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CONTENT

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Editorial office

LITHUANIAN SPORTS UNIVERSITY
Sporto str. 6, LT-44221 Kaunas, Lithuania
Tel. +370 37 302636
Fax +370 37 204515
E-mail zurnalas@lsu.lt
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EFFECT OF DIFFERENT OCCLUSION PRESSURE ON PECULIARITIES OF MUSCLE BLOOD FLOW

Kęstutis Bunevičius, Albinas Grunovas, Jonas Poderys
Lithuanian Sports University, Kaunas, Lithuania

ABSTRACT

Background. Occlusion pressure intensity influences the blood flow intensity. Immediately after the cuff pressure is released, reactive hyperaemia occurs. Increased blood flow and nutritive delivery are critical for an anabolic stimulus, such as insulin. The aim of study was to find which occlusion pressure was optimal to increase the highest level of post occlusion reactive hyperaemia.

Methods. Participants were randomly assigned into one of the four conditions ($n = 12$ per group): control group without blood flow restriction, experimental groups with 120; 200 or 300 mmHg occlusion pressure. We used venous occlusion plethysmography and arterial blood pressure measurements.

Results. After the onset of 120 and 200 mm Hg pressure occlusion, the blood flow intensity significantly decreased. Occlusion induced hyperaemia increased arterial blood flow intensity 134 ± 11.2% ($p < .05$) in the group with 120 mmHg, in the group with 200 mmHg it increased 267 ± 10.5% ($p < .05$), in the group with 300 mmHg it increased 233 ± 10.9% ($p < .05$)**.** Applied 300 mmHg occlusion from the 12 minute diastolic and systolic arterial blood pressure decreased statistically significantly.

Conclusions. Occlusion manoeuvre impacted the vascular vasodilatation, but the peak blood flow registered after occlusion did not relate to applied occlusion pressure. The pressure of 200 mmHg is optimal to impact the high level of vasodilatation. Longer than 12 min 300 mmHg could not be recommended due to the steep decrease of systolic and diastolic blood pressures.

Keywords: blood flow restriction, hyperaemia, blood flow intensity, arterial blood pressure.

INTRODUCTION

Athletes and coaches are looking for the most efficient training method so as to achieve maximum results and to maintain these results for the longest possible period. One of a non-traditional training methods has been developed that uses occlusion, in some literature known as the "Kaatsu" methodology (Ozawa, Koto, Shinoda, & Tsubota, 2015; Sato, 2005). The key point of occlusion training is that blood flow restriction in combination with low intensity (20–50% of maximal voluntary contraction) exercise training has consistently been shown to increase muscle size and enhance function (Dankel et al., 2016; Gundermann et al., 2012; Patterson & Ferguson 2010; Yasuda, Loenneke, Thiebaud, & Abe, 2015). Restriction of blood flow by occlusion applied during the exercise diminishes time or repetitions to task failure (Loenneke et al., 2012) and thus reduces the mechanical loading. The combination of low-intensity resistance training with restricted venous blood flow to the working muscle may provide an alternative training method to the traditional high-intensity resistance training that is used (Shinohara, Kouzaki, Yoshihisa, & Fukunaga, 1998).

Blood flow is one of the important parts in the chain of delivery oxygen and energy substrates to working muscles. Blood flow intensity in muscles varies depending on their functional activity. There are great differences in the data provided by various authors. When comparing the effects of different training exercises on muscle blood flow, it has been observed that endurance training reduces the intensity of blood flow at rest (Delp & Laughlin, 1998; Villar & Hughson, 2017). Exercise is one of the most powerful non-pharmacological methods of affecting cells and organs in the body (Shalaby, Saad, Akar, Reda, & Shalgham, 2012). Regular aerobic and resistance exercise training has a positive long-term impact on the cardiovascular system, which is a biologically complex adaptive system that is characterized by a variety of complex reactions to different training loads (Alex et al., 2013; Ellison, Waring, Vicinanza, & Torella, 2012; Gibala, Little, Macdonald, & Hawley, 2012).

Applied acute occlusion or occlusion training, its cuff pressure, length, and width are varied, the compressive pressure varies between studies, but typically, the cuff is inflated to a pressure greater than brachial diastolic blood pressure and upward of pressures exceeding systolic blood pressure (Horiuchi & Okita, 2012; Manini & Clark, 2009). Occlusion pressure intensity influences the blood flow intensity. Immediately after the cuff pressure is released, reactive hyperaemia occurs, increased blood flow and nutritive delivery are critical for an anabolic stimulus, such as insulin (Gundermann et al., 2012). After cuff release, nitric oxide and nitric oxide bioavailability increases, the endothelium of blood vessels use nitric oxide to signal the surrounding smooth muscle to relax, thus resulting in vasodilation and increasing blood flow (Horiuchi & Okita, 2012).

The aim of study was to find-out which occlusion pressure was optimal to increase the highest level of post occlusion reactive hyperaemia.

METHODS

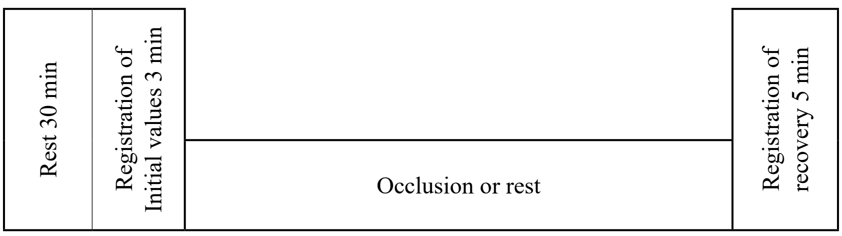
Participants. The participants in the study were amateur male middle and long distance track and field runners with 4–6 years of training experience. The study was performed when athletes had the rest period without active training; they had only muscle flexibility exercises, except for calf muscles. None of the participants exercised for at least 12 hours and before the test or ate for at least 3 hours before the test. The weight and body mass index (BMI) (TBF-300 body composition scale; Tanita, UK Ltd., West Drayton, UK) of the participants were estimated while they were semi-nude (shorts and T-shirts). This study was approved by the Regional Biomedical Research Ethics Committee. Participants were randomly assigned into one of the four conditions (*n* = 12 per group): control group without blood flow restriction, experimental groups with 120; 200 or 300 mmHg pressure occlusion (Table 1).

Study design. The participants were seated for 15 min on a chair, with the leg fixed at an angle of 90°, and the ankle at an angle of 70°. In the experimental groups, the participants underwent circulatory restriction with a 40-mm-wide cuff on the groin, the belt air pressure was respectively set at 120, 200 or 300 mmHg (respectively the approximate below, resting and more than resting systolic blood pressure in calf muscle). In the control group, participants seated on a chair without occlusion (Table 2).

Table 1. **Characteristics of the experimental and control groups**

Group	Occlusion pressure (mmHg)	Occlusion duration (min)	Age (years); Body mass index ($kg \cdot m^{-2}$)
Experimental group 1 (*n* = 12)	120	15	22.7 ± 0.7; 21.3 ± 0.4
Experimental group 2 (*n* = 12)	200	15	22.6 ± 0.6; 21.4 ± 0.3
Experimental group 3 (*n* = 12)	300	15	21.9 ± 0.3; 20.8 ± 0.5
Control group (*n* = 12)	0	0	22.1 ± 0.4; 22.5 ± 0.7

Table 2. **Organization of the study**



Measurements. Venous occlusion plethysmography. The arterial blood flow intensity in the calf muscles was measured using venous occlusion plethysmography. Changes in the calf volume were determined with a modified Dohn's plethysmograph. An air-filled measuring cuff of latex rubber (width, 5 cm; pressure, 4 cm H_2O) was fitted around the thickest portion of the calf. Venous occlusion on the distal part of the thigh was achieved by fast inflating the cuff to a pressure of 70 mmHg. The third cuff was fixed at the ankle, and closed off the circulation to the foot during the measurements. The examinations were conducted in the room temperature (22–23°C) with the subject in a sitting position.

Arterial blood pressure. Arterial blood pressure is an important cardiovascular functional parameter. It was measured using the cuff method and by listening to the "Korotkoff" tones (American Diagnostic Corporation Prosphyg™ 770 Aneroid Sphygmomanometer). Arterial blood pressure was measured before and after each set.

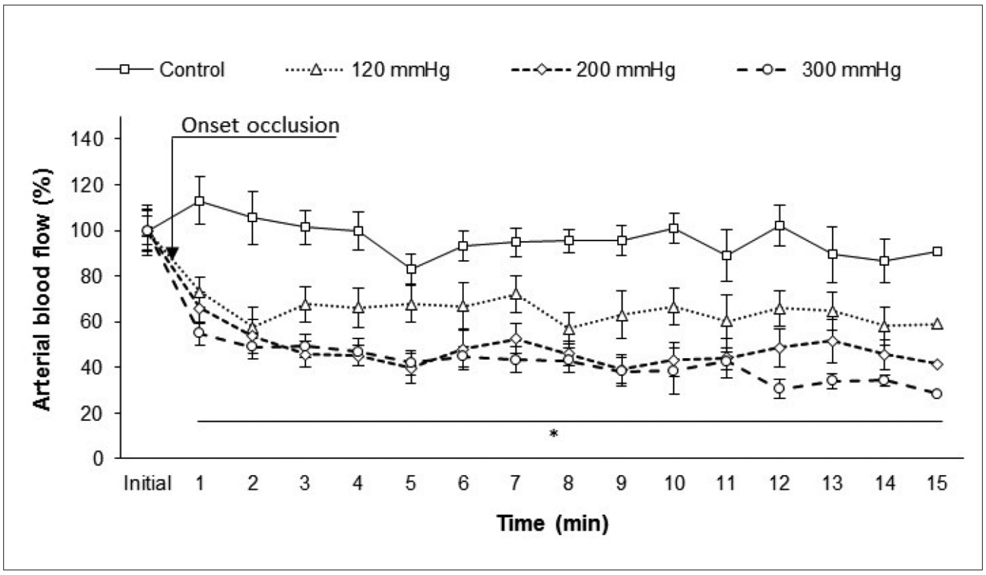
Statistical analysis. The data were tested for normal distribution using the Kolmogorov–Smirnov test, and all data were found to be normally distributed. Mixed analysis ANOVA (General Linear Model) with one between-subjects factor (control group and experimental group), and two conditional factors (exercise and recovery dynamics) as within-subjects factors of different levels was used. If significant effects were found, Sidak's post hoc adjustment was used for multiple comparisons within each repeated-measure ANOVA. The level of significance was set at $p < .05$. Herewith the calculations for observed power (OP) were performed and the partial eta squared ($\eta 2$) was estimated as a measure of the test-retest effect size. All statistical analyses were performed using IBM SPSS Statistics 22 (IBM Corporation, Armonk, New York). Data are presented as mean ± SE.

RESULTS

While the 15-min occlusion applied in the groups with 120 mmHg ($p < .05$, $\eta^2 = 0.879$, $OP = 1.0$), with 200 mmHg ($p < .05$, $\eta^2 = 0.761$, $OP = 1.0$) and with 300 mmHg ($p < .05$, $\eta^2 = 0.779$, $OP = 1.0$) pressure significantly decreased the blood flow intensity after onset of occlusion from the first minute compared to the initial blood flow before occlusion. However at the end of 15-min period, arterial blood flow intensity differed statistically significantly between all groups ($p < .05$). In experimental group with 120 mmHg, arterial blood flow decreased 41 ± 9.9 % ($p < .05$), with 200 mmHg decreased 58 ± 8.6% ($p < .05$) and with 300 mmHg occlusion pressure decreased 71 ± 8.9%. In the control group, while participants were at rest and sat without occlusion, arterial blood flow decreased only 9 ± 9.7% ($p <.05$) (Figure 1).

Applied 300 mmHg pressure occlusion ($p < .05$, $\eta^{2 = 0.174,}$ $OP = 0.893$) from the 13 minute statistically decreased diastolic and systolic arterial blood pressure compared to initial values before occlusion. In other experimental groups,

Figure 1. **Changes of arterial blood flow intensity in experimental groups during 120; 200 or 300 mmHg pressure occlusion and in control group without occlusion at rest**



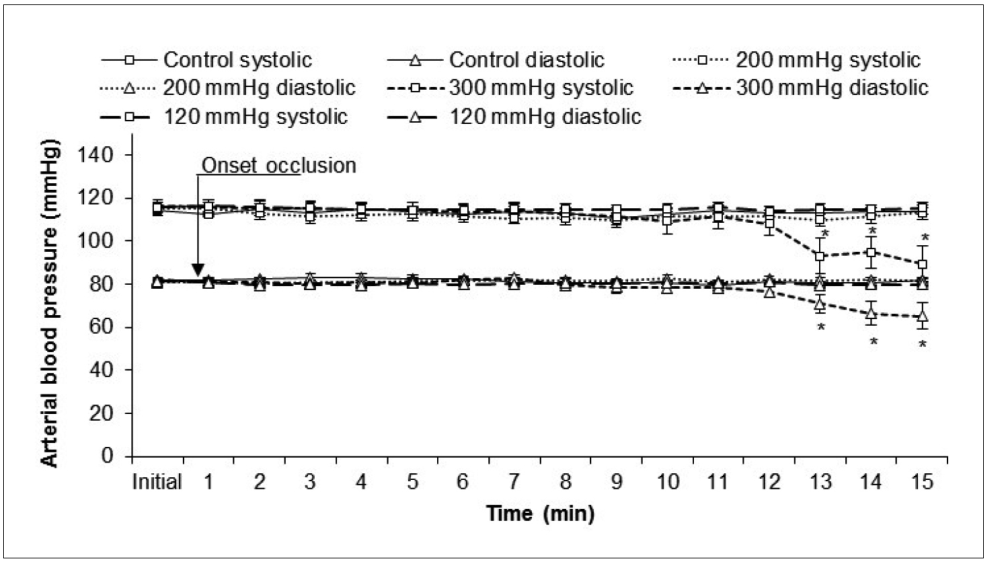


Figure 2. **Changes of arterial blood pressure in experimental groups during 120; 200 or 300 mmHg pressure occlusion and in control group without occlusion at rest**

120 and 200 mmHg occlusion pressure had no significant effect on systolic and diastolic blood pressure, there was also no change in the control group (Figure 2).

Immediately after occlusion removal in group with 120 mmHg ($p < .05$, $\eta^2 = 0.855$, $OP = 0.1$), 200 mmHg ($p < .05$, $\eta^2 = 0.924$, $OP = 1.0$) and 300 mmHg occlusion pressure ($p < .05$, $\eta^2 = 0.742$, $OP = 0.1$), arterial blood flow intensity increased statistically significantly compared to values at 15 min of occlusion. Occlusion induced hyperaemia increased arterial blood flow intensity 134 ± 11.2% ($p < .05$) in experimental group with 120 mmHg, in the group with 200 mmHg it increased 267 ± 10.5% ($p < .05$), and in the group with 300 mmHg occlusion pressure it increased 233 ± 10.9% ($p < .05$). In the control group after rest without occlusion, arterial blood flow intensity increased only 17 ± 9.9% ($p > .05$). After 3 min recovery, blood flow intensity returned to the baseline level (Figure 3).

Applied 300 mmHg occlusion ($p < .05$, $\eta^2 = 0.695$, $OP = 0.1$) immediately after occlusion removal, diastolic and systolic arterial blood pressure was decreased statistically significantly till 4 min of recovery ($p < .05$), compared to initial values before occlusion. In the other experimental groups with 120, 200 mmHg occlusion pressure, it had no significant effect on systolic and diastolic blood pressure ($p > .05$), there was also no change in the control group (Figure 4).

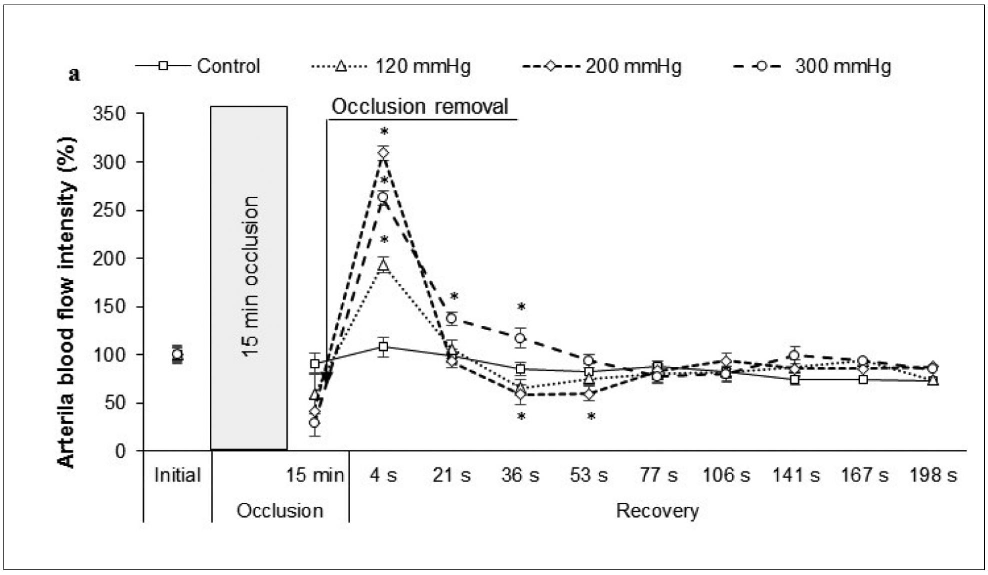
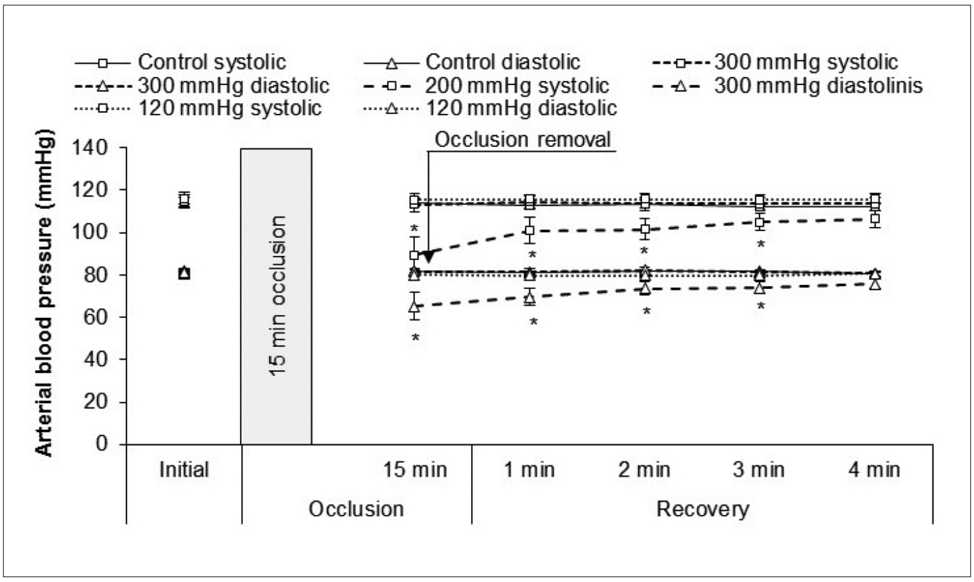


Figure 3. **Changes of arterial blood flow intensity in experimental groups after removal of 120; 200 or 300 mmHg pressure occlusion and in control group at rest without occlusion**

Figure 4. **Changes of arterial blood pressure in experimental groups after removal of 120; 200 or 300 mmHg pressure occlusion and in control group at rest without occlusion**



DISCUSSION

Rhythmic muscle contractions may affect the cardiovascular system in two ways: to reduce the blood flow within inactive muscles and increase arterial blood flow intensity in active musculature (Behringer & Segal, 2012; Fan et al., 2008; Holwerda, Restaino, & Fadel, 2015). Referring to the findings of various authors we can find sources about sufficiently high variations in arterial blood flow intensity at rest. Raitakari et al. (1996) found from 1.1 to 7.5 mL/100 mL/min of arterial blood flow intensity in the human muscles at rest. In our study, in the sample of muscle endurance representatives, arterial blood flow intensity ranged from 1.6 ± 0.2 mL/100 mL/min to 2.1 ± 0.3 mL/100 mL/min at rest (Raitakari et al., 1996). Blood flow intensity levels at rest were within the same limits as presented in the literature data. Muscle arterial blood flow intensity varies depending on the functional condition as well as on internal and external stimuli. As it was shown, short-term adaptation to endurance exercises does not have a significant effect on skeletal muscle arterial blood flow intensity at rest, while long-term adaptation to endurance exercises significantly effects the intensity of circulation, i.e. reduces the intensity of arterial blood flow in the muscles at rest (Delp & Laughlin 1998).

