soccer Players. *Int J Sports Med.*, *22*, 45–51.

Dargiewicz, R., Jastrzębski, Z. (2012). *Kinematyka lokomocji piłkarzy nożnych na różnych etapach przygotowań*. Gdańsk: AWFiS.

Dellal, A., Chamari, K., Wong, D.P., Ahmaidi, S., Keller, D., Barros, R.M.L., Bisciotti, G.N., Carling, Ch. (2011). Comparison of physical and technical performance in European soccer match-play: FA Premier League and La Liga. *European Journal of Sport Science*, *11* (1), 51–59.

Di Salvo, V., Baron, R., Tschan, H., Calderon Montero, F.J., Bachl, N., Pigozzi, F. (2007). Performance characteristic according to playing position in elite soccer. *International Journal & Sports Medicine*, *3*, 222–227.

Faude, O., Koch, T., Meyer, T. (2012). Straight sprinting is the most frequent action in goal situations in professional football. *J Sport Sci*., *30*, 625–631.

Ferro, A., Villacieros, J., Floría, P., Graupera, J.L. (2014). Analysis of Speed Performance In Soccer by a Playing Position and a Sports Level Using a Laser System. *Journal of Human Kinetics*, *44*, 143–153.

Lago, C., Casais, L., Dominguez, E., Sampaio, J. (2010). The effects of situational variables on distance covered at various speeds in elite soccer. *European Journal of Sport Science March*., *10* (2), 103–107.

Mohr, M., Krustrup, P., Bangsbo, J. (2003). Match performance of high-standard soccer players with special reference to development of fatigue. *Journal of Sports Sciences*, *21*, 519–528.

Cite this article as: Bojkowski, Ł., Śliwowski, R., Wieczorek, A. (2016). Maximum Locomotor Speed of the Best Football Players at the FIFA World Cup in Brazil. *Central European Journal of Sport Sciences and Medicine*, *16* (4), 103–110. DOI: 10.18276/cej.2016.4-11.

SMALL-SIDED SOCCER GAME (1V1) IN GOALKEEPERS' TRAINING

Dawid Goliński,[1, A, B, C, D] Jarosław Muracki,[2, A, E] Paweł Wolański,[1, A, B, D]
Sebastian Klich,[1, C] Eugenia Murawska-Ciałowicz[1, A, C, D]

[1] Department of Physiology and Biochemistry, University School of Physical Education in Wroclaw, Poland
[2] Department of Biomechanics, University School of Physical Education in Wroclaw, Poland
[A] Study Design; [B] Data Collection; [C] Statistical Analysis; [D] Manuscript Preparation; [E] Funds Collection

Address for correspondence:
Dawid Goliński
University School of Physical Education in Wroclaw
Department of Physiology and Biochemistry
J.I. Paderewskiego 35 Street, 51-612 Wroclaw, Poland
E-mail: dawidgolinski@o2.pl

Abstract Small-sided soccer games, i.e. 1v1 are often used in training, which results in a composite influence on the player. Training exercises stimulated in the game allow to master many skills, form habits and modify behaviors associated with solving specific situations during a match. The aim of the study was to assess the intensity of exercise during a 1v1 game for goalkeepers. Eight goalkeepers participated in the experiment (body weight 80.63 ±3.50 kg, body height 184.69 ±3.71 cm, BMI 23.64 ±0.74). All goalkeepers played 1v1 games. During the small-sided game players can use all the goalkeeper techniques to score a goal. During all of the matches, heart rate (HR) was recorded using a sport tester, LA was measured in the second minute after the end of each game. There was also collected data determining subjective assessment of the effort made by the players using Borg scale (RPE). The highest average HR and RPE were recorded in the third match, respectively (192.38 ±8.07 b/min; 14.38 ±2.07), while in the first match the examined parameters were on average 186 ±8.85 b/min; 11.38 ±1.51, and in the second 186.00 ±8.09 b/min; 13.50 ±1.85 respectively. The highest LA level was recorded after the second match and equaled 7.71 ±2.07 mmol/l (7.06 ±3.54 after the first match and 7.5 ±1.37 after the third match). The 1v1 game requires the use of similar to the real game actions, as well as the average exercise intensity is also similar to the scoring-opportunity situations and conditions of a match.