During passive recovery, occlusion influences muscle arterial blood flow significantly reducing the intensity of it. Results obtained in our study showed that immediately after the 15 min occlusion, arterial blood flow intensity significantly increased. Thus, the occlusion manoeuvres decreased arterial blood flow intensity, and after occlusion there was a short-term reactive hyperaemia. The most interesting fact was that the peak blood flow after occlusion was not related to applied occlusion pressure. The response of blood vessels to pressure of 300 and 120 mmHg was less than to the influence of 200 mmHg. The applied occlusion pressures in restricting blood flow varies between studies, but typically the cuff is inflated to a pressure greater than brachial diastolic blood pressure and upward of pressures exceeding systolic blood pressure (Manini & Clark, 2009).

Was observed arterial blood pressure changes at rest during occlusion, during the first three minutes, the systolic arterial blood pressure increased significantly. During ischemic manoeuvres arterial blood pressure increases, and when the air is released from the cuff, it decreases, but it can be vice versa, i.e., the systolic and diastolic arterial blood pressure can gradually increase (Horiuchi & Okita, 2012). In our study, applying 15 min 120 and 200 mmHg occlusion during passive recovery, we observed that systolic and diastolic arterial blood pressure was almost unaffected, while longer than 12 min 300 mmHg pressure occlusion extremely decreased systolic and diastolic blood pressures.

Dynamic hyperaemia due to the dilation of small blood vessels after the cuff release may act by increasing muscle performance because of the maximised oxygen supply via reduced lag in oxygen uptake (VO_2 transient) and diminished oxygen debt; it may also increase the early by-product wash-out. However, the metabolite build-up during the blood flow restriction could hinder/counteract the achieved benefits in augmented early circulation and in fact may reduce working capacity. The balance of ergogenic to ergolytic effects depends on the degree and duration of the occlusion applied. Among athletes of certain sporting events such as track running, there is a popular belief and practice based on some evidence (Salvador et al., 2016) that working capacity might be increased by raising the legs above the heart level for few minutes prior to the race. The proxy of this practice, also termed ischemic preconditioning, is repetitive blood flow restriction and relief cycles performed prior to exercise. Concomitant occlusion and elevation of the limbs is another variation of this practice. All of these practices are performed with an aim to reduce the blood flow during the procedure, and then induce reactive hyperaemia, oxygen delivery and then (maintenance of) intensity during subsequent competitive exercise. Aside from the effect on the ability to perform subsequent post-release exercise, blood flow restriction deserves investigation as a possible additive training stimulus.

CONCLUSIONS

Occlusion manoeuvre impacted the vascular vasodilatation, but the peak blood flow registered after occlusion did not relate to the applied occlusion pressure. The pressure of 200 mmHg is optimal to impact the high level of vasodilatation. Longer than 12 min 300 mmHg could not be recommended due to the steep decrease of systolic and diastolic blood pressures.

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Corresponding author **Kęstutis Bunevičius**
Lithuanian Sports University
Sporto str. 6, LT-44221 Kaunas
Lithuania
Tel. +370 37 302 621
Email k.bunevicius@gmail.com

PHYSICAL ACTIVITY, PHYSICAL FITNESS AND ACADEMIC ACHIEVEMENTS OF PRIMARY SCHOOL CHILDREN

Irina Klizienė[1], Laura Kimantienė[1], Ginas Čižauskas[1], Laura Daniusevičiūtė-Brazaitė[1], Gintautas Cibulskas[1], Arūnė Janulevičienė[2]
Kaunas University of Technology[1], Kaunas, Lithuania
Kaunas "Vyturys" Gymnasium[2], Kaunas, Lithuania

ABSTRACT

*Background.*The purpose of this study is to estimate physical activity, physical fitness and assessment of mathematical achievements in primary schoolchildren.

Methods. The study involved 1st grade students (N = 93), 45 of which were girls and 48 were boys. The flexibility test, the long jump test, 3 × 10 m speed shuttle run test, a medical (stuffed) 1 kg ball pushing from the chest test were used. Physical activity was measured using Children's Physical Activity Questionnaire. Academic achievements were assessed using Mathematical diagnostic progress tests and mathematical learning achievements according to curriculum content.

Results. It turned out that both boys (95.87 MET/min/week) and girls (91.30 MET / min/ week) were physically active in physical education lessons ($p > 0.05$). Long jump results ranged from 105.2 cm (girls) to 118.3 cm (boys), statistically significant differences were detected ($p < 0.05$) The best score of the girls' shuttle running 3 × 10 m was 9.55 s, for boys it was 9.2 s, the worst performance time for boys was 13.68 s, for girls – 13.54 s ($p < .05$). Mathematics Diagnostic Progress Tests for both girls and boys indicated satisfactory levels.

*Conclusion***.** We should note that all 4 fitness tests had a positive, linear association with physical fitness tests and mathematics test scores.

Keywords: physical activity, physical fitness, mathematical achievements, academic achievements, primary education.

INTRODUCTION

The observed magnitude of the relation between physical activity and health varies considerably, especially in children (Rowlands, Ingledew, & Eston, 2000). However, an active lifestyle contributes significantly to health and the prevention of diseases (Janssen & LeBlanc., 2010) and has been further linked to an adequate development of motor and cognitive functions (Erickson, Hillman, & Kramer, 2015). The application of PA at schools is very important; primary school can increase the physical activity of children from moderate to intensive, for example, time of the breaks (Powell et al., 2016). Low PA and long sitting, for example, in lessons, as well as immobility during breaks lead to poorer learning achievements in children (Syväoja et al., 2013). Children who have increased PA levels from moderate to severe before 11 years of age achieve better learning outcomes at the age of 11, 13 and 16 (Booth et al., 2014). This indicates that PA in primary classes is a very important factor. Physical activity (PA) researchers have often proposed the necessity of school-affiliated PA, suggesting that the time spent in PA would benefit health and might contribute to academic performance. Especially in children cognitive functions seem to benefit from physical activity (PA), with their highly plastic brains as one possible explanation (Tomporowski, Davis, Miller, & Naglieri, 2008). As a key aspect of cognitive functioning, working memory reflects the ability to hold and manipulate information to regulate thoughts and behaviour (Diamond, 2013). Therefore working memory is a crucial cognitive aspect in children for success at school.

The purpose of this study was to estimate physical activity, physical fitness and mathematical achievements in primary schoolchildren.

METHODS

Participants. According to the SVIS data base statistics (http://www.svis.smm.lt/), the number of first grade students in year 2017/2018 was 30.126 in total (14.609 of girls). All in all, 384 first form students had to be tested. This study was only observational and therefore a smaller number of respondents were selected.

The school was randomly selected from primary schools in Lithuania. The study took place in 2017 from September to November in four Lithuanian general education schools that had primary education and primary education classes. The time and place of the study, with the consent of the parents, were agreed upon in advance with the school administration. The study involved 1st grade students ($N = 93$), 45 of which were girls and 48 were boys. Mean weight, height for girls were 24.3 ± 9 (kg), 1.25 ± 11 (m) and for boys 29.3 ± 6 (kg), 1.33 ± 9 (m).

The testing of physical fitness. The students performed four physical fitness tests (PFT) during physical education lessons They performed the European Physical Fitness Test Battery (Eurofit) in the following test order: the long jump test to test explosive power of children's leg muscles; flexibility (sit and reach test) (Venckunas, Emeljanovas, Miezienė, & Volbekienė, 2017); 3 × 10 m speed shuttle run test – agility (Ivanovas & Paškevičienė, 2003); medical (stuffed) 1 kg ball pushing from the chest test explosive power of the hands (Fjørtoft, Pedersen, Sigmundsson, & Vereijken, 2011).

The evaluation of physical activity. Children's Physical Activity Questionnaire (Corder, van Sluijs, Wright, Whincup, Wareham, & Ekelund, 2009) was used. It was also based on the Children's Leisure Activities Study Survey (CLASS) questionnaire, which included activities specific to young children, such as "playing in a playhouse." The original intent of the proxy-reported CLASS questionnaire for 6–7-year-olds was to assess type, frequency, and intensity of physical activity over a usual week.

Mathematical diagnostic progress tests. Mathematical Diagnostic Progress tests (MDPT) were prepared in accordance with the requirements of the General Mathematics Education Curriculum (approved by ISAK-2433 of 26 August 2008). Diagnostic progress tests are an objective way to measure the achievement of skills and abilities. MDPT is divided into two parts: the division of tasks by achievement levels; the division of tasks according to the content and fields of activity; the division of tasks according to cognitive skill groups. The assessment of all areas of activity is based on the levels of student achievement levels (unsatisfactory, satisfactory, basic, and advanced).

Distribution of mathematical learning achievements by curriculum content. Diagnostic tests of mathematics evaluate the students' knowledge, skills, subject and general skills of mathematics acquired in the first grade according to the five fields of mathematics education curriculum:

1) numbers and calculations;
2) phenomena, equations, inequalities;
3) geometry, measures and measurements;
4) statistics;
5) communication and general problem-solving strategies.

The learning achievements described in the General Programs in the fields of Geometry, Measures and Measurement are combined in the Diagnostic Assessment Program and described in one area of the curriculum content – Geometry, Measures and Measurements. It were 7 possible MDPT tasks.

Learning achievements of mathematics according to the groups' cognitive abilities. The tasks of the mathematical diagnostic tests are aimed at assessing the abilities of students according to three groups of cognitive abilities: mathematical knowledge and understanding, application of mathematics and higher thinking abilities.

Instructions for evaluating all mathematical diagnostic progress tests were developed to assess pupils 'achievement, helping to ensure a uniform assessment of all students' work. All fields of activity are based on student achievement levels (unsatisfactory, satisfactory, basic, and advanced).

Mathematical statistics. The arithmetic mean (x) and the average standard deviation (SD) were determined for comparison. Differences between different genders, age and physical fitness were estimated using one-factor dispersion analysis (ANOVA). The relationship between variables was calculated on the basis of the correlation coefficient of the Spearman correlation coefficient. Differences between different genders and physical activity were estimated using Mann-Whitney *U* test. The following reliability levels were used for statistical outputs: $p > .05$ – insignificant; $p < .05$ – significant. All calculations were performed using MS Excel and SPSS programs.

RESULTS

Physical activity of 7-year-old children. Analysing the results of 7-year-old students' physical activity (PA), it turned out that both boys (95.87 MET / min / week) and girls (91.30 MET / min/ week) were physically active in physical education lessons ($p > .05$).

The analysis of PA types such as cycling to school and walking to school showed that there were no differences of gender according to MET. The higher number of boys (1095.65 MET / min / week) was found to be of the average PA compared to the girls (657.39 MET, min / week). The statistically significant difference was found in the analysis of the MET average per boy (1191.52 MET / min / week) compared to the girls (785.86 MET, min / week, $p < .05$; Table 1).

Physical fitness of 7-year-old children. While analysing the results of 7-year-old students' (boys and girls) physical fitness (PF) tests, it turned out that the results of the long jump test ranged from 105.2 cm (girls) to 118.3 cm (boys), statistically significant differences were detected ($p < .05$) (Table 2). The girls ($r = 2.73$ m) performed worse than the boys (3.35 m) ($p < .05$) in the medical (stuffed) 1 kg ball pushing from the chest test. The best score of the girls' 3 × 10 m speed shuttle run test was 9.55 s, for boys it was 9.2 s, the worst performance time for boys was 13.68 s, for girls 13.54 s ($p < .05$). Comparing the results of boys' and girls' flexibility, there were no statistically significant differences ($p > .05$): the girls' flexibility was about 0.05 cm, for boys -1.6 cm.

Statistically significant correlations were determined between the standing long jump test and 3 × 10 m speed shuttle run test results ($r = –.939$, $p < .01$); between the long jump and the medical (stuffed) 1 kg of ball pushing from the chest ($r = –.945$, $p < .01$); between the long jump and the flexibility test – sit and reach ($r = .945$, $p < .01$).

A strong correlation was identified between the results of 3 × 10 m speed shuttle run test and the medical (stuffed) 1 kg ball pushing from the chest ($r = –.960$, $p < .01$); between the 3 × 10 m speed shuttle run test and flexibility test – sit and reach ($r = .949$, $p < .01$). A strong correlation (Table 2) was also identified between the medical (stuffed) 1 kg ball pushing from the chest and flexibility test – sit and reach ($r = .942$, $p < .01$). A statistically significant ($p < .05$) strong ($r = .722$) correlation was identified after conducting Spearman correlation analysis between physical activity and physical fitness. This shows that PA affects PF.

Table 1. **Determining physical activity levels using the MET method**

Type of physical activity	MET	1 day/min	Days per week	MET (min/week)
Boys				
Physical Education lesson	3.5	30	1	95.87
Cycling to school	4	0	3	0.00
Walking to school	3.3	0	4	0.00
Sport groups(medium FA)	6	60	1	1095.65
			On average for one boy	1191.52*
Girls				
Physical Education lesson	3.5	30	1	91.30
Cycling to school	4	0.45	3	15.65
Walking to school	3.3	0.87	4	21.52
Sport groups(medium FA)	6	60	1	657.39
			On average for one girl	785.86*

Note. *$p < .05$ (according to Mann-Whitney *U* test).

Table 2. **Comparison of 7- year-old boys' and girls' indicators of physical fitness**

Test	Girls	Boys	F criterion value; p level	Observed Power
Long jump (cm)	105.2 (12.1)	118.3 (9.8)	**28.017 .000**	**1.000**
Medical (stuffed) 1 kg ball pushing from the chest (m)	2.73 (0.27)	3.35 (0.65)	73.460 .000	1.000
3 × 10 m speed shuttle run	11.61 (0.914)	10.99 (1.06)	21.082 .000	0.996
Sit and reach (cm)	0.05 (7.09)	–1.6 (6.25)	3.475 .064	0.459
Relationships between students' physical fitness				
	Long jump (cm)	**3 × 10 m speed shuttle run**	**Medical (stuffed) 1 kg ball pushing from the chest (m)**	**Sit and reach (cm)**
Long jump (cm)	1			
Medical (stuffed) 1 kg ball pusshing from the chest (m)	–.939**	1		
3 × 10 m speed shuttle run	.945**	–.960**	1	
Sit and reach (cm)	.945**	–.949**	.942**	1

Note. ***p* < .01.

Mathematical diagnostic progress tests. Analysing the results of 7-year-old students' (boys and girls) Mathematical Diagnostic Progress Tests (MDPT), it appeared that in the 7 possible MDPT tasks, both girls and boys demonstrated satisfactory levels, whereas the upper level (of 3 MDPT tasks) was not found (Figure 1). There were no significant gender differences ($p > .05$).

Distribution of mathematical learning achievements according to curriculum content. When assessing students' learning achievements in terms of curriculum content, the numbers and calculations out of 9 presented the tasks were correct for girls – 7.86 ± 1.07, for boys – 7.75 ± 1.37, and differences between genders were not determined ($p > .05$); phenomena, equations, inequalities - from the one presented was correctly performed by girls – 0.83 ± 0.38, by boys – 0.79 ± 0.41, and gender difference were not significant ($p > .05$); Geometry, Measures and Measurements tasks correctly solved out of the four was as follows: girls – 3.72 ± 0.51, boys – 3.71 ± 0.50, difference between genders was insignificant ($p > .05$); statistics – 1 task solved correctly: girls – 0.33 ± 0.48, boys – 0.31 ± 0.47, the difference between genders was insignificant ($p > .05$).