Key words small games, goalkeeper, football

Introduction

Football is characterized by a large number of 1v1 situations that require excellent technical and tactical skills and very good motor and mental preparation. Modern motor preparation is developing rapidly, many coaches are introducing new methods and forms of training. Training exercises are developed in the context of ergonomics and their structure is supposed to be similar to match conditions. That is the reason why the correct programming of the training process should be based on the results of physiological and biochemical monitoring during exercise with characteristics of the efforts performed in a match or in a real game. Using 1v1 duels seems to be right in order to train players in a complex way. By introducing this method of training, coaches can improve technical, tactical

skills and mental abilities while controlling physiological parameters (Bangsbo, 1994; Coutts, Rampinini, Marcora, Castanga, Impellizzieri, 2009; Ngo et al., 2012). Owen, Twist, Ford (2004) confirmed that the intensity measured by a heart rate (*HR*) during 1v1 game corresponds to the level of intensity during a championship match. Endeavoring to full customization, not only the physiological indicators should be controlled but also practical assumptions must be adapted. Extensive research has shown that the intensity of exercise attained in small-sided games is dependent on: rules of the game (Sampaio et al. 2007), number of players (Hill-Haas, Couts, Rowsell, Dawson, 2009a; Hill-Haas, Dawson, Coutts, Rowsell, 2009b; Jones, Drust, 2007; Köklü, Asci, Kocak, Alemdaroglu, Dundar, 2011), size of the playing field (Kelly, Drust, 2009) coaches' verbal support (Rampinini et al., 2007), duration (Fanchini et al., 2011), and presence or absence of a goalkeeper (Rampinini et al., 2007; Kalapotharakos et al., 2011). In addition, Coutts et al. (2009) reported that the RPE (*Rate of Perceived Exertion*) is also a good indicator of the intensity of the global effort. It is strongly correlated with physiological markers and mental commitment of the player performing exercise.

Goalkeeper's position in football, as well as in other team sport, is crucial. Goalkeepers' interventions often decide about the result of a match. Goalkeepers need special training because of the differences in technical skills, tactical behaviors, motor requirements and specific psychical load comparing to outfield players. The role of a goalkeeper is not limited to only defending shots, dealing with crosses or 1v1 defending. An effective goalkeeper needs to secure a defending line, participate in a positional play, and, what is very important, initiate counterattacks with fast, far and precise passes to his partners. It is worth mentioning, that playing on a goalkeeper's position demands rapid decision making which is allowed only by an optimal function of the central nervous system. That is why an optimally adapted direct 1v1 duel between two goalkeepers supported by appropriate tactical assumptions, may be an effective and varied training drill. Reduced playing field forces players to perform more actions occurring in a real game on a goalkeeper's position. What is more, it demands rapid decision making under growing fatigue. In addition, such a rivalry increases motivation and improves spatial perception. Another proof, confirming usefulness of this form of training, is brought by the Fanchini et al. (2011) examination in which they claimed the interval method is optimal for developing specific resistance.

The idea of small-sided games grew out of simple games played on the beaches, on streets or in the parks. The match analysis proves that 1v1 situation is an indispensable part of 11v11 game. For many years coaches have been cautiously using this drill. Coaches have been modifying the game decreasing the playing field, decreasing the number of players and changing the rules (Stephen, Hill-Haas, Dawson, Impellizzeri, Coutts, 2011). In recent years the methods of current monitoring have become usable during training which gave the scientific base to appropriate adjustment of training loads.

The aim of the study was to asses ~~of~~ the efforts' intensity examining the heart rate (HR), lactate acid in blood concentration (LA) and the rate of perceived exertion (RPE) in football goalkeepers competing in 1v1 duel characterized by precise rules.

Methods

Participants

Eight amateur football goalkeepers were examined in the study (body weight 80.63 ±3.50 kg, body height 184.69 ±3.71 cm, BMI 23.64 ±0.74). All of them were competitors in the nationwide goalkeepers' tournament organized by Total Goalkeeping Goalkeepers' Academy „Bitwa Bramkarska" in June 2015 in Wroclaw, Poland. All of the investigated were classified to senior category and they expressed willingness to participate in a voluntary experiment.

Procedures

Participants played three 1v1 duels. These duels were the group phase of the tournament. Each game lasted 2 minutes, the players alternately attacked the opponents' goal with any style of striking and throwing the ball from the attacking zone which was limited to 6 meters from the goal (red markers on the Figure 1). The length of the pitch was 22 meters with half-line on 11 meters from the goal (Figure 1). The players had 10 minutes passive resting brakes between the following matches which were set by the tournament's timetable. Before attempting the experiment, HR and LA were measured in every subject. HR_{max} was calculated as HR_{max} = 220-age (Robergs, Landwehr, 2002). HR was registered continuously during all of the duels with POLAR TEAM 2 (*Kempele, Finland*). Lactate acid concentration in capillary blood taken from the fingertip was examined 2 minutes after every duel end. The measure was made with Lactate Scout (*Barleben, Germany*). The subjects assessed their fatigue after every match end using Rate of Perceived Exertion (RPE) with 20-degrees Borg scale (Borg, 1998).

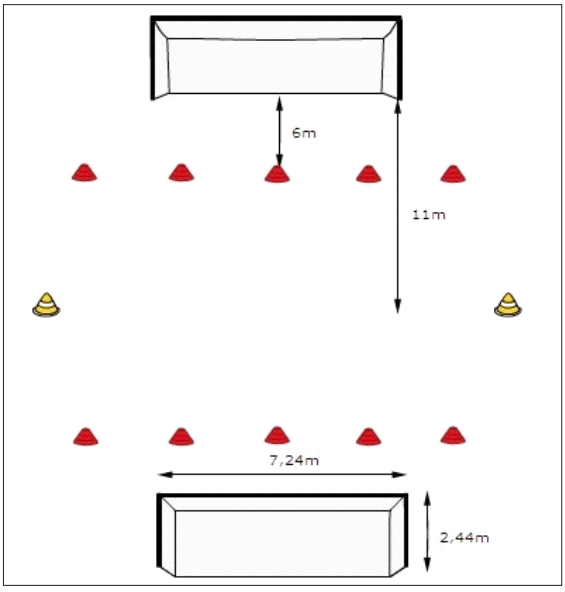


Figure 1. The scheme of the field used for 1v1 matches

Statistical analysis

A statistical analysis was performed in the Statistica12.0 (*Poland*) using basic descriptive statistics and a nonparametric analysis of variance (*ANOVA Friedman*) for repeated measures and post hoc Bonfferoni test. The test of correlation between the examined parameters was performed using the Spearman rank correlation coefficient. The value of $p \leq 0.05$ was set for assessing differences significance.

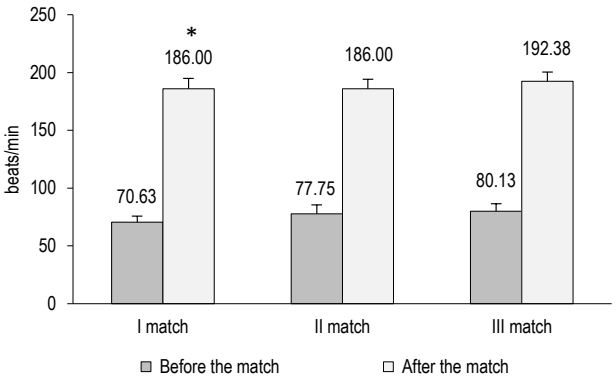
Results

The data presented in Table 1 shows that the average heart rate, lactate concentration and RPE were at a similar level in all duels, and that the highest average levels of these parameters were recorded in the third match. The LA level was the highest in 2nd match.