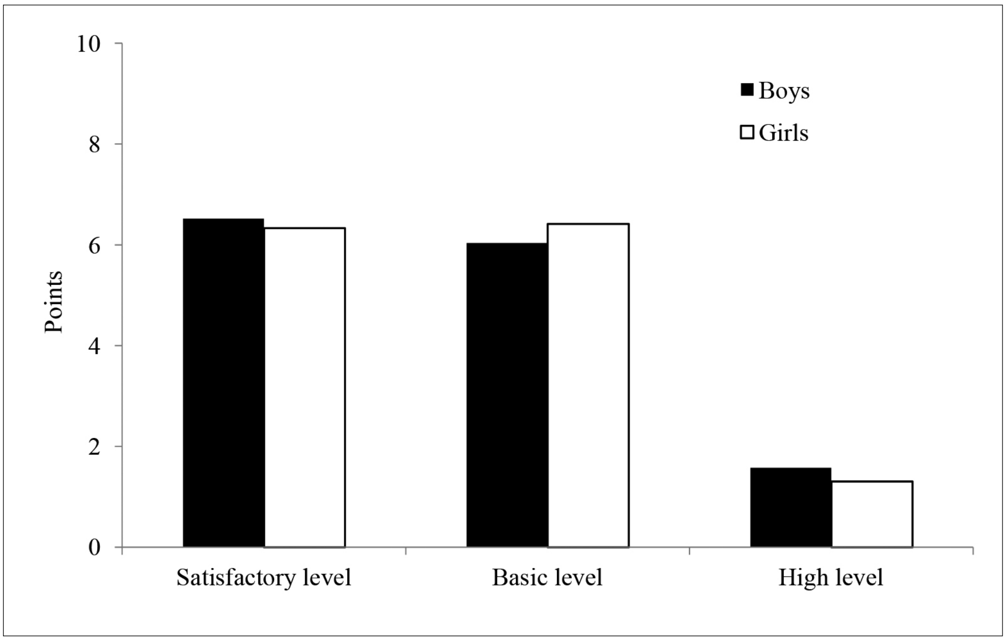
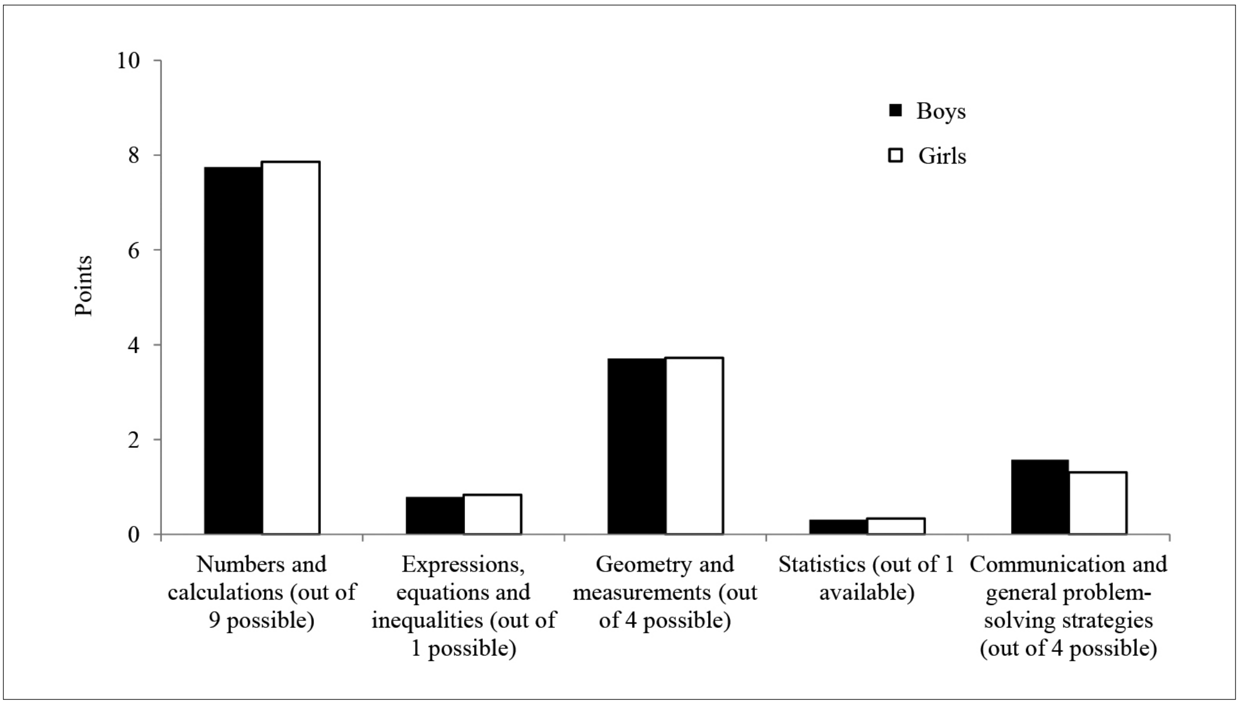


Figure 1. **Distribution of Mathematical diagnostic progress test results**

Figure 2. **Distribution of mathematical learning achievements according to the curriculum content**



We suggest that this corresponds to the learning outcomes described in the general curriculum for boys and girls. However, communication and general problem-solving strategies of the four tasks presented correctly were: for girls – 1.31 ± 0.69, for boys – 1.58 ± 0.96, and the difference between the genders was significant ($p < .05$) (Figure 2). This indicates that this area is the weakest and there is a need for improvement.

Learning achievements of mathematics according to the group's cognitive abilities. It was found that mathematical knowledge and understanding of the 6 tasks presented were correct for girls 5.53 ± 0.56, for boys – 5.58 ± 0.67, gender differences were not found ($p > .05$) while assessing the achievements of students' mathematics learning in cognitive capacity groups; out of eight mathematics tasks presented correctly were solved: girls – 6.47 ± 0.88, boys – 6.25 ± 1.36, gender differences were not determined ($p > .05$), and according to the higher thinking abilities of the four tasks presented, correctly were done: girls – 2.06 ± 1.19, boys – 2.31 ± 1.20, no gender difference was established ($p > .05$).

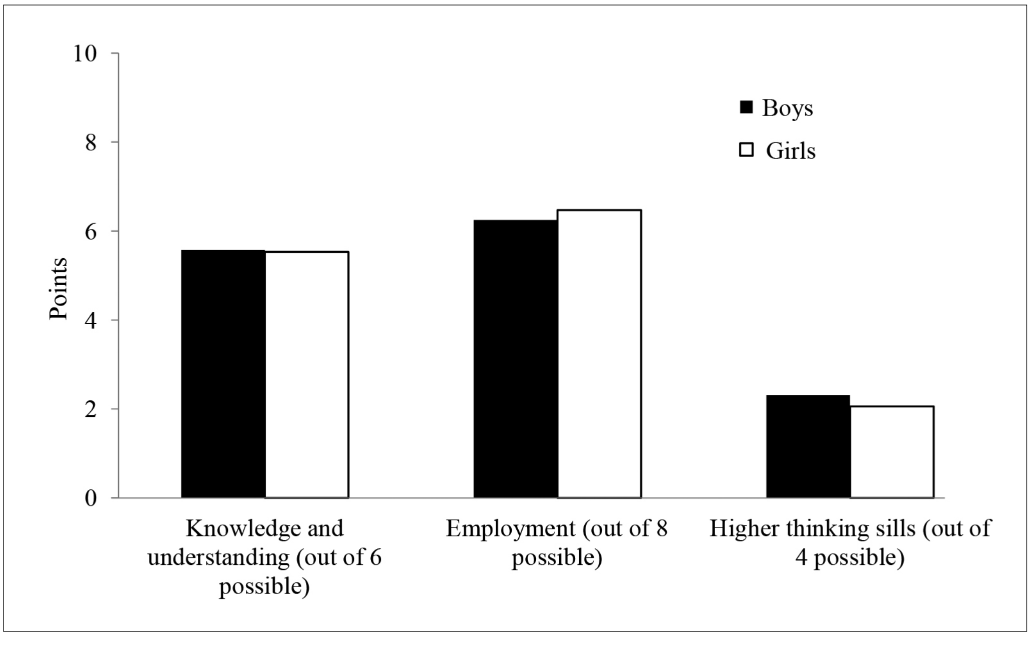


Figure 3. **Learning achievements in mathematics according to cognitive capacity groups**

DISCUSSION

The findings of this study add evidence and detail to the proposition that an association exists between physical activity, physical fitness and academic achievements in primary school children. It should be noted that all 4 fitness tests had a positive, linear association with physical fitness tests and mathematics test scores.

Physical Activity. Over the last few decades, children's physical activity levels have changed dramatically. Outdoor physical play is increasingly being replaced by less physical indoor activities (Anderssen, Harro, & Sardinha, 2006), 6–8-year-old children are increasingly being driven to school by car or bus instead of cycling or walking, and participation in organized sports is declining (Grund, Dilba, & Forberger, 2000). A similar pattern of a substantial contribution from walking and a comparatively small contribution to overall physical activity from sport has also been reported in adults in England (Bélanger, Townsend, & Foster, 2011) indicating that this pattern continues into adulthood. Active play was the largest contributor to overall physical activity in younger children but with increasing age walking took over. Such changes with age in the type of activity undertaken by children are not unexpected given their changing maturity across the age range of 5–15 years and their increasing independence, particularly given that some of the time spent walking may be for active travel purposes (excluding to/from school). The contribution from sport increased with age for both boys and girls, contributing the most among older boys (Allender, Cowburn, & Foster, 2006). The main differences in our study between the activity profile of girls and boy were the contributions from sport, which made a smaller contribution among girls than boys (on average for one boy 1095.65 MET min/week, on average for one girl 785.86 MET min/week). At all ages, sport contributed a larger proportion to physical activity among boys than among girls. Few other studies have looked at the role of informal play, active travel and domestic activity in addition to structured sport and exercise, in the total physical activity of children (Telama et al., 2005) and yet this study shows that play in particular is an important contributor. Differences in the activity profile of boys and girls, particularly the role played by sport, may reflect gender differences in motivations for physical activity. Several studies have found that males are more motivated by competition than females (Vilhjalmsson & Kristjansdottir, 2003). Vilhjalmsson and Kristjansdottir (2003) concluded, in a study of the gender differences in activity among Icelandic schoolchildren, that the difference in overall physical activity between boys and girls was entirely attributable to lower participation in sport among girls. Our study indicates that although the proportion of all activity achieved through sport differs between boys and girls. Therefore, still the question is how the frequency, intensity, and duration of physical activity in children affect their physical fitness and how decreasing levels of physical activity may be related to possible changes in physical fitness and to further health problems later in life, such as obesity, diabetes, osteoporosis, back pain, cardiovascular disease (Timpka, Petersson, & Zhou, 2014), hypertension (Faselis, Doumas, & Kokkinos, 2012) and cancer (Marshall & Bouffard, 1997).

Physical Fitness. For investigating such relationships, reliable tests that can establish children's physical fitness in large population samples are needed. The optimal use of the analysis of the physical strength of each child allows predicting the extent and intensity of physical activity, with emphasis on relevant attributes.

Physical exercises can be used to strengthen the health and individual exercises that have a positive effect on their physical development by knowing the abilities of a particular child (Visagurskienė & Grigonienė, 2016). Childhood is an important stage in which one can build fitness potential and develop lifestyle habits to maintain it (Venckunas et al., 2017). To this line, the recent prospective study has shown that physical fitness and fundamental movement skills developed in early adolescence predict total, moderate, and vigorous physical activity levels 6 years later (Jaakkola, Yli-Piipari, & Huotari, 2016).

The article presents physical fitness of younger schoolchildren in Lithuania. PF tests are presented that are simple to use but reflect the physical activity of the students in the initial classes, hand muscle strength, motor skills, coordination, flexibility, and agility. Physical fitness tests were evaluated in accordance with Buliuolienė Daukšaitė, Klizas, Klizienė, and Cibulskas (2017), the reference tables for physical development and physical fitness were developed. The tables allowed classifying the students according to physical fitness levels. The explosive strength of the muscles of the primary school students has a satisfactory level of achievement (Buliuolienė et al., 2017). Our obtained results compared to the research done by Greek scientists showed that the result of the long jump of girls living in Greece is significantly better (141 ± 1.2 cm) than that of girls studying in Lithuania, the results of boys are similar (132 ± 0.2 cm) (Velikoek, Tsoukos, & Bogdan, 2012).

Academic achievements. PA-related changes in children's brain function and cognition (e.g., attention, information processing, executive function, and memory) have been implicated as cornerstones for gains in academic performance (Donnelly et al., 2016). Coe, Peterson, Blair, Schutten, and Peddie (2013) found that high fitness levels are positively associated with academic achievement in school-aged youth. The findings of this study add evidence and detail to the proposition that an association exists between physical activity, physical fitness and mathematic achievement of the primary schoolchildren.

Nirio et al. (2014) found that academic achievement scores were positively related to fitness levels. Good cardio-respiratory and speed/agility levels were associated with high academic achievement after controlling for confounders. Van Dusen et al. (2011) found that cardiovascular fitness was found to have the strongest direct associations with academic achievement, with a standardized mean difference effect size of .34 (.32–.35) for boys-math and .33 (.31–.35) for girls-math. The next largest associations (as measured by effect size and mean difference in TAKS score) were with curl-ups, followed by push-ups, sit and reach, and trunk-lift which registered the lowest effect size of .07 (95% CI: .05–.08).

CONCLUSION

The findings of this study add evidence and detail to the proposition that an association exists between physical activity, physical fitness and academic achievement of the primary schoolchildren. It should be noted that all 4 fitness tests had a positive, linear association with physical fitness tests and mathematics test scores.

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Corresponding author **Irina Klizienė**
Department of Education Sciences
Kaunas University of Technology
Donelaičio str. 73, Kaunas LT-44239
Lithuania
Tel. +370 682 39370
Email irina.kliziene@ktu.lt

THE EFFECT OF BLOCK AND TRADITIONAL PERIODIZATION MODELS ON JUMPING AND SPRINTING DYNAMICS DURING THE SIMULATED BASKETBALL GAMES

Vytautas Pliauga[1,2], Inga Lukonaitienė[1], Kristina Bradauskienė[1], Irina Klizienė[2], Daniele Conte[1], Jūratė Stanislovaitienė[1]
Lithuanian Sports University[1], Kaunas, Lithuania
Kaunas University of Technology[2], Kaunas, Lithuania

ABSTRACT

Background. The aim of the study was to compare the effect of block and traditional periodization preseason preparation on advanced players' jumping and sprinting dynamics during the simulated basketball games.

Methods. Ten college-level males (age (mean ± standard deviation (SD)), 21.5 ± 1.7 years; weight, 83.5 ± 8.9 kg; height, 192.5 ± 5.4 cm) were divided into two teams according to the training model: block periodization (BP) and traditional periodization (TP). Block periodization (BP) consisted of the following blocks: aerobic endurance (AE), power endurance (PE), basketball specific aerobic endurance (BSAE), and power (P). Both groups played a simulated basketball game with each other before and after preseason preparation. Vertical countermovement jump and 20 meters sprint were measured before each simulated game and after each quarter of the game.

Results. In BP, the 8 weeks of preseason training resulted in elevated vertical jump and 20 meters sprint dynamics during simulated games ($p < .05$).

Conclusion. We conclude that 8 weeks of block periodization enhanced leg power production and sprint abilities during simulated games and therefore is more effective than traditional periodization model.

Keywords: basketball, power, periodization.

INTRODUCTION

Coaches search for training methods which might imitate the real match demands, aiming to develop both sport-specific skills and improving physical fitness performance (Marcelino et al., 2016). In basketball, it is particularly important to have highly developed power capabilities because this sport includes high-intensity game elements, such as changes of direction, dribble, sprints, jumps, shots, and passes (Abdelkrim et al., 2010; Conte et al., 2015; Scanlan at al., 2012). The external load of players per game consists of up to 1,000 different actions (Conte et al., 2015; Conte, Tessitore, Smiley, Thomas, & Favero, 2016; Scanlan et al., 2012), including about 45 jumps, whereas movement sequences are performed in an intermittent fashion and seldom last for longer than 20 s (Conte at al., 2016). Because of this, basketball training requires understanding of the demands of the game and methodological approach is essential for combining all subcomponents of the basketball-training program.

The traditional approach of designing training plans of traditional development of different physical abilities at the same time is still widely used (Issurin, 2016). In contrast, the block periodization training employs highly focused training workloads on particular physical ability for approximately 3–6 weeks (Issurin, 2016). Some studies have reported superior strength, power, and local muscular endurance gains using traditional periodization (Monteiro et al., 2009; Rhea, Ball, Phillips, & Burkett, 2002), whereas other studies have shown no significant differences in these strategies or have favoured block periodization (Bartolomei, Hoffman, Merni, & Stout, 2014; Buford, Rossi, Smith, & Warren, 2007; García-Pallarés, García-Fernández, Sánchez-Medina, & Izquierdo, 2010; Hartmann, Bob, Wirth, & Schmidtbleicher, 2009; Hoffman et al., 2009). It should be noted that the majority of studies used strength training programs that compared the two periodization models. Hence, the training process in team sports is more complex compared with individual strength training, as preseason conditioning activities should replicate game situations to ensure that players are prepared appropriately for competition.

When coaches design training plans, they have limited time to provide training only for power enhancement; therefore, they combine power exercises with specific basketball drills by alternating exercise intensity and duration. The effect of such training strategies on athletes' physical abilities is poorly understood. It is unclear how combined training translates into actual power production in players. Therefore, the current study aimed to compare the effects of basketball specific block and traditional periodization models on advanced players' jumping and sprinting dynamics during the simulated games. Taking into consideration the greater concentration of loads, it was expected that by applying block periodization, athletes would achieve higher results in both vertical jump and 20 meters sprint dynamics during simulated games.

METHODS

Subjects. Ten (6 frontcourt and 4 backcourt) college-level male basketball players (mean ± *SD*; age: 21.5 ± 1.7 y-o; body mass: 83.5 ± 8.9 kg; stature: 192.5 ± 5.4 cm; training experience: 7.6 ± 1.1 years) belonging to the same team voluntarily participated in this study. Participants were free of injuries in the 6 months before the start of the study. The experiment was performed during the preseason period, during which players trained 1–2 h per day and 5–6 days per week. Players did not undertake intensive exercise in the 48 h before each testing procedure. All players were notified about the aim of the study, research procedures, requirements, benefits, and all participants and parents gave informed consent. Ethics approval was granted from the Kaunas Regional Ethical Committee Review Board.

Procedure. This is an intervention study and data were gathered before and after the 8-week preseason preparation. Participants were equally divided in two training groups according to the two analysed training periodization models: block periodization (BP) and traditional periodization (TP). Players within each group were matched by the coaching staff according to their skill levels and on-court positions. The principal loading scheme of different periodization models is presented in Table 1. The BP model consisted of the four blocks (aerobic endurance, power endurance, basketball specific aerobic endurance, and power) with 2-week duration each (Table 2).

In the TP model, similar training stimuli were combined within each microcycle as shown in Table 3. In both TP and BP, similar exercise intensity and volume were administered in the 8 analysed weeks. Moreover, training stimuli were mainly characterized by the same basketball-specific technical and tactical drills except for the first block in the BP model (aerobic endurance) in which players were only involved in jogging and running activities. Each training session was preceded by 20–25 min standardized warm-up including jogging, dynamic stretching, and basketball-specific drills (i.e. ball-handling, shooting and free throws) and followed by 15 to 20–min cool down in which core conditioning exercises and static stretching were performed.

In this study, the training periodization model was the independent variables, while vertical jump height and sprint dynamics during the simulated basketball game were used as dependent variables. Each participant completed two testing sessions: before intervention (baseline) and after 8 weeks of preseason preparation. In the first testing session, the body height and mass were measured and then the subjects completed a standardized questionnaire indicating their age and training experience. Afterwards, the two teams played a simulated game following a standardized warm-up consisting of 7-min jogging, 5-min dynamic stretching, and 10-min low-intensity basketball-specific drills. 20 meter sprint and vertical counter-movement jump tests were performed before and after the warmup and immediately after each of the four quarters of the simulated games.