Table 1. The values of physiological parameters characterizing the intensity of the goalkeepers' exertion

Parameter	1v1 duel		
	1st	2nd	3rd
	average	average	average
Heart rate (HR) (b/min)	186.00 ±8.85	186.00 ±8.09	192.38 ±8.07
Percent of Maximum Heart Rate (% HR_{max})	95.09 ±4.58	95.09 ±4.21	98.32 ±3.29
Lactate Accumulation (LA) (mmol/l)	7.06 ±3.54	7.71 ±1.37	7.5 ±2.07
Rating of Perceived Exertion (RPE)	11.38 ±1.51	13.5 ±1.85	14.38 ±2.07

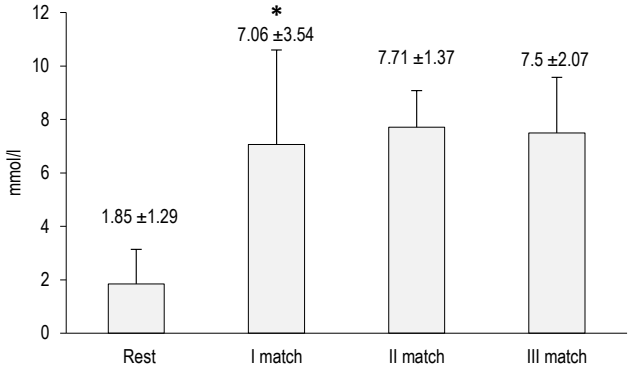
In addition, very strong relationship between HR and RPE (R = 0.75; p = 0.000001); LA and RPE (R = 0.82; p = 0.000001) and between HR and LA (R = 0.73; p = 0.000003) was demonstrated. The intensity of 2 minutes efforts was on extremely high level according to Christensen's scale (Kirschner, 1970). The efforts had exhausting character for the goalkeepers' organisms.



* $p \leq 0.05$ (rest to 1 match, 2 match, 3 match).

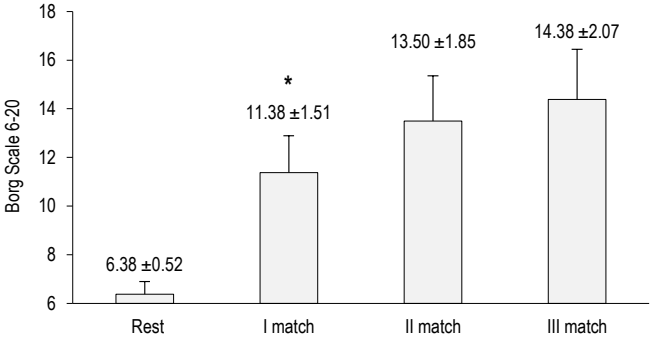
Figure 2. Average HR values in a steady state before starting the exertion and after the end of a duel

The analysis of all measured parameters showed statistically significant differences only between steady state and the values after the first match (HR: 70.63 ±5.26 b/min; 186.00 ±8.85 b/min; $Chi^2 = 16.63$, $p = 0.012$; LA: 1.85 ±1.29 mmol/l ; 7.06 ±3.54 mmol/l; $Chi^2 = 12.90$; $p = 0.017$; RPE: 6.38 ±0.52; 11.38 ±1.51; $Chi^2 = 19.04$; $p = 0.012$) (Figures 2–4). According to the Borg scale, the rate of perceived exertion declared by the goalkeepers was on the light level in the first played duel. The second and third match occurred to be heavy to the goalkeepers' subjective feeling.



* p ≤ 0.05 (rest to 1 match, 2 match, 3 match).

Figure 3. Average LA values in a steady state before starting the exertion and after the end of a duel



* p ≤ 0.05 (rest to 1 match, 2 match, 3 match).

Figure 4. Average RPE values in a steady state and fater the end of a duel

Discussion

The competition, based on the rules of the small sided game 1v1 for goalkeepers, has been organized anually since 2013 in Poland under the name of Bitwa Bramkarska. The number of competitors increases every year. Both male and female players at ages ranging from 8 to senior age are involved in the tournament. This type of tournaments is gaining bigger and bigger popularity in other countries. The participation of an increasing number of players in this kind of tournaments justifies the need to examine the body response to this specific type of effort, which we have made in our studies. From the standpoint of coaches, it allows to prepare their players to compete through the use of training drills similar in terms of exercise parameters and characteristics of a motor behavior typical of a goalkeeper. Similarly – using this type of training drills requires knowledge about the training load it causes. Our research has shown that a 1v1 game is a heavy load for the organism characterized by high intensity – the average HR above 80% of maximum heart rate and a high level LA (average of 3 matches was 7.42 mmol/L). The high correlation between HR and RPE and between RPE and LA suggests the possibility of using the RPE by trainers as an indirect method of assessing fatigue during this type of effort. The confirmation of the validity of the assessment of the intensity, using the variables we have studied was also shown by other authors (Rampinini et al., 2007).