Table 1. **Principal loading scheme of different periodization models**

1st Microcycle (week 1–2) *(same load for both weeks)*								Total			
	Mon	Tues	Wed	Thurs	Fri	Sat	Sun	A	P	PE	R
BP	A	A	A	A	A	R	R	**10**	-	-	4
TP	P	PE	A	P	PE	A	R	4	4	4	4
2nd Microcycle (week 3–4) *(same load for both weeks)*								**Total**			
BP	PE	PE	A	PE	PE	A	R	4	-	**8**	2
TP	P	PE	A	P	PE	A	R	4	4	4	4
3rd Microcycle (week 5–6) *(same load for both weeks)*								**Total**			
BP	A	A	A	A	A	R	R	**10**	-	-	4
TP	P	PE	A	P	PE	A	R	4	4	4	4
4th Microcycle (week 7–8) *(same load for both weeks)*								**Total**			
BP	P	P	A	P	P	R	R	2	**8**	-	4
TB	P	PE	A	P	PE	A	R	4	4	4	4

Note. TP – traditional periodization, BP – block periodization, A – aerobic endurance, P – power, PE – power endurance, R – rest.

Table 2. **Block periodization scheme**

Microcycles (weeks)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Block	Aerobic endurance		Power endurance		Basketball-specific aerobic endurance		Power	
Content	Jogging		• Technical drills • Shooting drills • Dribbling • Variations of sprint, jumps, & core conditioning		• Technical drills • Shooting drills • Tactical drills, & core conditioning		• Technical drills • Shooting drills • Dribbling • Variations of sprint, jumps, & core conditioning	
Total session duration	90 min		90 min		90 min		90 min	
Warm-up	20–25 min		20–25 min		20–25 min		20–25 min	
Exercise typology	Continuous		Intermittent		Continuous		Intermittent	
Sets	1		1–2		1		2	
Repetitions	1		20–30		1		4–5	
Repetition duration	/		4 s		/		4 s	
Repetition rest	/		10 s		/		1 min	
Work/rest ratio within each set	/		1:2.5		/		1:15	
Rest between sets	/		5 min		/		5–7 min	
Cool down	10 min		15–20 min		15–20 min		15–20 min	
Sessions per week	5		5		5		5	

Table 3. **Traditional periodization microcycle**

Week days	Days 1 and 4	Days 2 and 5	Day 3 and 6
Training session	Power	Power endurance	Basketball-specific aerobic endurance
Contents	• Technical drills • Shooting drills • Dribbling • Variations of sprint, jumps, & core conditioning	• Technical drills • Shooting drills • Dribbling • Variations of sprint, jumps, & core conditioning	• Technical drills • Shooting drills • Tactical drills, & core conditioning
Total session duration	90 min	90 min	90 min
Warm-up	20–25 min	20–25 min	20–25 min
Exercise typology	Intermittent	Intermittent	Continuous
Sets	2	1–2	1
Repetitions	4–5	20–30	1
Repetition duration	4 s	4 s	/
Repetition rest	1 min	10 s	/
Work/rest ratio within each set	1:15	1:2.5	/
Rest between sets	5–7 min	5 min	/
Cool down	15–20 min	15–20 min	15–20 min
Sessions per week	2	2	2

Counter-movement jump (CMJ) with arm swing. This test had been previously used in basketball to assess vertical jump performance (Boccolini, Brazzit, Bonfanti, & Alberti, 2013; Nikolaidis, Calleja-González, & Padulo, 2014). Participants performed the vertical jump on a contact mat (Powertimer Testing System, New Test, Oulu, Finland) starting from an upright standing position with preliminary downward movement to a knee angle of approximately 90° with an arm swing. Three trials were performed with 20 s of rest between each trial. The best result was used for analysis. If the third trial result was the best, one additional trial was carried out (Pliauga et al., 2015). The height of the jumps was calculated by applying the following equation: H = 1.226 x Tf2 (m), where Tf = flight time (s) (Bosco, Viitasalo, Komi, & Luhtanen., 1982). The best result was used for further analysis. The ICC for this test was established previously (0.95 (Kamandulis et al., 2013)).

20-meter sprint test, which had been widely used previously (Kamandulis et al., 2013; Pliauga et al., 2015). Running time was recorded using the Power time Testing System (New Test, Oulu, Finland). Photo-sensing elements connected to an electronic chronometer were placed 20 m apart. The starting position was 70 cm from the first photo-sensing element. Two trials were conducted with a recovery time of approximately 2 min between them. The best result was used for analysis. The intra-class correlation coefficient (ICC) for this test was established previously (0.95) (Kamandulis et al., 2013).

Simulated basketball game. The participants were then divided into two teams by the coach. The criteria for team assignment were the basketball performance level and playing position. The two teams played a simulated game that consisted of four 10 min quarters with a 15 min break at half time and 8-min breaks after the first and the third quarters. The players usually had a 2 min break for rest after the first and the third quarters, but the subjects in the present study rested for 2 min during those breaks and then performed tests for 6 min. The game involved official umpires, and took place on an indoor basketball court. Player substitutions were not allowed, and the players stayed in the game even when they had five fouls. This protocol of simulated basketball game was established previously (Pliauga et al., 2015).

Statistical Analysis. Descriptive data are presented as the mean ± SD. A nonparametric

Mann–Whitney test was used to compare differences in jump height and 20 meters sprint results between the control and experimental groups. Jump height and 20 meters sprint speed comparison within groups was performed using a nonparametric Wilcoxon test. The level of significance was set at .05. All analyses were performed using SPSS (SPSS, Inc., Version 20.0, Chicago, IL).

RESULTS

The height of vertical jumps before and after preseason preparation in BP and TP is presented in Figure 1. No differences were found between the BP and TP before the preseason preparation. The BP group exhibited major increases in jump height dynamics during the simulated games ($p < .05$). In contrast, there was no increase in jump height in the TP group at any time point of simulated basketball games.

The changes in 20 meters sprint are presented in Figure 2. BP and TP groups before the preseason preparation did not differ. After the preparation the BP group increased 20 meter sprint results during the simulated games with significant differences after second, third and fourth quarters ($p < .05$). However, there were no significant increases in TP group.

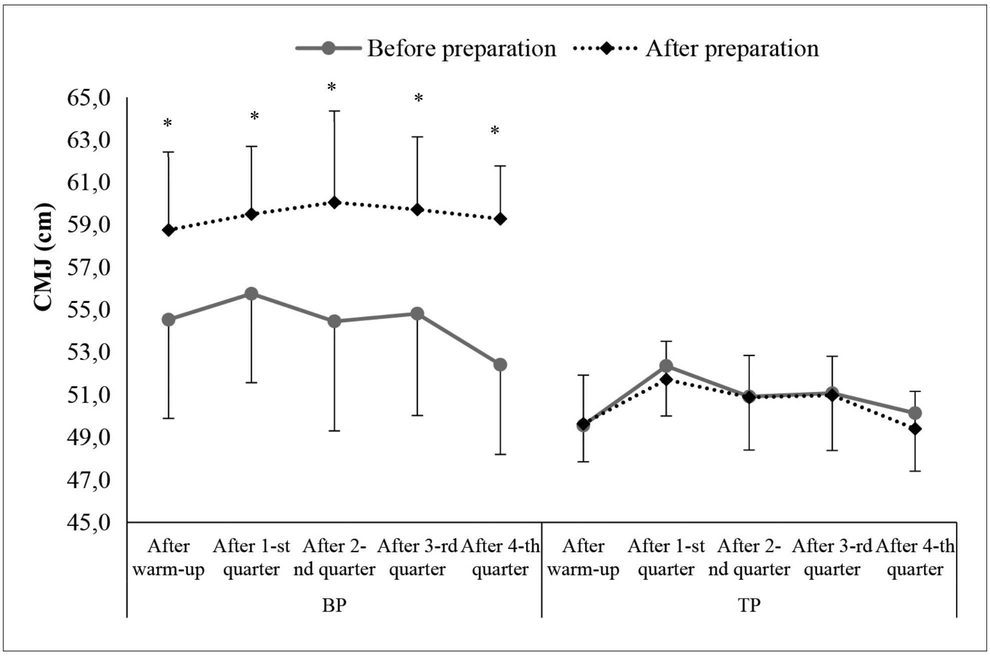

Figure 1. **Mean (± SD) values of vertical jump height during the simulated basketball games in block periodization (BP) and traditional periodization (TP) groups**

Note. * – significantly different compared to before preparation.

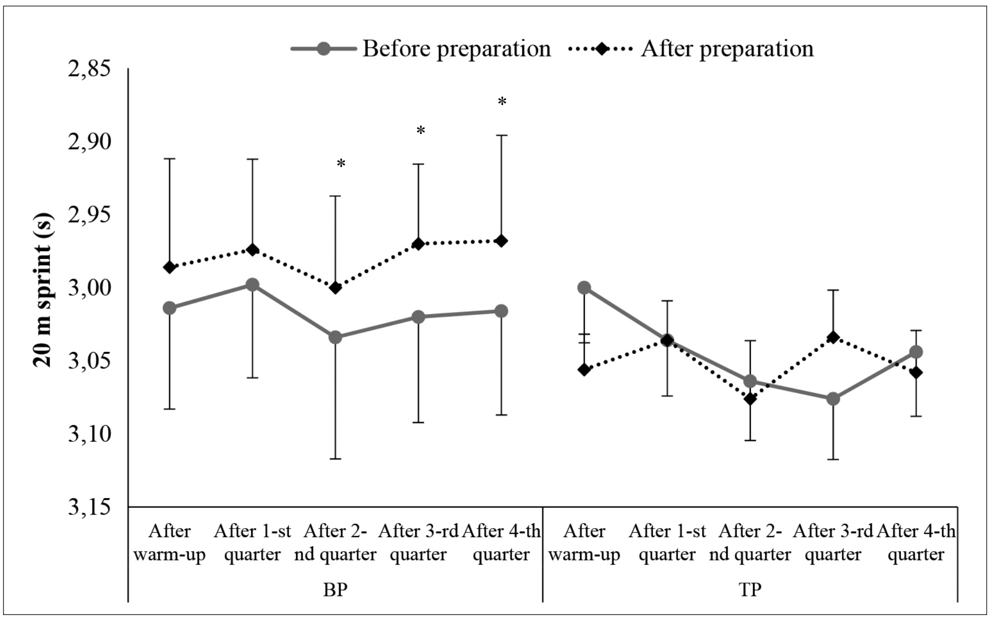

Figure 2. **Mean (± SD) values of 20 meter sprint during the simulated basketball games**

Note. * – significantly different compared to before preparation.

DISCUSSION

The aim of the study was to compare the effect of block and traditional periodization preseason preparation on advanced players' jumping and sprinting dynamics during the simulated basketball games. The training time to prepare basketball team is limited and in short duration of preparation coaches tend to cover many aspects of the game and conditioning, e.g. tactical preparation, defensive and offensive drills, shooting, endurance training and power. With that in mind, by using specific basketball drills and variations of work-rest ratio and intensity we expected not only developed the players' physical condition but also improved their game related skills. We confirmed that short concentrated training loads with a gradual increase in intensity (BP) tended to improve athletes' jumping and sprinting performance during the simulated basketball games. Block loading strategy appeared to have advantage over traditional periodization.

Different periodization approaches to improve athletes' anaerobic capacity have been studied previously (Bartolomei et al., 2014; García-Pallarés et al., 2010; Hartmann et al., 2009; Marques, Franchini, Drago, Aoki, & Moreira, 2017). One investigation analysing the effect of 15 weeks of BP and TP training structured with an equal volume of anaerobic exercises indicated an improvement of upper body power in BP compared to TP in power athletes, while no substantial changes were noted between groups in lower body strength and jump performances (Bartolomei et al., 2014). Conversely, in the current investigation a substantial improvement in CMJ and 20 meters sprint during simulated basketball games was shown following 8-week BP training, while no substantial changes were observed after the TP training. These data suggest that BP can induce performance increases in both 20 meters sprint and in CMJ.

In the TP model proposed by Matveev (1965), macrocycles and mesocycles are arranged for transition from high-volume and low-intensity workloads to high-intensity and low-volume workloads. Moreover, this model is based on the simultaneous development of many fitness components, e.g. aerobic capacity, strength, power, within a regular workload distribution (Matveev, 1965; Issurin, 2008; Issurin, 2016). In our study, the same microcycle was used during the whole preseason preparation and different training stimuli (P, PE, BSAE training sessions) were combined within each microcycle. This loading strategy is still popular among the coaches (Issurin, 2016). However, Kirby, Erickson, & McBride (2010) suggested that athlete cannot train for different concurrent variables at once optimally. Each variable must be addressed in various training blocks so that the best combination can be obtained and result in success for the athlete (Kirby et al., 2010).

The BP model was constituted by mesocycles with a specific training goal and their progression is performed in logical order aiming to prepare athletes for the subsequent training block (Bondarchuk, 1988; Issurin, 2008, 2016). In our study, 2-week specific blocks were adopted: accumulation (aerobic endurance and power endurance), transformation (basketball specific aerobic endurance) and realization (power). Aerobic endurance training block prepared players for more intensive and challenging power endurance block. It was showed that power endurance training produced significant increases in anaerobic capacity (Balčiūnas, Stonkus, Abrantes, & Sampaio, 2006). However, vertical jump and 20 m sprint test did not change after intermittent power endurance training (Balčiūnas et al., 2006). Conversely, in our study the results of CMJ during the simulated games increased significantly during the whole game compared to the first simulated games. This could be due to the use of basketball specific aerobic endurance and power blocks after intermittent power endurance training. Moreover, considering that athletes' performance increased at the end of the preseason period, it seems fundamental the use conjugated sequence model correctly sequenced and integrated.

The major limitation of this study was the low number of players examined. However, we preferred to restrict our investigation to a single basketball team, to avoid complications related to the attitude and training discipline variations of members of other teams.

CONCLUSION

Eight weeks of block periodization training including specific basketball drills tended to enhance leg power and sprint performance during the simulated basketball games. In addition, there was a clear tendency for greater effectiveness of the block periodization compared to traditional periodization strategy that may be meaningful for coaches who aim to combine conditioning and specific basketball exercises in the preseason preparation of players.

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Conflict of interest. The authors declare no conflict of interests regarding the publication of this manuscript.

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Corresponding author **Jūratė Stanislovaitienė**
Lithuanian Sports University
Sporto str. 6, LT-44221 Kaunas
Lithuania
Tel. +370 68626255
Email jurate.stanislovaitiene@lsu.lt

THE EFFECT OF DIFFERENT DOSE OF DROP JUMPING ON SYMPTOMS OF MUSCLE DAMAGE

Albertas Skurvydas, Gediminas Mamkus, Dalia Mickevičienė, Diana Karanauskienė, Dovilė Valančienė, Mantas Mickevičius, Sigitas Kamandulis
Lithuanian Sports University, Kaunas, Lithuania

ABSTRACT

Background. The aim of this study was to follow symptoms of exercise induced muscle damage in response to 50, 100 and 200 drop jumps with maximal intensity.

Methods. Three groups of young healthy men (n = 10 in each group) performed a bout of mechanically demanding stretch shortening cycle exercise consisting of 50, 100 and 200 drop jumps. Voluntary and electrically induced knee extension torque, creatine kinase, muscle soreness were measured before and 24 h after exercise.

Results. Indirect symptoms of exercise induced damage were dependent on DJs volume: the higher the numbers of jumps, the more symptoms were observed. Only after 200 DJs compared to 50-100 DJ there was decrease of CAR and H of DJ, and 24 h after 200 DJs CK was greater than after 50-100 DJs.

Conclusion. In response to acute severe muscle-damaging exercise (after 200 DJs), indirect symptoms of exercise-induced muscle damage occurred.

Keywords: stretch-shortening cycle exercise, motor fatigue, muscle soreness, muscle torque.

INTRODUCTION

Resistance and jumping exercises involving stretch-shortening muscular contractions may induce muscle damage (Byrne, Twist, & Eston, 2004; Gorianovas et al. 2013; Skurvydas, Brazaitis, Venckūnas, & Kamandulis, 2011) and result in a prolonged depression in muscle force, especially that is induced by low-frequency stimulation (Allen, Lamb, & Westerblad, 2008; Kamandulis, Skurvydas, Masiulis, Mamkus, & Westerblad, 2010; Proske & Allen, 2005; Skurvydas & Zachovajevas, 1998), and voluntary muscle activation (Fouré et al. 2014). In addition, increased plasma activity of muscle enzymes such as creatine kinase (CK) (Choi, 2014) is often observed. It is generally agreed that muscle tension and muscle length are main factors in determining the magnitude of exercise-induced muscle damage (EIMD (Proske & Allen, 2005). Basically it was concluded that the number of contractions performed could not explain the variability in EIMD markers among studies. However, a large fraction of muscle damage may occur early during exercise with further increase in the number of eccentric contractions causing progressively less damage (Morgan & Allen, 1999). Though the decrease in isometric and concentric torque and muscle soreness was smaller after 10 DJs compared with 50 DJs (Miyama & Nosaka, 2007), it has been shown that increase in the number further than 50 drop jumps did not increase electrically stimulated force reduction (Kamandulis et al., 2010). These facts suggest that severity of muscle damage might have very different effect on muscle damage markers.

Therefore, the aim of the present study was to compare the indirect symptoms of exercise induced muscle damage after 50, 100 and 200 drop jumps.

METHODS

Subjects. Three groups including 10 healthy untrained men participated in the study. The subjects' age, height and weight were similar (19–24 years, height = 179.9 ± 3.6 cm, body weight = 77.2 ± 4.5 kg). Subjects had not been involved in any type of systematic resistance or plyometric training program for at least 6 months before the study. Before being included into the study, subjects read and voluntarily signed an informed consent form consistent with the principles outlined in the Declaration of Helsinki. The study was approved by the Regional Ethics Committee.

Stretch-shortening cycle exercise. Subjects performed 50 (group of 50 DJs), 100 (group of 100 DJs) and 200 (group of 200 DJs) intermittent (30 s interval between each) drop jumps (DJs) from a 0.5 m height to a 90° knee angle with immediate maximal vertical rebound. Knee angle was controlled and recorded using a goniometer (Biometrics, UK). If the angle diverged from 90° during exercise, subjects were immediately instructed to adjust it on the subsequent jumps. During jumping, subjects held their hands on their waists. Jumps were performed using a contact mat (Power Timer Testing System, Newest, Finland). The rebound jump height (in cm) was calculated as (flight time in seconds)^2 × 122.6 (BOSCO, Viitasalo, Komi, & Luhtanen, 1982). The highest jump values of the first and last three of 50, 100, 200 DJs and at 24 h post-exercise were used in the analyses.

Knee extension torques. Torque of knee extensor muscles on the dominant leg was measured using an isokinetic dynamometer (System 3; Biodex Medical Systems, Shiley, New York). Subjects seated themselves upright in the dynamometer chair with their knee joint positioned at 110° angle (where 180° is full knee extension). Maximal voluntary knee extension for ~2 s was attempted twice; the larger value was used in analyses. The equipment and procedure for electrical stimulation were the same as in our previous studies (Skurvydas et al., 2011; Verbickas et al., 2018). Direct muscle stimulation was applied using two carbonized rubber surface electrodes, covered with a thin layer of electrode gel (Medigel, Modi'in, Israel). One electrode (6 × 11 cm) was positioned on the skin transversely across the width of the proximal portion of the quadriceps femoris. Another electrode (6 × 20 cm) covered the distal portion of the muscle above the patella. A standard electrical stimulator (MG 440; Medicor, Budapest, Hungary) was used to deliver supramaximal 0.5 ms square-wave pulses at 20 and 100 Hz frequencies for P20 and P100 torque measurement, respectively. Low-frequency fatigue (reflected as a drop in P20/P100 ratio) was calculated. The central activation was measured during ~5 s of maximal voluntary contraction; at ~3 s after beginning the attempt, a 250 ms test train of pulses at 100 Hz (TT100) was superimposed while the subject continued maximal efforts of knee extension. The central activation was calculated as the ratio of the maximal voluntary torque to peak torque generated with a superimposed TT100 (Gorianovas et al., 2013). The test was performed twice, and the larger central activation ratio value was used in the analyses.

Plasma creatine kinase (CK) activity. Approximately 0.5 mL of mixed capillary blood was drawn from the subject's fingertip at baseline and 24 h post-exercise. Samples were immediately centrifuged and the plasma analysed for creatine kinase activity using the biochemical analyzer Spotchem™ EZ SP-4430 (Menarini Diagnostics, UK) with soft reagent strips (ARKRAY Factory, Inc., Shiga, Japan).

Muscle soreness. Muscle soreness was reported subjectively using an ordinal scale of 0–10, where 0 represented "no pain" and 10 represented "intolerably intense pain" (Kamandulis et al., 2010). Subjects rated the severity of soreness in their quadriceps while performing 2–3 slow squats at baseline, and then on day 1 (24 h) post-exercise.

Statistical Analysis. Descriptive data are presented as means and standard deviation (SD). A Kolmogorov–Smirnov test confirmed that all data were normally distributed. One-way repeated-measures analysis of variance (ANOVA) was used to identify differences. Statistical significance was set at $p < .05$. Data analysis was performed using SPSS 22.0 statistical software package (SPSS Inc. Chicago, IL).

RESULTS

Motor performance. There was no significant difference between the values of motor performance pre-exercise in the groups (Table). MVC after exercise decreased for all groups ($p < .001$; $OP = 1$), but after 200 DJs it decreased more than after 100 DJs and 50 DJs ($p < .01$) (Figure 1A). Besides, 24 h after 200 DJs and 100 DJs MVC did not recover. CAR significantly decreased only after 200 DJs

Table 1. **Pre-exercise values of muscle torque and power indices (mean ± SD)**

Group	MVC (N·m)	DJs height (cm)	P20 (N·m)	P100 (N·m)	CAR (%)
50 DJs	291.6 71.5	36.8 6.8	166.5 29.9	245.2 45.6	95.8 7.5
100 DJs	290.9 44.3	35.1 4.5	178.1 24.4	254.2 38.1	95.4 8.0
200 DJs	279.1 40.3	34.9 5.9	169.1 29.9	259.9 31.1	94.4 7.3

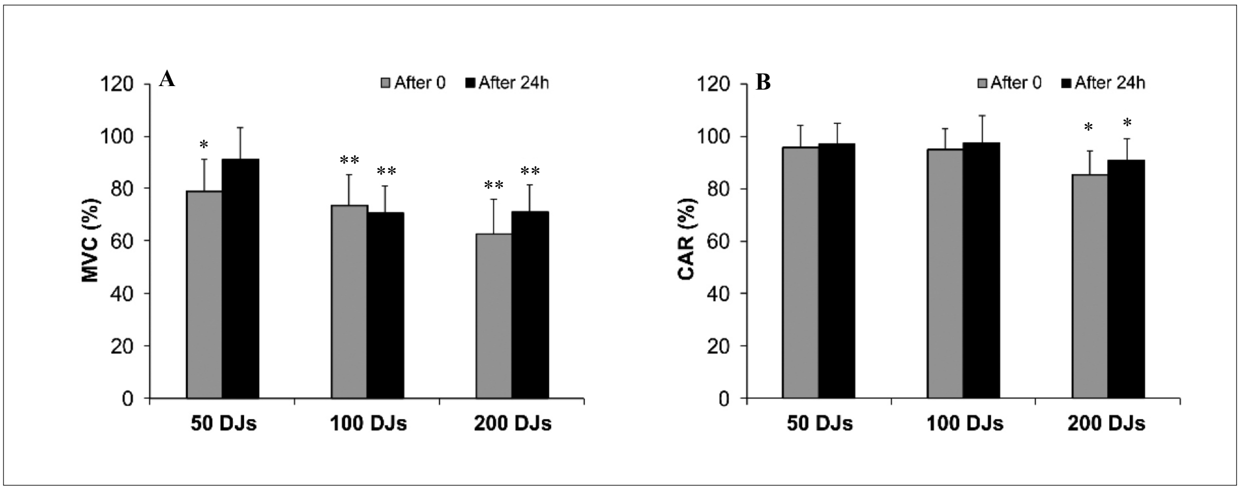
Note. MVC – maximal voluntary contraction torque; P20 and P100 – electrical stimulation at 20 and 100 Hz evoked torque; CAR – central activation ratio; DJs – drop jumps.

and did not recover within 24 h ($p < .01$) (Figure 1B). H of DJs significantly decreased only after 100 and 200 DJ ($p < .01$), but after 200 DJs it decreased more than after 100 DJs ($p < .05$) (Figure 2).

P20, P100 and P20/P100 decreased significantly after 50, 100 and 200 DJs and it did not recover within 24 h ($p < .001$; *OP* = 1) (Figure 3). However, P20, P100 and P20/P100 decreased more after 100 and P200 DJs than after 50 DJs ($p < .01$).

Muscle soreness and CK were greater after 100 and 200 DJs than after 50 DJs ($p < .01$) (Figure 4A and 4B). There was no difference in muscle soreness after 100 DJs and 200 DJs, however, CK after 200 DJs was greater than after 100 DJs ($p < .01$).

Figure 1. **MVC (A) and CAR (B) changes after 50, 100 and 200 DJs**



Note. * $p < .05$ and **$p < .001$ compared to pre-exercise values.

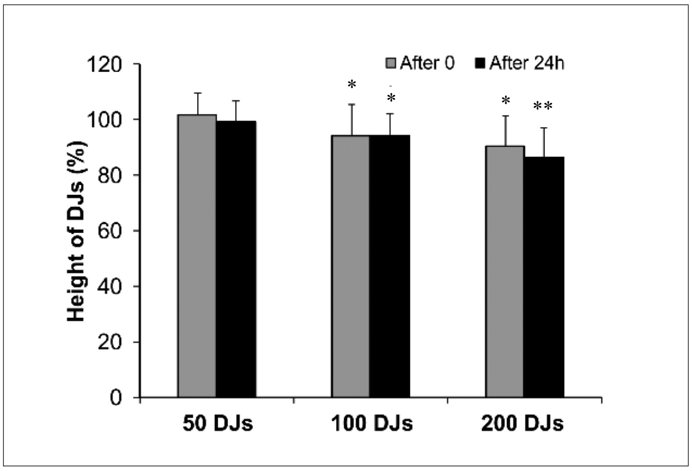
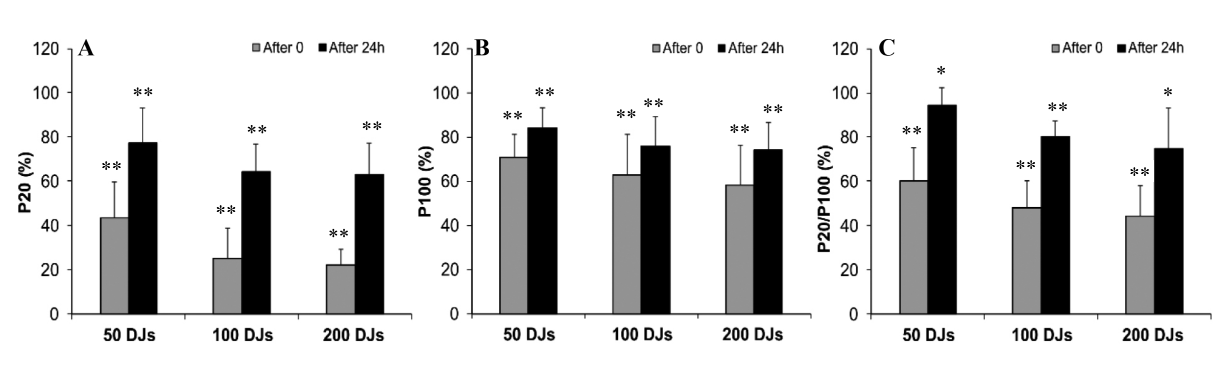


Figure 2. **Height of drop jumps (DJs) changes after 50, 100 and 200 DJs**

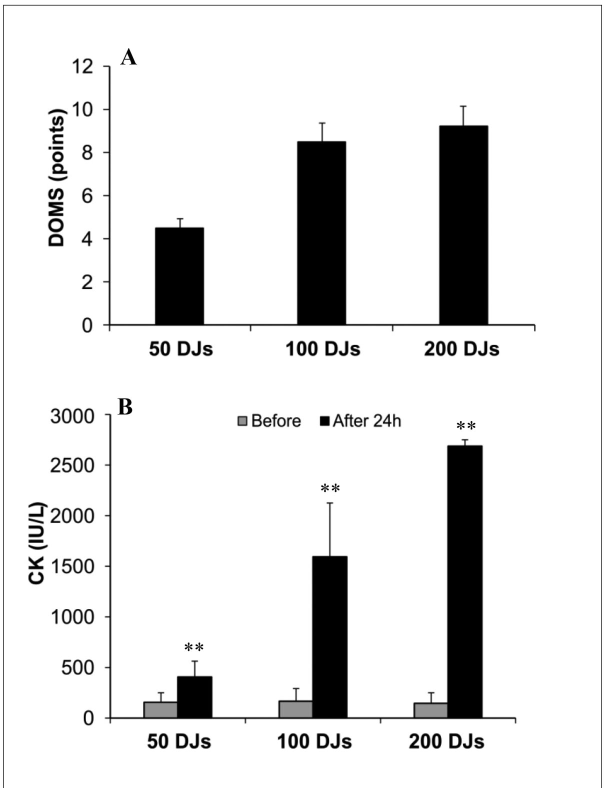
Note. *$p < .05$ and ** $p < .001$ compared to pre-exercise values.

Figure 3. **P20 (A), P100 (B) and P20/P100 (C) changes after 50, 100 and 200 DJs**



Note. *$p < .05$ and ** $p < .001$ compared to pre-exercise values.

Figure 4. **DOMS (A), CK (B) changes after 50, 100 and 200 DJs**



Note. *$p < .05$ and ** $p < .001$ compared to pre-exercise values.

DISCUSSION

Indirect symptoms of EIMD after 50 DJs are smaller than after 100 and 200 DJS. Compared to 100 DJS, 200 DJs increased CK and decreased voluntary motor performance. LFF remained the same after 100 and 200 DJS.

After all three exercise bouts, the symptoms of muscle damage manifested themselves: decrease in muscle voluntary and electrically induced torque, the rise of muscle soreness and increased plasma CK activity. Most symptoms show that exercise-induced muscle damage increased with the increase in DHS volume: 50 vs 100 vs 200 DS. In addition, P20 had decreased to a greater extent than the P100 suggesting that the muscles were subjected to LFF. These markers indicate that the main causes for the decrease in voluntary and electrically induced muscle performance after drop jumping are related to damage force-bearing structures (Byrne et al., 2004; Morgan & Proske, 2004; Proske & Allen, 2005) and excitation-contraction coupling system (Allen et al., 2008; Kamandulis et al., 2010; Verbickas et al., 2018).

The largest decrease, compared to other strength indicators, was registered for torque evoked by 20 Hz stimulation frequencies after 50–200 DJs. The decreased torque production of exercise-exposed muscle cells can, in principle, be due to (i) reduced Ca^{2+} release from the sarcoplasmic reticulum leading to decreased free myoplasmic [Ca^{2+}] ([Ca^{2+}]i), (ii) decreased myofibrillar Ca^{2+} sensitivity, and (iii) reduced ability of contractile machinery to produce force (Allen et al. 2008). On a simplified model, factors (i) and (ii) would result in a larger force depression rather at low than at high stimulation frequencies due to the sigmoidal shape of the force-[Ca^{2+}]i relationship, whereas factor (iii) would give a similar force decrease at all stimulation frequencies. We observed markedly larger force reductions during after SSE at 20 Hz than at 100 Hz stimulation, which indicate important roles of factor (i) and (ii) in the SSE-induced force depression (especially after 100-200 DJs). It should be noted, however, that sarcomere instability induced by eccentric contractions can shift the optimal length for active force production to longer lengths, which may exaggerate the force depression at low stimulation frequencies (Morgan & Proske, 2004).

The decrease in CAR was observed immediately after 200 DJs, while it did not change significantly after 50 DJs and 100 DJs and it shows that central activation is associated with stretch-shortening cycle exercise volume. Muscle fatigue may have inhibitory influence on central motor drive to keep the central output at a certain submaximal level presumably to avoid further accumulation of peripheral fatigue (Enoka & Duchateau, 2008).

CONCLUSION

In conclusion, though indirect symptoms of exercise induced muscle damage manifested itself after 50, 100 and 200 DJs, however, it was considerable greater after 100 and 200 DJs. Besides the changes in central fatigue, height of DJs was only after 200 DJs.

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Corresponding author **Dalia Mickevičienė**
Institute of Sports Science and Innovations
Lithuanian Sports University
Sporto str. 6, Kaunas LT-44221
Lithuania
Tel. +370 600 73 021
Email dalia.mickeviciene@lsu.lt

ARE MOTOR AND COGNITIVE CONTROL, IMPULSIVITY AND RISK-TAKING BEHAVIOUR AS WELL AS MORAL DECISION MAKING DETERMINED BY THE ACTIVITY OF PREFRONTAL CORTEX DURING STROOP TEST?

Albertas Skurvydas, Dovilė Valančiene, Andrius Šatas, Dalia Mickevičiene, Kazys Vadopalas, Diana Karanauskienė
Lithuanian Sports University, Kaunas, Lithuania

ABSTRACT

Background. The main aim of our research was to determine if there was a relationship between prefrontal cortex activity during Stroop test (dependent variables) and variables of "Go/NoGo", Balloon Analogue Risk Task, impulsivity score, different tests of cognitive functions, moral decisions tests (altruistic or egoistic), Fitts-like motor control task, five character traits, emotional intelligence, mood, sleepiness and perceived stress, total physical activity of subjects (independent variables).

*Methods.*In total, 20 undergraduate students (mean age were 21.3, *SD* = 1) met the criteria and agreed to participate in this study.

Results. Our research has shown that different brain functional outcomes, that is speed-accuracy motor control, inhibition response control and cognitive performance, risky-taking behaviour and impulsivity control, management of emotion, personality consciousness and physical activity have a common correlation with the increase in prefrontal cortex activity (measured by fNIRS) during Stroop test.

Conclusion. Our studies have clearly shown that different brain functional outcomes, that is speed-accuracy motor control, inhibition response control and cognitive performance, risky-taking behaviour and impulsivity control, management of emotion, personality consciousness and physical activity have a common correlation with the increase in prefrontal cortex activity (measured by fNIRS) during Stroop test. Considerable number of studies are needed to understand what is the functional essence of these relationships, but currently there is an increase of research establishing correlations between motor behaviour and cognition control.

Keywords: prefrontal cortex, motor and cognitive control, impulsivity, risk-taking, moral decision making.

INTRODUCTION

Behavioural inhibition, sustained attention, decision making, executive functions and self-control are basic behaviour determinants of healthy brain (Bari & Robbins, 2013; Barkley, 1997; Diamond, 2013; Hare, Camerer, & Rangel, 2009; Heatherton & Wagner, 2011; Pratt, Winchester, Egerton, Cochran, & Morris, 2008). It has been concluded that low self-control is a significant risk factor for a broad range of personal and interpersonal problems, while higher scores on self-control correlated with a higher grade point average, better adjustment (fewer reports of psychopathology, higher self-esteem), less binge eating and alcohol abuse, better relationships and interpersonal skills, secure attachment, and more optimal emotional responses (Tangney, Baumeister, & Boone, 2004). The childhood self-control predicts physical health, substance dependence, personal finances, and criminal offending outcomes, following a gradient of self-control (Moffitt et al., 2011). Thus, the executive functions and self-control are included as most important mechanisms in motor and cognition control (Diamond, 2013; Heatherton & Wagner, 2011; Wolpert & Landy, 2012).

A number of tests are known to directly or indirectly assess certain self-control and executive function components. For example, response inhibition paradigm ("Go/NoGo" and "Stroop" tests) (Chikazoe, 2010; Kueider, Parisi, Gross, & Rebok, 2012), behavioural decision-making tasks (such as the Iowa Gambling Task and Balloon Analogue Risk Task, BART) (Buelow & Barnhart, 2017; Lejuez et al., 2002), impulsivity score (BIS-11) (Patton, Stanford, & others, 1995), Fitts-like motor control task (Bertucco, Bhanpuri, & Sanger, 2015), five character traits (conscientiousness, which is related to impulse control) (Costa & MacCrae, 1992), emotional intelligence (Schutte et al., 1998), different tests of cognitive functions (Reeves, Winter, Bleiberg, & Kane, 2007) and moral decisions tests (altruistic or egoistic) (Starcke, Polzer, Wolf, & Brand, 2011).

Frontal and prefrontal cortex is one of major brain structures responsible for cognition and motor control as well as decision-making, self-control and executive functions (Bechara, 2005; Cohen & Poldrack, 2009; Diamond, 2013; Dunning, Ghoreyshi, Bertucco, & Sanger, 2015; Heatherton & Wagner, 2011; Krain, Wilson, Arbuckle, Castellanos, & Milham, 2006; Miller & Cohen, 2001; Shadmehr, Smith, & Krakauer, 2010; Wolpert & Landy, 2012).