The analysis of the movements made by the goalkeepers during this specific 1v1 game showed clear differences comparing to the movements observed in typical 1v1 game for the outfield players. In a typical 1v1 SSG, the most time is spent on dribbling, keeping the ball with low speed and running (Owen et al., 2004). The most common way of scoring is shooting the ball with a leg from the surface of the pitch after a feint or after running with the ball. The way of defeating an opponent is dribbling and making faster movements with a ball. However, in 1v1 game for goalkeepers there are several different ways of scoring: shooting a ball after throwing it up (volley), shooting a ball from the surface, throwing a ball to the opponents goal. There are not many feints and they have different character from typical 1v1 SSG for outfield players. Running with a ball is nearly absent, and the distances covered by players are significantly lower which is caused by the limited attacking zone. The wag for defeating the opponent is strong and precise attacking with shots and throws from a distance forced by the rules. In addition – using a real size goals gives some stimulation and motivation to the players and these rules let reduce the random effects (Duarte et al., 2010).

The differences in the motion structure stand as a benefit in goalkeepers training, but they cause a specific fatigue which has not been featured so far in the scientific literature. We believe that this kind of 1v1 game can be an effective training drill for goalkeepers. It is very similar to the real game conditions. The effort has a very similar characteristic – in both situations aero-anaerobic (Owen et.al., 2004; Hill-Haas et al., 2009a). The motion structure is very similar – there are dynamic interventions with and without fall, playing with foot, throwing. What is more, in terms of motivation there can be found similarities – in both cases there is a high contribution of the inner motivation, which source in a real game is a goal to defeat the opponent team, and in this kind of 1v1 game – to defeat a direct opponent. Having in mind the growing popularity and training usability of this kind of 1v1 game for goalkeepers. We believe that further studies examining different age groups, different game-time and playing field's dimensions are needed in order to create detailed description of specific fatigue.

Practical Applications

1. 1v1 game is a very exhausting training drill, which intensity should be controlled in order to precisely fulfill the training program.

2. The intensity in this 1v1 game is near to maximal capabilities of the players and has an anaerobic character.

3. This kind of 1v1 game reflects the actions and effort of real match situations.

4. This kind of 1v1 game can be used to increase the tolerance of fatigue,5. This kind of 1v1 game engages offensive and defensive goalkeepers' techniques with a high motivation.

References

Bangsbo, J. (1994). The physiology of soccer with special reference to intense intermittent exercise. *Acta Physiologica Scandinavica*, *51* (Suppl. 619), 1–156.

Borg, G. (1998). Borg's perceived exertion and pain scales. *Human Kinetics*, Champaigns.

Brito, J., Krustrup, P., Rebelo, A. (2012). The influence of the playing surface on the exercise intensity of small-sided recreational soccer games. *Human Movement Science*, *31*, 946–956.

Coutts, A.J., Rampinini, E., Marcora, S.M., Castanga, C., Impellizzeri, F.R. (2009). Heart rate and blood lactate correlates of perceived exertion during small-sided soccer games. *Journal of Science and Medicine in Sport*, *12*, 79–84,

Duarte, R., Araújo, D., Fernandes, O., Travassos, B., Folgado, H., Diniz, A., Davids, K. (2010). Effects of different practice task constraints on fluctuations of player heart rate in small-sided football games. *The Open Sports Sciences Journal*, *3*, 13–15.

Fanchini, M., Azzalin, A., Castanga, C., Schena, F., McCall, A., Impellizzeri, F.M. (2011). Effect of bout duration on exercise intensity and technical Performance of small-sided games in soccer. *Journal of Strength and Conditioning Research*, *25*, 453–458.