It is generally accepted that the more complex the cognition and motor control, the more prefrontal and frontal cortex are activated in healthy people. Recently it has been established that neurons in the frontal cortex become more active when the activity is more risky (Krain et al., 2006; Schultz, O'Neill, Tobler, & Kobayashi, 2011). Taken together, if cognitive and motor control is mentally demanding, then frontal and prefrontal cortex activity is decreased due to self-control and impulsivity control diminishing (Muraven & Baumeister, 2000; Qi et al., 2015), due to aging (Pratt et al., 2008), in suicidal patients (Desmyter, van Heeringen, & Audenaert, 2011), due to impaired control over drinking (Weafer et al., 2015).

The main aim of our research was to find out if there was a relationship between prefrontal cortex activity during Stroop test (dependent variables) and variables of "Go/NoGo", Balloon Analogue Risk Task, impulsivity score, different tests of cognitive functions, moral decisions tests (altruistic or egoistic), Fitts-like motor control task, five character traits, emotional intelligence, mood, sleepiness and perceived stress, total physical activity of subjects (independent variables). We expected that there would be a strong correlation between the prefrontal cortex activity, established fNIRS help (Ferrari & Quaresima, 2012) during Stroop test, which demands executive function and self-control, and various motor, cognitive and emotional control tests, which determine executive functions and self-control). In this case we believe that by relatively simple tests we will get a clearer understanding of how the brain functions and executive self-control mechanisms operate.

METHODS

Participants. Twenty seven men were assessed for eligibility. Participant inclusion criteria were: age between 20 and 30 years; non-smoker, no excessive sporting activities, i.e., < 3 times per week, and exclusion criteria were: history of *drug*/ alcohol dependence or abuse, night/shift-work, medications that could influence central nervous system activity, and history of any neurological or psychiatric disorders. In total, 20 *undergraduate students* (age: 21.3 ± 1.0 yr.) met the criteria and agreed to participate in this study. All participants were right-handed, and had normal or corrected-to-normal vision. The present study was approved by the Human Research Ethics Committee. All participants independently provided written and verbal informed consent in accordance with the Declaration of Helsinki. The research was approved by the local Ethics Committee (The Kaunas Regional Ethics Committee, No. BE-2-40), performed in accordance with the Declaration of Helsinki.

Experimental design. To attain a stable level of performance, one week before the experimental visits, participants attended a familiarization session during which they were introduced to the experimental procedures for cognitive and motor testing. The participants then were given three self-report measures, which incorporated measures of stress level in the past month, emotional intelligence and personality traits. During the second visit, a functional near-infrared spectroscopy (fNIRS) probe was attached to the frontal areas of the forehead. The participant was asked to rest in a sitting position for 5 min and then complete the Stroop colour and word task. Subsequently, the participant completed code substitution, mathematical processing, go/no-go, and code substitution delayed tasks, and performed pursuit tracking. The participant then completed a self-report measure about his mood and physical activity level in the past week. The participant was asked to complete simple reaction, maximal velocity and speed-accuracy motor tasks. The participant then completed a self-report measure about his motivation toward the speed-accuracy motor task performance. During third day, the participant was asked to complete BART and self-report measures about impulsivity and moral decision making. Thus, each participant completed all four visits. Participants were given instructions to sleep for at least 7 h, refrain from consumption of alcohol, and avoid any intense physical and mental work the day before each further visit. Participants were also instructed not to consume caffeine and nicotine for at least 3 h before each visit.

Assessment of chronic stress. Perceived stress last month was assessed using the Perceived Stress Scale-14 (PSS-14) (S. Cohen, Kamarck, & Mermelstein, 1983). The PSS-14 is a *14-item* questionnaire divided into two subscales: stress and coping. The items are answered on a five-point scale ranging from 0 (never) to 4 (very often), and each subscale, with seven relevant items, are summed to produce a raw score in the range of 0 to 28. Total scores range from 0 to 56, with higher scores representing higher perceived stress level last month.

Assessment of emotional intelligence. Emotional intelligence was assessed using the Schutte Self-Report Emotional Intelligence Test (SSREIT) (Schutte et al., 1998). The SSREIT is a 33-item questionnaire divided into six 4 subscales: perception of emotion assessed by 10 items, managing own emotions assessed by 9 items, managing others' emotions assessed by 8 items, and utilization of emotions assessed by 5 items. The items are answered on a five-point scale ranging from 1 (strongly agree) to 5 (strongly agree). Total score range from 33 to 165, with the higher scores indicating greater ability in emotional intelligence.

Assessment of personality. Big *Five personality traits* was assessed using the Neo Five-Factor Inventory (NEO-FFI) (Costa & MacCrae, 1992) .The NEO-FFI is a *60-item* questionnaire divided into five subscales: neuroticism, extroversion, openness to experience, agreeableness and conscientiousness. The items are answered on a five-point scale ranging from 0 (strongly disagree) to 4 (strongly agree), and each subscale, with twelve relevant items, are summed to produce a raw score in the range of 0 to 48, with higher scores reflecting greater endorsement of the specific trait.

Assessment of mood. Current mood was assessed using the Brunel Mood Scale (BRUMS) (Terry, Lane, & Fogarty, 2003). The BRUMS is a *24-item* questionnaire divided into six subscales: anger, confusion, depression, fatigue, tension, and vigour. The items are answered on a five-point scale ranging from 0 (not at all) to 4 (extremely), and each subscale, with four relevant items, are summed to produce a raw score in the range of 0 to 16, with higher scores reflecting greater endorsement of the specific mood state.

Assessment of physical activity level. The physical activity level was assessed using the International Physical Activity Questionnaire-Short Form (IPAQ-SF) (Craig et al., 2003). In the current study, we included a six-items assessing the frequency and duration of moderate and vigorous intensity activity and walking physical activity. These data were summarized by weighting the energy expenditure for these categories of activity to produce MET-minutes/week of physical activity, with higher scores reflecting higher amount of activity.

Assessment of motivation. Based on scale used in a previous studies (Kleih & Kübler, 2013; Solianik et al., 2016), motivation with regard to the speed-accuracy motor task performance was assessed on a visual analog scale (VAS) ranging from 1 (not motivated at all) to 10 (extremely motivated) on a 10 cm long horizontal line.

Assessment of impulsivity. Impulsivity was assessed using the Barratt Impulsiveness Scale Version 11 (BIS-11) (Patton et al., 1995). The BIS-11 is a *30-item* questionnaire divided into three subscales: attentional impulsiveness assessed by 8 items, motor impulsiveness assessed by 11 items, and nonplanning impulsiveness assessed by 11 items. The items are answered on a four-point scale ranging from 1 (rarely/never) to 4 (almost always/always). Total score range from 30 to 120, with higher scores representing higher impulsivity.

Assessment of everyday moral decision making. Moral decision making was assessed using the Everyday Moral Decision-Making Task (EMDM) (Starcke et al., 2011). EMDM is a

20-item questionnaire, half of which represents high emotional personal dilemmas, and the remaining items represent low emotional impersonal dilemmas. The items are answered with "yes" (egoistic decision) or "no" (altruistic decision). The percentage of altruistic judgments was calculated.

Assessment of risky decision making. Risky decision making was assessed with the Psychology Experiment Building Language (PEBL) test battery using the Balloon Analog Risk Task (BART) (Lejuez et al., 2002; Mueller & Piper, 2014). During BART, the average number of pumps made on trials in which the balloon did not explode was examined.

Assessment of prefrontal cortex activity. Activity of prefrontal cortex was monitored using fNIRS (Masataka, Perlovsky, & Hiraki, 2015). Measurements were performed on a continuous wave system (fNIR Imager 1100, fNIR Devices LLC, USA), using a flexible 16-optode probe set (consisting of 10 photodetectors and 4 light emitters each using 730 and 850 wavelength of light) placed over the eyebrows on the participant's forehead and centered vertically. The sensor has a temporal resolution of 500 ms per scan with 2.5 cm source-detector separation allowing for about 1.25 cm penetration depth and 16 measurement locations on a rectangular grid covering the forehead region. *For data acquisition COBI Studio software* was used (Ayaz et al., 2011). The signals of all channels were verified before recording. Data analysis was performed using fNIRSoft analysis software (BIOPAC Systems Inc., USA). Oxygenated haemoglobin (HBO) concentrations were calculated from the raw data by solving the modified Beer-Lambert equation. Data were filtered to remove HF noise, physiological artefacts such as heartbeats, and motion-derived artefacts. The relative changes in the concentrations of HBO were acquired for all participants in all 16 channels and the data were averaged.

Assessment of cognitive performance. To assess cognitive performance, the Automated Neuropsychological Assessment Metric (*ANAM-4,* VistaLifeSciences, USA) was administered (Reeves et al., 2007; Woodhouse et al., 2013). The test battery included the following chosen tasks measuring three scores: accuracy defined as the percentage of correct responses, mean reaction time for responses time, and throughput which is considered a measure of effectiveness or cognitive efficiency, and is a combination of reaction time and accuracy (Thorne, 2006).

Go/No-Go Task (GNGT) evaluates inhibitory control (Diamond, 2013). During this task, the participant was instructed to respond as quickly as possible to an "x" on the screen by pressing the left mouse button each time the stimulus appeared; when an "o" appeared, the participant was required to withhold his response. This task comprised 120 trials. The go ("x") stimuli occurred in 80% of trials and the no-go ("o") stimuli occurred in the remaining 20% of trials.

Mathematical Processing Task (MPT) evaluates working memory (Reeves et al., 2007; Woodhouse et al., 2013). During this task, an arithmetic problem requiring an addition and subtraction of three single-digit numbers was displayed (e.g., "4 – 2 + 1 ="). The participant was instructed to respond as quickly as possible and to press the left mouse button if the answer to the equation was > 5 or to press the right mouse button if the answer was <5. The correct answer may be any number from 1 to 9, except 5. This task comprised 20 trials.

Code Substitution (CST) and Code Substitution Delayed Tasks (CSDT) evaluate immediate and delayed recognition memory (Reeves et al., 2007; Woodhouse et al., 2013). Participant was presented to 9 different symbol-digit pairs and was instructed to remember as many symbol-digit pairs as possible, in any order, as they will be asked to recall them later. During CST and CSDT, the participant was presented only with a single "test" pair and was instructed to respond as quickly as possible by press the left mouse button if the pair is correct and consistent with pairings presented earlier or by pressing the right mouse button if the pair is incorrect. CST comprised 72 trials and CSDT comprised 32 trials.

The Lithuanian version of the Stroop colour and word task (SCWT) was used to evaluate information processing speed and executive functioning (Golden & Freshwater, 1978) and was created using OpenSesame software (Mathôt, Schreij, & Theeuwes, 2012) based on the previous English version used in an ANAM-4. The participant was instructed to respond as quickly as possible to the colour used to print the colour names on the screen by pressing an associated keyboard key (A for red, S for green, D for blue, and F for yellow). On each trial, a word indicating a colour name ("žalia" (green), "mėlyna" (blue), "raudona" (red), or "geltona" (yellow)) was presented on the screen in red, green, blue, or yellow for 2 s. The task comprised 100 congruent (e.g., the word "blue" printed in blue) and 100 incongruent (e.g., the word "green" printed in yellow) stimuli presented in random order. During Stroop colour and word task, mean reaction time and percentage error were examined.

Assessment of motor tasks performance. Psychomotor coordination was assessed with the ANAM-4 battery during the pursuit tracking task (PTT) (Woodhouse et al., 2013). During PTT task, the participant was instructed to move the computer mouse so that the mouse cursor tracked a moving box with a + symbol inside. The cursor was required to remain inside the box and be kept as close to the + as possible as it moves across the screen in a circular pattern for 120 s. The mean distance from the + target was recorded.

The simple motor reaction time was assessed with the simple reaction task (SRT) (Woodhouse et al., 2013), maximal speed was assessed with the maximal velocity task (MVT), and motor control was assessed with the speed-accuracy motor task (SAMT) (Mickevičienė, Skurvydas, & Karanauskienė, 2015). Tasks were performed using an analyser of dynamic parameters of human movements (DPA-1; Kaunas, Lithuania). The participant positioning has been described previously (Mickevičienė et al., 2015; Zuoza et al., 2009). During each task, the participant was required to position the 3.5-mm radius handle symbol in the start zone (green circle, 10-mm radius) on the computer screen using the handle of the apparatus. Then program generated an auditory stimulus and a target (a red circle, 7-mm radius) appeared in the same place on the computer screen in front of the start zone and at a 170-mm distance. During SRT, the participant was asked to react as quickly as possible to the target appearing on the computer by pushing the handle. SRT comprised 10 trials. During this task, the mean reaction time (RT) was recorded. During MVT task, the participant was asked to move the handle to the target with maximal speed. MVT comprised 5 trials. During this task, the mean maximal velocity (Vmax) was recorded. During SAMT, the participant was asked to react to the target appearing on the computer screen and to reach the target while moving the handle forward as quickly as possible and in the most accurate trajectory. The endpoint of the movement was recorded when the cursor stopped in the target circle and stayed there for at least 0.02 s. MVT comprised 20 trials. The RT, average velocity (V), Vmax, and distance (D) of total motion from the initial to the final position were recorded. The intraindividual variability (coefficient of variation, CV) was calculated.

Statistical analysis. Data are reported as means and standard deviations (SDs). Pearson's correlation coefficients (r) were used to analyse the relationships between prefrontal cortex activity during Stroop test (dependent variables) and variables of "Go/NoGo", Balloon Analogue Risk Task, impulsivity score, different tests of cognitive functions, moral decisions tests (altruistic or egoistic), Fitts-like motor control task, five character traits, emotional intelligence, mood, sleepiness and perceived stress, total physical activity of subjects (independent variables). The level of significance of difference between variables was set at $p < .05$. All statistical analyses were performed using SPSS (version 21.0; IBM Corp., USA).

RESULTS

The average of total physical activity was 6224.2, (*SD*=1245.2) METmin/week. Motivation was 8.5 (1.9) points. RT correct, RT incorrect and percent of correct responses during "Go/NoGo" test was respectively 327.7 (*SD* = 25.9) ms, 273.7 (*SD* = 13.4) ms and 96.2 (*SD* = 3.3)%. RT incorrect was significantly shorter than RT correct ($p < .01$). RT, percent correct and throughput of mathematical processing was respectively 1837.8 ms (*SD* = 248.8), 86.4% (*SD* = 13.1) and 28.9 (*SD* = 6.1). The result of CS and CSD is shown in Table 1. The distance Pursuit tracking test was 6.2 (*SD* = 1.2) mm. The

Table 1. **The average (*SD*) of code substitution (CS) and code substitution delayed (CSD) tasks**

CS RT (ms)	CS percent correct	CS throughput	CSD RT (ms)	CSD percent correct	CS throughput
867.9 (112.5)	97.7 (1.7)	67.9 (7.5)	935.4 (145.2)	93.3 (6.4)	61.1 (10.1)

Note. Data are presented as average (standard deviation).

Table 2. **The average (SD) of motor control variables**

RT simple (s)	Vmax (m/s)	RT (s)	CV of RT (%)	VA (m/s)	CV of VA (%)	VM (m/s)	CV of VM (%)	S (m)	CV of S (%)
0.21 (0.02)	1.7 (0.32)	0.26 (0.02)	15.2 (4.1)	0.174 (0.02)	29.7 (5.6)	0.63 (0.14)	16.1 (5.4)	0.19 (0.01)	7.7 (3.6)

Note. Data are presented as average (standard deviation).

Orange (pumps)	Yellow (pumps)	Blue (pumps)	Total (pumps)
3.5 (1.1)	5.1 (1.3)	11.4 (5.8)	8.1 (3.1)

Table 3. **The average of risk-taking behaviour during BART Balloon Analogue Risk Task**

Note. Data are presented as average (standard deviation).

Attentional	Motor	Nonplanning	Total
15.3 (3.1)	20.0 (3.6)	22.4 (5.1)	57.7 (9.5)

Table 4. **The average of impulsivity of BIS-11 Barratt Impulsiveness Scale Version 11**

Note. Data are presented as average (standard deviation).

Perception of emotion	Managing of emotion	Managing others emotion	Utilization of emotion	Total
34.9 (7.2)	36.2 (5.6)	28.6 (4.1)	22.6 (4.4)	122.3 (17.4)

Table 5. **The average (*SD*) of Schutte Self Report Emotional Intelligence Test**

Note. Data are presented as average (standard deviation).

Anger	Confusion	Depression	Fatigue	Tension	Vigour
0.7 (1.5)	0.6 (1.3)	0.7 (1.6)	2.5 (2.2)	1.3 (1.9)	6.9 (1.6)

Table 6. **The average (*SD*) variables of BRUMS Brunel Mood Scale**

Note. Data are presented as average (standard deviation).

Emotionality or neuroticism	Extraversion	Openness to experience	Agreeableness	Conscientiousness
20.1 (4.5)	28.3 (7.4)	20.1 (2.9)	29.3 (5.7)	32.2 (8.3)

Table 7. **Character traits according NEO-FFI NEO Five Factor Inventory**

Note. Data are presented as average (standard deviation).

results of motor control variables during speed-accuracy task are shown in Table 2. Time to VM was 0.24 (*SD* = 0.04) s; VM/Vmax – 38.3 (*SD* = 9.2)%. RT during speed-accuracy task was by 124.8 (*SD* = 14.8)% longer compared to RT simple ($p < .05$). The averages (SD) of risk-taking during BART Analogue risk task and Barat impulsiveness is show respectively in Table 3 and Table 4. The altruistic answers (%) of low, high and total emotional dilemmas are respectively 56.0 (*SD* = 15.7)%, 63.0 (*SD* = 17.6)% and 59.5 (*SD* = 12.3)%. The results of emotional intelligence are shown in Table 5. The total stress, stress and coping perceived stress (PSS-14 Perceived stress scale-14) was respectively 22.0 (*SD* = 5.5), 18.3 (*SD* = 4.1) and 24.3 (*SD* = 2.5). The average (SD) mood variables are shown respectively in Table 6. The results of character traits are shown in the Table 7. Rest, Stroop HBO were 1.1 (*SD* = 1.1), 2.1 (*SD* = 1.5). Stroop/rest ratio HBO was 1.84 (*SD* = 2.3). Stroop RT was 640.2 (*SD* = 63.4) ms; error – 4.3 (*SD* = 2.4)%. RT of STROOP test was by 300.2 (*SD* = 20.8)%.

The increases of activity of prefrontal cortex during Stroop test is significantly correlated with motor control variables (RT, VM, S and CV of RT during speed-accuracy task respectively: –.71; .79; –.77; –.69), RT correct of "Go/NoGo" (–.64), impulsivity (–.83); risk-taking behaviour (total pumps: .74), emotional intelligence (managing of emotion: .87), character traits (conscientiousness: .67), total physical activity (.73); however there was no significant relation with perceived stress, mood, altruistic total answers, CS, SCD, mathematical processing and Stroop test variables, as well as, motivation level.

DISCUSSION

The main findings of our studies are based on correlation data: the more increases prefrontal cortex activity during Stroop (established fNIRS help, Ferrari and Quaresima, 2012), the faster and more stable speed and accuracy motor planning, the faster and more accurate movement performance, the greater inhibition during "Go/NoGo" test, the greater risk, the less impulsivity, the better emotional control, character is of conscious type, as well as more total physical activity. However, there was no significant relation with perceived stress, altruistic total answers, CS, SCD, mathematical processing and Stroop test variables, as well as HR variability (RMSD).

Obtained significant correlations were not unexpected, since, according to studies by other researchers that decreased activity prefrontal and frontal cortex is marker of failure of self-control (Desmyter et al., 2011; Pratt et al., 2008; Qi et al., 2015), we expected to find between increased prefrontal cortex activity during Stroop test and various task performance, which demand prefrontal cortex activity.

Motor control. There is no doubt that motor planning and control during speed-accuracy task is dependent on optimal activity of frontal and prefrontal cortex because the brain is characterized by trade-off between speed and accuracy, and this is related to perceived risk (Bertucco et al., 2015). Based on research in recent years, we suggest that motor control and behaviour may be viewed as a problem of maximizing the utility of movement outcome in the face of sensory, motor and task uncertainty (Wolpert & Landy, 2012). For example, if noise in the motor system increases as the movement speed increases, then increasing accuracy can only be achieved by decreasing the speed of movement (Harris & Wolpert, 1998). Taken together, it can be easily understood that the velocity of speed-accuracy motor planning and its stability (intraindividual variability), as well as speed and accuracy of motor performance must be efficiently controlled by prefrontal and frontal cortex. On the other hand, we can speculate that our speed-accuracy task variables predict/show "healthy activity" of prefrontal cortex. Of course, if the movement is very well learned and simple, then prefrontal brain activity might be slightly lower because the brain tries to control the tasks that they would require effort management as little as possible (Kool, McGuire, Rosen, & Botvinick, 2010).

Response Inhibition control and cognitive function. We were not surprised that in our case the faster inhibition of the task (RT) during "Go/NoGo" test directly correlated significantly with increases in prefrontal brain activity during Stroop test because the reaction inhibition task requires working memory, attention, concentration and flexibility of executive function (Verbruggen & Logan, 2008). We were more surprised that there was no significant correlation with inhibition error during „Go/NoGo"test because people with increased impulsivity (Logan, Schachar, & Tannock, 1997) or with substance abuse problems (Monterosso, Aron, Cordova, Xu, & London, 2005) make more errors in the "Go/NoGo" task than healthy control subjects. It was also unexpected that there was no significant correlation with Stroop test variables because "Go/NoGo" and Stroop tests belong to the same response inhibition paradigm (Chikazoe, 2010; Kueider et al., 2012).

Risk-taking behaviour (BART) and the impulsivity (BIS-11). In our case the established correlation relationship between mobilization prefrontal cortex activity during Stroop test and total pumps during BART test is consistent with data of other researchers (J. R. Cohen & Poldrack, 2009; Kohno, Morales, Ghahremani, Hellemann, & London, 2014; Schonberg et al., 2012). Namely, Schnonberg et al. (2012) scanned participants using fMRI while they completed the Balloon Analog Risk Task. They found that areas previously linked to risk and risk-taking (bilateral anterior insula, anterior cingulate cortex, and right dorsolateral prefrontal cortex) were activated as participants continued to inflate balloons. Other researchers showed that in the balloon test case, the more risk the participants take, the greater the increase in prefrontal activity (J. R. Cohen & Poldrack, 2009; Kohno et al., 2014). Evidence from neuropsychological, neuroimaging, and animal studies suggest that decision making under risk involves a network of cortical and subcortical regions including orbitofrontal cortex (OFC), dorsolateral prefrontal cortex (DLPFC), parietal cortices, and caudate, anterior cingulate cortex (ACC) and thalamus (Krain et al., 2006).

The correlation analysis shows that impulsivity (BIS-11) inversely significantly related to mobilization of prefrontal cortex activity during BART. Qi et al. (2015) showed that there was a significant negative correlation between the risk-related DLPFC activation during the active BART and the Barratt impulsivity scale (BIS-11) scores. This is also consistent with our data that the relationship between mobilization of prefrontal cortex activity during Stroop test and BART total balloon was positive, while with BISS-11 impulsivity the score was negative. Besides, it has been recently shown that BART, impulsivity, and sensation seeking scores loaded on separate factors (Meda et al., 2009).

Impulsivity is a complex and multifaceted construct, comprising of impaired behavioural inhibition, increased reward sensitivity, acting without thinking, and favouring immediate rewards over long-term goals (Reynolds, Ortengren, Richards, & de Wit, 2006). Generally, both impulsivity and low self-control are related to increased levels of risk-taking behaviour such as aggression, substance use, criminal behaviour, reckless driving and risky sexual behaviour (Feil et al., 2010; Griffin, Scheier, Acevedo, Grenard, & Botvin, 2012; Stanford, Greve, Boudreaux, Mathias, & L. Brumbelow, 1996).

Impulsivity and self-control are believed to stem from different neurological bases (Lieberman, 2007). The neural structures involved in impulsivity are activated under conditions that promote automatic, implicit or non-conscious processing of information (Lieberman, 2007). In contrast, self-control is reflected in higher cognitive processes that are experienced as intentional and effortful including implementation of goals and plans and inhibition (Cabeza & Nyberg, 2000). Low self-control may be related to risk-taking behaviour because individuals with low self-control have difficulty suppressing actions which are inappropriate (Verbruggen & Logan, 2008).

To measure people's sensitivity of the dopamine system, the Balloon Analogue Risk Task (Lejuez et al., 2002) was employed. The larger the balloon sizes the higher the probability of the explosion as well as the larger the collectable reward if the explosion is avoided. Several studies have shown that people's risk-taking tendencies are a function of the availability of dopamine receptors in the midbrain (Bijleveld & Veling, 2014; Buckholtz et al., 2010; Driver-Dunckley, Samanta, & Stacy, 2003; Zald et al., 2008). Taken together, prior research suggests that people who score high on risk-taking measures, and on the BART specifically, have a more sensitive dopamine system. However, previous studies in economics have shown that individual risk-sensitivity tends to be context-dependent, such that the same individual can be risk-averse in one domain but risk-seeking in another (Hanoch, Johnson, & Wilke, 2006).

Emotional intelligence, character traits and altruistic decision making. It was not unexpected that mobilization of prefrontal cortex activity during Stroop task very strongly related to one of factor of EI, that is managing of emotion, and to character traits (conscientiousness) because they are both linked to self-control. For example, Costa and MacCrae (1992) and Gerlach et al. (2015) concluded that conscientiousness is related to impulse control and self-discipline. We did not expect to find a strong correlation between the increases of prefrontal activity and altruistic decision making because altruistic decision making is more related to emotional component of brain (limbic system) and orbital and ventromedial prefrontal cortices (Pascual, Rodrigues, & Gallardo-Pujol, 2013) rather than DLPFC prefrontal cortex (Raine & Yang, 2006).

Mood, stress and PA. There was a significant relationship between increase in prefrontal cortex activity during Stroop test and PA, and this perhaps can be explained by the fact that PA trains self-control "structures" (Bardo & Compton, 2015). Generally, the findings of Hillman et al. (2015) have indicated that daily physical activity is related to greater volume and integrity of brain structure, efficient and effective brain function, and superior executive control. Kelley et al. (2015) concluded that the capacity for self-regulation allows people to control their thoughts, behaviours, emotions, and desires. Such failures frequently occur following exposure to highly tempting cues, during negative moods. However, we did not find any link between cortex activity and perceived stress and mood variable.

CONCLUSIONS

In conclusion, our studies have clearly shown that different brain functional outcomes, that is speed-accuracy motor control, inhibition response control and cognitive performance, risky-taking behaviour and impulsivity control, management of emotion, personality consciousness and physical activity have a common correlation with the increase in prefrontal cortex activity (measured by fNIRS) during Stroop test. Considerable number of studies are needed to understand what is the functional essence of these relationships, but currently there is an increase of research establishing correlations between motor behaviour and cognition control (Cook, 2016; Hillman et al., 2015; Seegelke & Schack, 2016).

Compliance with ethical standards. Conflict of interest. The authors declare that they have no conflict of interest.

Ethical approval. All procedures performed in studies involving human participants were in accordance with the ethical standards of the local Ethics Committee and with the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards.

Informed consent. Written informed consent was obtained from all participants included in the study.

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Corresponding author **Dalia Mickevičienė**
Institute of Sports Science and Innovations
Lithuanian Sports University
Sporto str. 6, Kaunas LT-44221
Lithuania
Tel. +370 600 73 021
Fax +370 37 204 515
Email dalia.mickeviciene@lsu.lt

LIFESTYLE PERCEPTIONS AMONG MIDDLE – AGED OBESE WOMEN

Živilė Vasiliauskaitė, Diana Karanauskienė
Lithuanian Sports University, Kaunas, Lithuania

ABSTRACT

Background. The aim of the study was to establish the perceptions of lifestyles among middle-aged obese women.

Methods. Data collection method was semi-structured face-to-face interview. Interview guide was based on short form 36 (SF-36), long form of IPAQ and previous research (Bukman et al., 2014).

Results. All obese women of our study feel inferiority complex due to their physical appearance, feel dissatisfied with themselves trying to hide their appearance, discomfort, and disadvantages. They have a lot of health problems: joint pain, increased cholesterol level, increased blood pressure, heart beat rate, dyspnoea, as well as chronic diseases such as type 2 diabetes, thyroid gland dysfunction and sleep disorders. All the subjects both had poor eating habits and ate inadequate food. Some of the participants ate a lot before bedtime and skip breakfast. The physical activity is limited and reduced of all subjects.

Conclusions. The relationship between excess weight and psychological well-being is complex, encompassing physical, social and psychological factors. All obese women of our study feel inferiority complex due to their physical appearance, dissatisfied with themselves. They complained of cardiovascular problems, sleep disorders and chronic diseases. The physical activity was limited and decreased. Also, such a great weight excess caused a discomfort in their daily life. Obese women in our study negatively view smoking effects, but they tolerate or even have positive attitudes to alcohol consumption, though they acknowledge that alcohol increases their weight. Malnutrition is most common problem of our respondents. They both had poor eating habits and ate inadequate food. Some of the participants ate a lot before bedtime and skip breakfast. A lot of participants reported about their negative attitude to their diet, but this attitude did not always act like a stimulus to change. Most of respondents could not find the time or motivation to engage in the adequate physical activity. They wanted to increase their physical activity, but found excuses not to do that – their excess of weight, lack of time, as well as laziness, passivity - the main causes of their inactivity or poor physical activity.

Keywords: obesity-related health problems, lifestyle perceptions, adequate physical activity.

INTRODUCTION

Physical activity carries immediate and long-term benefits for middle-aged and older women; however, physical activity in women decreases in adulthood and aging. Despite an increasing prevalence of obesity and inactive lifestyle among the middle aged population, few studies have examined people's perception of body weight and lifestyle in this population. As an appropriate perception of one's own weight is important for improved weight control and healthy lifestyle behaviour (Bukman et al., 2014), understanding people's perception will help in designing educational and intervention programs to address these problems.

Nowadays the worldwide prevalence of obesity nearly tripled since 1975 (WHO, 2017). Obesity becomes worldwide epidemics; it is one of the biggest risk factor for a huge number of non-communicable diseases, as diabetes, cardiovascular diseases and various types of cancer. These unhealthy conditions are associated with greater use of health care services among obese patients. The risk for these non-communicable diseases increases, with increases in BMI (Bleich, Bennett, Gudzune, & Cooper, 2012). Weight gain is a major health anxiety for all adults because weight gradually increases at a rate of about 0.5 kg/year. It is a particular concern for women in their midlife. Obesity is various and increased risk of premature death, decreased quality of life and caused chronic diseases, such as cardiovascular diseases, diabetes and musculoskeletal disorders. Also, obesity has an impact on women's reproduction, menstrual cycle and menopause (Lobo et al., 2014). In women, obesity is a risk factor for breast cancer and it also increases the risk of depression mostly as a result of poor body image (Sutin & Zonderman, 2012).

The best ways to reduce obesity rates is to work with persons at the individual level; the main responsibilities go to professionals who work with individuals as personal trainers, lifestyle and physical activity professionals, also family doctors and others. The interventions such as limiting energy intake from total fats and sugars, increasing consumption of fruit and vegetables, as well as legumes, whole grains and nuts; and engaging in regular physical activity (60 minutes a day for children and 150 minutes spread through the week for adults) is the best way to decrease obesity in any age group (WHO, 2016). The accuracy is very important in all these interventions, firstly, the professionals must correctly evaluate the previous behaviours of the individuals, create adequate plans and programs for a lifestyle change. It is known that women tend to evaluate and percept their physical activity and nutrition habits wrongly, people tend to think, that they are physically active enough, and that their nutrition habits are healthy, even though the reality it is different (Edwards, Pettingell, & Borowsky, 2010). In studies that use questionnaires persons tend to produce socially acceptable answers, sometimes they misunderstand questions or even to lie, and questionnaires with multiple choice answer options do now allow respondents to show their perceptions, feelings or ideas. For those reasons the best way to carry out a study about women's perceptions of physical activity is a face-to-face interview method because there many different answers can be obtained and collected. Besides, interviews allow us to collect non-verbal data, the interviewer can ask follow-up questions to evoke a more thorough response, which leads to more detailed and thorough data.

The *aim* of the study was to establish the perceptions of lifestyles among middle-aged obese women. Research objectives were to establish the perceived relationship of overweight and obesity with the quality of life and health in obese middle-aged women, the perceptions of harmful habits in relationship with overweight and obesity in obese middle-aged women, the perceptions of nutrition in relationship with overweight and obesity in obese middle-aged women and the perceptions of physical activity in relationship with overweight and obesity in obese middle-aged women.

METHODS

The object of this research was obese middle-aged women's lifestyle perceptions. **Research participants** were 15 middle aged women purposefully selected using a typical case convenience sampling strategy.

Inclusion criteria to select participants were as follows:

- Women aged 45–65 years,
- BMI – 30 kg/m^2 or more,
- Formally physically inactive,
- Volunteers to participate in the study,
- Living in Kaunas city.

All participants were from Kaunas. Their age ranged from 45 to 65 years.

Data collection method was semi-structured *face-to-face interview.* Interview guide was based on previous research (Bukman et al., 2014) also referring to the short form 36 (SF-36) and long form of IPAQ. SF-36 is the most widely used generic self-report health questionnaire, which is based on a multidimensional model of health (Ware, 2000). The scale assesses health related quality of life outcomes, known to be most directly affected by unspecific disease and treatment. Long form of international physical activity questionnaire (IPAQ) assesses the types of intensity of physical activity and sitting time that people do as part of their daily lives are considered to estimate total physical activity in MET-min/week and time spent sitting (IPAQ Research Committee, 2005).

Interview was constructed in five parts: contextual information, questions about life quality, habits, nutrition behaviours and physical activity status.

Research organization. Research was held in October–November 2017. The participants were selected according to the criteria: middle aged women, obese. According to the *Oxford English Dictionary* (2016), middle age is between 45 and 65. For adults, WHO (2017) defines overweight and obesity as follows: obesity is a BMI greater than or equal to 30. The participants were volunteers from Kaunas city that matched the inclusion criteria. The participants that agreed to participate in the study were asked to sign in an informed consent form. The respondents were informed about confidentiality and anonymity; also they were acquainted with the research topic and methods. In the investigation, 15 participants (middle-aged obese women) were interviewed (BMI more or equal to 30) face-to-face. The semi-structured interviews were held in the Hospital of Lithuanian University of Health Sciences Kauno Klinikos. The respondents were hospitalized due to obesity-related diseases. The time and location of the interviews were determined by the participants themselves. The interviews lasted approximately 1–1.5 hours. After interviewing all participants, the information was transcribed, the interview data were analysed and discussed.

Data analysis. The results of the research were processed using a qualitative data analysis method (content analysis) (Bitinas et al., 2008). All the data were empirically gathered on respondents' experiences. The data analysis was started by taking the research data (interview), looking for meaningful interfaces, the data were grouped, regrouped, searched for common, similar categories, after which those categories were linked, visual models and tables were created.

RESULTS

Perceived relationship of overweight and obesity with the quality of life and health in obese middle-aged women. Analysing interviews with respondents about their health and quality of life, it emerged that those obese women felt inferiority complex due to their physical appearance, denied their body weight, and therefore identified problems in work and daily activities due to their overweight or obesity. By analysing the answers of interviews about their physical health, we found that the subjects complained of poor health, joint pain, increased cholesterol level, increased blood pressure, heart beat rate, dyspnoea, as well as chronic diseases such as type 2 diabetes, thyroid gland dysfunction and sleep disorders. Also, the participants admitted that increased body weight limited their physical work and lowered the level of their physical activity – they were frustrated by a higher physical load, it was difficult to climb upstairs, some of them could not walk for more than 10 minutes. However, the majority of them took great care of themselves: women could go shopping, carry packs, and have a bath without any problem. They also tried to walk as much as possible, climb up to several floors, but the third and the fourth floor caused difficulties and breathlessness for them. However, what was very interesting to hear was that women enjoyed life, and they lived every day with a smile.

The perceived relationship of overweight and obesity with the quality of life and health is given in Table 1.

Perceptions of harmful habits in relationship with overweight and obesity in obese middle-aged women. The assessment of harmful habits given in Table 2. All participants agreed that smoking had a particular impact on women's health and aesthetic appearance. However, a big part of participants of the study revealed a sufficiently positive view on alcohol consumption. Only one woman said that "Alcohol is in fact puts on weight <...>". One more lady also had a very negative opinion about alcohol's harmful effect on women's health. The majority of respondents drink alcohol very rationally, only 1–2 cups of wine during celebrations, but for the others, alcohol is a kind of relaxation after a week's work.