Hill-Haas, S., Coutts, A.J, Rowsell, G.J, Dawson, B.T. (2009a) Generic versus small-sided game training in soccer. *International Journal of Sports Medicine*, *30*, 636–642.

Hill-Haas, S., Dawson, B.T., Coutts, A.J., Rowsell, G.J. (2009b). Physiological responses and time – motion characteristics of various small-sided soccer games in youth players. *Journal of Sports Sciences*, *27*, 1–8.

Hill-Haas, S., Dawson, B., Impellizzeri, F.M., Coutts, A.J. (2011). Physiology of small-sided games training in football: a systematic review. *Sports Medicine*, *41*, 199–220.

Jones, S., Drust, B. (2007). Physiological and Technical demands of 4v4 and 8v8 games in elite youth soccer players. *Kinesiology*, *39* (2), 150–156.

Kalapotharakos, V., Douda, H., Spassis, A., Vonortas, G., Tokmakidis, S., Ziogas, G. (2011). Heart rate responses during small-sided games. *Soccer Journal*, March–April, 46–49.

Kelly, D.M., Drust, B. (2009). The effect of pitch dimensions on heart rate responses and technical demands of small-sided soccer games in elite players. *Journal of Science and Medicine in Sport*, *12*, 475–479.

Kirschner, A. (1970). Ergonomic analysis of arduous work. in A. Hansen (ed). Warszawa. Wydanie Związkowe, CRZZ1.

Köklü, Y., Asci, A., Kocak, F.U., Alemdaroglu, U., Dundar, U. (2011). Comparison of the physiological responses to different small-sided games in elite Young soccer players. *Journal of Strength and Conditioning Research*, *25*, 1522–1528.

Ngo, J.K., Tsui, M-Ch., Smith, A.W., Carling, Ch., Chan, G-S., Wong Del, P. (2012). The effects of man – marking on work intensity in small-sided soccer games. *Journal of Sports Science and Medicine*, *11*, 109–114.

Owen, A., Twist, C., Ford, P. (2004). Small-sided games: the physiological and technical effect of altering pitch size and player numbers. *Insight*, *4*; *7* (2), 50–53.

Rampinini, E., Impellizzeri, F.M., Castanga, C., Abt, G., Chamari, K., Sassi, A., Marcora, S.M. (2007). Factors influencing physiological responses to small-sided soccer games. *Journal of Sports Sciences*, *25*, 659–666.

Robergs, R., Landwehr, R. (2002). The Surprising History of the "HR_{max} = 220-age" Equation. *Official Journal of The American Society of Exercise Physiologists (ASEP)*, *5* (2), 1–10.

Sampaio, J., Garcia, G., Macas, V., Ibanez, S.J., Abrantes, C., Caixinha, P. (2007). Heart rate and perceptual responses to 2 × 2 and 3 × 3 small-sided youth soccer games. *Journal of Sports Science and Medicine*, *6*, 121–122.

Stephen, V., Hill-Haas, D., Dawson, B., Impellizzeri, F.M., Coutts, A.J. (2011). Physiology of Small-Sided Games Training in Football. *Sports Medicine*, *41* (3), 199–220.

Cite this article as: Goliński, D., Muracki, J., Wolański, P., Klich, S., Murawska-Ciałowicz, E. (2016). Small-Sided Soccer Game (1v1) in Goalkeepers' Training. *Central European Journal of Sport Sciences and Medicine*, *16* (4), 111–118. DOI: 10.18276/cej.2016.4-12.

Guide for Authors

Authors are encouraged to submit high quality, original works which have not appeared, nor are under consideration in other journals.
Contributors are invited to submit their manuscripts electronically to e-mail: joanna.latka@usz.edu.pl. Central European Journal of Sport Sciences and Medicine considers for publication manuscripts in the categories of Original Research, Review Article and Short Communication. The manuscripts should be in one of the following sub-disciplines: exercise physiology and biology, sports nutrition, sports science, biomechanics, coaching and training, sports medicine, sports injury and rehabilitation, physical activity and health, public health, physical education and health promotion as well as methodology of sport and history of physical culture and sport. Manuscripts with an interdisciplinary perspective with specific applications to sport and exercise and its interaction with health will also be considered. Papers are published only in English.

Preparation of manuscripts

The manuscript must be word-processed, double-spaced throughout, with a 2.5 cm margin all around, with no 'headers and footers' (other than page numbers), and without footnotes unless these are absolutely necessary. Use Arial, size twelve (12) point font.
All experimental work in which humans are participants must conform to the laws of the country in which the work took place. The manuscript should contain a statement to the effect that the work reported has been approved by a local ethics committee or review board. The statements about ethics approval or sources of data should be made at the beginning of the methods section.
Manuscripts should be compiled in the following order: title page; abstract; keywords; main text; acknowledgments; references; list of table(s) caption(s) and figure(s) legend(s) (on individual page at the end of the manuscript). The table(s) and figure(s) have to be uploaded as separated file(s). The main text can be arranged under headings such as Introduction, Methods, Results, Discussion and Conclusion if this is appropriate. Number the pages consecutively, beginning with the title page as page 1 and ending with the Figure pages. 6,000 word count limit (including title, abstract, acknowledgements, and references).

Title page

Include the following information on the first page of the manuscript: the full title; a running title of no more than 75 characters and spaces. List all authors by first name, all initials and family name. List departmental affiliations of each author affiliated with institutions where the study described was carried out. Connect authors to departments using numbers superscripts. Contributions of the author and each co-author considering the following categories: A – Study Design; B – Data Collection; C – Statistical Analysis; D – Manuscript Preparation; E – Funds Collection. No names of co-authors will be published unless their contributions are indicated. Connect authors to contributions using alphabetic superscripts.
Provide the name, full address and e-mail address of the corresponding author to whom communications, proofs and requests for reprints should be sent. Provide up to five keywords for indexing purposes.

Abstract

The abstract should be placed on individual page (second page of the manuscript) and must not exceed 200 words and it must summarize the paper, giving a clear indication of the conclusions it contains.

Tables and illustrations

Illustrations (photographs and line drawings) and tables must not be included in the text file. The table(s) and figure(s) have to be submitted as separated, source file(s). Table(s) files should be prepared as .doc files. Tables, referred to as 'Table 1', 'Table 2', and so on, must be numbered in the order in which they occur in the text. Illustrations should be prepared referred to as 'Figure 1', 'Figure 2', and so on, must be numbered in the order in which they occur in the text. Diagrams and drawings should be produced using a computer drawing or graphics package at the appropriate resolution. It is in the Author's interest to provide the highest quality figure format possible. Colour figures will be reproduced in the on-line edition of the journal free of charge, in the print version all figures will be reproduced in the greyscale. If you wish to have figures in colour online and black and white figures printed, please prepare both versions.

References

All references must be alphabetized by surname of first author and numbered at the end of the article. Please use APA style for references and citations (see the files "A guide to APA English" and "Styl APA-WNUS Polish" on our website).

Submission of manuscripts

All manuscripts, correspondence and editorial material for publication should be submitted online to: e-mail: joanna.latka@usz.edu.pl.
The entire peer-review process will be managed electronically to ensure timely review and publication.
PLEASE NOTE that papers will NOT be assigned for peer review until they are formatted as outlined in the Guide for Authors. The review process will consist of reviews by at least two independent reviewers. Contributors may suggest the names and full contact details of 2 possible reviewers. The reviewers must not be from the same institutions as the authors. The Editor may, at his or her discretion, choose no more than one of those suggested. The reviewers will be blinded to the authorship of the manuscript. The Editor will make a final decision about the manuscript, based on consideration of the reviewers' comments. The journal's Editorial Board does not enter into negotiations once a decision on a manuscript has been made. The Editor's decision is final.
Authors will be asked to sign a transfer of copyright form. This enables the publisher to administer copyright on behalf of the authors and the society, while allowing the continued use of the material by the author for scholarly communication.

ISSN 2300-9705

71-101 Szczecin, ul. Mickiewicza 66
tel. 91 444 20 06, 91 444 20 12
e-mail: wydawnictwo@univ.szczecin.pl
www.wn.usz.edu.pl