Perceptions of nutrition in relationship with overweight and obesity in overweight and obese middle-aged women. By analysing interview respondents' responses about their diet, we found that most of them consumed unhealthy food. Malnutrition was the most common problem of our respondents. *Malnutrition* is a serious condition that occurs when a person's diet does

Table 1. **Overweight and obesity trigger health and lifestyle problems**

Category	Subcategory	Examples
Physical problems	Diseases	*"Asthma, bronchitis."* *"<...> increased sugar, glycaemia."* «<...> diabetes.» *„<...> because of the thyroid gland dysfunction heart rate is increased, high pressure, overweight."* *„<...> troubles with joint pain."*
	Cardiovascular problems	*„<...> blood pressure is high, so breathlessness appears very quickly <...>."* *„<...> increment of heart beat rate <...>."* *„Increased blood pressure <...>."*
	Sleep disorders	*„The sleep quality is so so <...>."* *„Sleep quality becomes worse every year with age <...>."* *„<...> I have sleep dysfunction <...>."* *„I sleep poorly enough, restlessly; maybe those two cups of coffee and tea before bedtime affect my sleep."* *„<...> sometimes I wake up in the night due to my spine, neck pains, sometimes it goes away, then I sleep better."*
	Decreased physical fitness	*„When there is an elevator I use it..."* *„<...> I don't lift any packages now ...* *„<...> I can go upstairs till the third floor."* *„<...> I cannot walk now."* *„It's a bit harder for me to put on socks."*
	Limited level of physical activity	*„<...> I can lift up hard things/packages, but not running, not any sport, because joint pain doesn't allow me."* *„<...> my physical activity decreased by weight change."* *„I will try to lift package up to 10 kg, no more."* *„<...> It is necessary for me to climb up to the third floor or above, and sometimes it is really difficult."*
Psychological problems	Negative evaluation of the body mass	*"My weight is horrible; It is double <...>."* *„I would like to reduce it, it would be easier to move and live."* *„<...> I would like to weigh less ..."* *„<...> I am not satisfied with such weight <...>."*
	Inferiority complex	*„ <...> when you see others being slimmer, more beautiful, healthier, I also want to look like them."* *„<...> my weight always bothered me, especially during communication with other people, during some kind of gatherings, that minute I would like to have a weight of at least 100 kg."* *„<...> aesthetic attitude is very important for me, but overweight disturbs it."* *„Having weight affects my self-esteem, it is less now, the sense of satisfaction is lower, the possibilities lower <...>."*
Social problems	Problems at work	*„<...> Especially if there is a stress situation in work, I think it is also related to my weight ..."*
	Problems in daily activities	*„<...> mobility has diminished, my whole youth I was active, and now the weight has grown up, so now I am sedentary."* *„<...> Such big overweight causes discomfort in daily life – it is hard to move, to lift something, to dress up."* *„Of course it's hard to do usual activities at home..."*

Table 2. **Perception of harmful habits**

Category	Subcategory	Examples
Smoking	Negative effect on the health	*„<...> smoking is stifle ... harmful to health.“* *„<...> everyone knows that smoking is not good, but probably it is a way to escape from the troubles.“* *„<...> it is especially harmful to health, especially for all young people.“*
	Negative effect on physical appearance	*„<...> the voice is stuttered, the face darkened.“* *„Woman‘s face becomes aged earlier.“*
Alcohol	Sufficiently positive view on alcohol consumption	*„Moderately. I use it during the holidays, but not every day.“* *„<...> Rational alcohol consumption will not harm.“* *„<...> if you work hard all week, you can have some wine during the weekend.“* *„<...> Alcohol at certain doses is nothing terrible.“* *„<...> Rational consumption is permissible, but you should to know a measure.“* *„I use, usually wine, but only on trips, during Christmas, New Year, it‘s a cup one, really no more. Traveling is just about exciting.“* *„<...> it all depends on the amount, when and how much, if there is a birthday or a new year, dry wine, champagne, cup, two are positive effect.“* *„... and alcohol, as much as I use, it‘s a positive thing to me. When you need to work I use brandy, if I want sleep, I drink a glass of wine.“* *„I think this is bad, and I do not believe in the benefits when it‘s said that a small dose is good, but I don’t restrict myself and I suspect that drinking alcohol will not harm <...>.“*
	Negative effect on physical appearance	*„Alcohol puts on weight ...“* *„It is a terrible thing, especially for women, alcohol.“*

not contain the right amount of nutrients. Some participants indicated that they were trying to use healthy food – in summer they consumed more vegetables, drank water, cooked at home, some subjects had regular meals, at certain intervals and in appropriate quantities. But the others tended to use high-calorie foods, consumed them in the evening very often. We also found that most respondents at a lot of confectionery, unhealthy fats, added a lot of sugar to coffee and salt to food while cooking. Most participants reported about their negative attitude to their diet, but this attitude did not always act as a stimulus to change. Some women revealed that they had already tried a lot of weight loss methods, but they all were still unsuccessful. The nutritional characteristics of the participants are presented in Table 3.

Perceptions of physical activity in relationship with overweight and obesity in obese middle-aged women. Analysing participants’ responses about their physical activity, it was found that obese women spent much time sitting on weekdays as well as at weekends. They often spent weekends sleeping and watching TV. All the subjects of the study admitted that their physical condition was poor; they wanted to be more physically active. They remembered that they were active enough in their youth, but now, most of them were passive and the only reason for this was their overweight. Most of the subjects said they wanted to increase their physical activity, but they found excuses not to do it – overweight, obesity, lack of time, as well as laziness, passivity were the main causes of their inactivity or poor physical activity.

Table 3. **Obesity and nutrition**

Category	Subcategory	Examples
Day time meals	Not eating breakfast	*„Never eat breakfast <…>.“* *„<...> I do not have breakfast because I do not want to eat in the morning.“* *„Usually I don't eat any food in the morning <...>.“* *„I miss my breakfast <…>.”*
	Junk food	*„It happens that all day I do not eat anything at all, and when return in the evening, <…> I'm hungry and then I eat a lot <…> I have a lot of snack sitting near the TV or reading book.“* *„<...> My diet is not always healthy, I eat pizza in cafes, and also I buy some fast food going out somewhere.“* *„... back in the evening after a day's work, I will not lie, I eat a lot, I eat a lot of pasta with rissoles.“* *„Usually there are sandwiches during my dinner, and my dinner is very satisfying.“*
Unhealthy ingredients	"Unhealthy" fats	*„Refined oil anyway, butter.“* *„<...> I really love mayonnaise, and I use it.“* *„I like to cook on butter, and on oil, sunflower oil.“* *„<...> butter and oil basically.“* *„<...> rapeseed oil is so optimal for me. Of course, and butter.“*
	Sugar to coffee	*„<...> I consume a lot of sugar I put it to the tea and coffee.“* *„I put at least two teaspoons to tea or coffee, and I drink coffee and tea 3–4 times a day.“*
	Added salt	*„Yes, I really like salt. ... I use salt a lot.“* *„<...> I do not eat without enough salt.“* *„I use salt a lot, in every meal <...>.“*
	Sweets drinks/ sweets	*„I eat sweets every day <...>.“* *„<...> I am dependent on sweets <...>.“* *„... I eat sweets, cakes, I like them, I buy a couple of times for a week or a cake, or a biscuit or a doughnut.“* *„I like sweets <...> I can eat another half a week in a week, and I cannot eat at all.“*
Eating behaviours and their assessment	Negative evaluation of nutrition	*„Ordinary nutrition, <...> I should eat more in the first half of the day, because I have a greater physical activity, and in the evening I should eat less, <...> but I do not do it.“* *„<...> I eat too little vegetables, meat and sweets too much, I do not think that I eat healthily ... but relatively healthily because I am preparing myself ...“* *„I would not say that my diet is healthy, because I like to eat potato pancakes ...“* *„I do not, but I try. <...> I would like to give up flour dishes.”* *„I do not think that I eat very well ... because of the presence of sweets ...“* *„Negative, because I don't have any purpose.“*
	Trying to change eating behaviours	*„<...> I have tried all diets as many times as possible.“* *„I've tried, of course. And then, when weight decreases a little, I reward myself with tortillas, roast, sausage, coffee and sweets.. and then the whole cycle screws up.“* *„I tried, but it was a short-term effect, <...> you should simply shift the intensity of the eating to the first part of the day, and in the second half of the day, <...> reduce portions, don't eat snacks <...>.* *„<...> I went to a dietitian, she gave me recommendations, I asked for advice <...> I started to be more active <...> but it was not enough. My daughter is little enough, I can't walk 10 km with her, my husband works, and I'm with the child without any additional help. It seems to me that I do not do enough for my health; I need to eat healthier and to be more active. „* *„I would like to cut down on sweets; I tried to do it, but not successfully. It's just a wrong habit.“* *„I want to eat more vegetables and fruits. Fruits should be eaten in the morning, and I want to eat them in the evening, but then blood sugar increases. I would like to have more vegetables in the diet, we need more vegetables, and I try, but not always successfully.“* *„<...> I would like to change <...> snacks are the biggest problem for me.“* *„<...> I try often, almost every month, sometimes success smiles at me.“*

Table 4. **Perceptions of lifestyle and physical activity in relationship with obesity**

Category	Subcategory	Examples
Sedentary lifestyle	Long-time sitting on weekdays	*„Sometimes I have to sit more than 6 hours a day <...>."* *„A lot of hours. My job is sitting at the desk."* *„I sit a lot, all the time, sitting at the computer, for 8 hours per day. I come back home and sit at the TV again ..."* *„<...> I sit every day for seven to eight hours every day for five days a week. And two days, I sit maybe shorter, 4 hours a day."* *„I sit quite a lot because the job is sedentary, 8 hours/day, and when I return home I sit again watching TV."*
	Long-time sitting at weekends	*„I sit more than 8 hours."* *„It's time to rest and relax on the weekend, so I sit a lot."* *„My weekends are passive; I sit watching TV a lot."* *„<...> I sit half a day watching a movie or something on TV."*
Potentials for physical activity	Dissatisfaction with their body physical condition	*„Poor. Overweight causes immobility. If you need to go somewhere soon, it's hard to breathe normally if you carry something heavier."* *„It could be better if the weight was lower; I could walk and run more than now."* *„I am poorly evaluated because when I have to run, I become to stifle, when I go upstairs, the same thing happens <...> the condition deteriorated much after my daughter's birth ..."* *„Not very well, I would like to lose weight."* *„It's bad, it's hard to bend, I must exercise every day."*
	Wish to be more physically active	*„I would like to increase my physical activity; I think weight would start to decrease when I will change diet and physical activity."* *„I think that I should increase my activity. There is a street near our house, about 100 meters. So I should go at least 100 m forward and 100 m back. I could walk and after weeks increase that distance, but ... Everything is only in my mind, I promise to myself that I will start the next day."* *„<...> I am not physically active I would like to find time for training ..."* *„I know that I must increase my physical activity more than I have now."* *„Maybe I would like to exercise, but I do not have time for that activity."*
	Recognition of unwillingness to move	*„<...> I'm lifeless."* *„I like to watch sports on TV, but I do not do enough in real life."* *„<...> I'm a passive woman <...>."* *„<...> physical activity gives way to TV, board games."*

DISCUSSION

Obesity is caused by a complex interaction between the environment, genetic predisposition, and human behaviour. Environmental factors are likely to be major contributors to the obesity epidemic (Nguyen & El-Serag, 2010). The relationship between excess weight and psychological well-being is complex, encompassing physical, social and psychological factors. Many individuals living with obesity experience self-blame, low self-esteem, and general negativity towards themselves and their situation (Taylor, Forhan, Vigod, McIntyre, & Morrison, 2013). In our study, analysing interviews with respondents, we found that all obese women felt inferiority complex due to their physical appearance, they were dissatisfied with themselves trying to hide their appearance, discomfort, and disadvantages. Our results agree with those in other studies

(Hilbert, Braehler, Haeuser, & Zenger, 2013) which reported that overweight and obesity are associated with poor self-esteem, while increasing the risk of depression and anxiety. In addition, women can develop unhealthy mental activities by having a negative body image due to obesity. Therefore, the basis for a healthy life should be established through appropriate lifestyle interventions, which in turn can help women build a more positive body image and greater self-esteem (Chao, 2015).

Physical activity plays a critical role in improving cardiovascular health in obese individuals. But the problem is that most individuals cannot find the time or motivation to engage in the high volume of activity (Mora, Cook, Buring, Ridker, & Lee, 2007). The results from our study are in line with these findings. Our research results showed that all participants were not physically active enough. They would like to increase their physical activity, but they found excuses not to do it – their excess of weight, lack of time, as well as laziness, passivity were the main causes of their inactivity or poor physical activity. Tudor Locke with his colleagues (2010) described an accelerometer-derived physical activity/inactivity profile in normal weight, overweight and obese adults and computed physical activity volume indicator (e.g. counts/day), rate indicators (e.g., steps/minute), time indicators, the number of breaks in sedentary time and classified by step-defined physical activity levels. Based on Tudor-Locke, step defined activity levels could be classified into such categories: basal activity is < 2,500 censored steps/day, limited activity 2,500 to 4,999 steps/day, low active 5,000–7,499 steps/day, somewhat active 7,500–9,999 steps/day, active 10,000–12,499 steps/day, highly active ≥ 12,500 steps/day. So, the results showed, that adults for the overweight category took 6879 ± 140 steps/day, 25.3 ± 0.9 minutes/day in moderate intensity, and 5.3 ± 0.5 minutes/day in vigorous intensity, and for the obese category 5784 ± 124 steps/day, 17.3 ± 0.7 minutes/day in moderate intensity, and 3.2 ± 0.4 minutes/day in vigorous intensity. So, physical activity of overweight and obese people was too low. Our results also showed the same – obese women were inactive or their activity was low enough. Gupta and his colleagues (2016) evaluated association between temporal patterns of sitting (long, moderate and brief uninterrupted bouts) and obesity indicators, such as body mass index, waist circumference and fat percentage. The scientists found that brief bouts of sitting were negatively associated with obesity for the whole day and work, but not for leisure. Sitting time in long bouts was positively associated with obesity indicators for the whole day also. Our participants, obese women, also sit a lot during a working day. They emphasize this. Findings of Henson and his colleagues (2016) indicate that even lower activity stimulus (e.g., standing) may yield metabolic advantages for a minimum of 24 hours. This study demonstrated that breaking up prolonged sitting with 5-min bouts of standing or walking at a self-perceived low intensity reduces postprandial glucose, insulin levels in postmenopausal women who have a high risk of type 2 diabetes. Light-intensity physical activity and even standing can prevent metabolic health problems.

By analysing women's responses about their diet, we found that most of them consumed unhealthy food. Malnutrition is the most common problem of our respondents. Obese individuals can lose weight by following calorie restriction diets that vary widely in macronutrient composition. Caloric restriction, however, rather than macronutrient composition, is the key determinant of weight loss. A big part of participants in our study tended to use high-calorie foods, consumed them in the evening very often. We also found that most respondents ate a lot of confectionery, unhealthy fats, used a lot of added sugar and salt. Most participants reported about their negative attitudes to their diets, but these attitudes did not always act like stimulus to change.

Saneei et al. (2016) showed that individuals with irregular eating habits were more overweight or obese, abdominally overweight/obese and abdominally obese compared with those who had regular eating habits. One more study (Al-Rethaiaa, Fahmy, & Al-Shwaiyat, 2010) also showed that 65% of overweight students and 66% of obese students ate irregularly, 58% of overweight subjects ate 2 times a day, 15% – 1 time per day, and only 27% – 3 and more times. While 60% of obese students ate 2 times a day, 6% ate one time and 34% – 3 and more times a day. Fried food was eaten daily by 13% of overweight people and 12.5% of obese people. The results of this study revealed that overweight people tended to skip meals, usually breakfast, consumed alcohol and ate late in the evening before bedtime. We also found from the interviews that a big part of women liked to drink alcohol occasionally, some of them drank in the weekends and their opinion about the alcohol consumption was rather positive. Breakfast is very important for weight gain. Skipping breakfast is considered to be an unhealthy eating habit linked to the risk of obesity and type 2 diabetes. Eating dinner late at night can elicit subsequent breakfast skipping (Odegaard et al., 2013). Scientists (Kutsuma, Kei, & Kaname, 2014) clarified that habitual breakfast skipping related with late night dinner eating may represent poorer eating behaviour than skipping breakfast alone, associated with metabolic syndrome and obesity in the general Japanese population. Our results agree with these findings because many participants also ate a lot before bedtime and skipped breakfast.

Our obese participants had health problems: joint pain, increased cholesterol level, increased blood pressure, heart beat rate, dyspnoea, as well as chronic diseases such as type 2 diabetes, thyroid gland dysfunction and sleep disorders. The other studies (Tsai, Abbo, & Ogden, 2011) reported that obese and overweight people had various health problems: 4.27% of overweight people and 9.29% of obese had diabetes, 96.91% of overweight and 97.55% obese people had increased blood pressure, high cholesterol level was typical of 18.73% overweight and 23.08% of obese people. Also 6.05% of those with overweight and 5.26% of obese respondents suffered from cardiovascular diseases.

After analysing the results, we found that the participants of our study had a variety of problems, most of them were related to health and emotions, but we have very little information about the social problems caused by overweight and obesity. So, the study of this phenomenon is also relevant in further research. Further research also should focus more on changing behaviours to make it easier to turn people's knowledge and perceptions into stimulus to take actions to be healthy and fit. Behavioural changes should be considered a viable treatment option for the population of obese people.

CONCLUSIONS

The relationship between excess weight and psychological well-being is complex, encompassing physical, social and psychological factors. All obese women of our study felt inferiority complex due to their physical appearance, they were dissatisfied with themselves trying to hide their appearance, discomfort, and disadvantages. They complained of poor health: joint pain, increased cholesterol level, most of them had cardiovascular problems, sleep disorders as well as chronic diseases such as type 2 diabetes, thyroid gland dysfunction. Their physical activity was limited. Also, such a great weight excess caused a discomfort in their daily life: it was hard for them to move, to lift something, to dress up.

Obese women in our study negatively viewed smoking effects, but they tolerated or even had positive attitudes to alcohol consumption, though they acknowledged that alcohol increased their weight.

Malnutrition is most common problem of our respondents. They both had poor eating habits and ate inadequate food. The majority of participants used high-calorie foods; very often they consumed them in the evening. Most respondents ate a lot of confectionery, unhealthy fats, used a lot of added sugar and salt. Some of the participants ate a lot before bedtime and skipped breakfast. A lot of participants reported about their negative attitudes to their diets, but these attitudes did not always act like a stimulus to change.

Most of our respondents could not find time or motivation to engage in the adequate physical activity. They wanted to increase their physical activity, but found excuses not to do that – their excess of weight, lack of time, as well as laziness, passivity were the main causes of their inactivity or poor physical activity. Also the majority of obese women were sedentary a lot during their working day as well as weekend.

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Corresponding author **Diana Karanauskienė**
Lithuanian Sports University
Sporto str. 6, Kaunas LT-44221
Lithuania
Tel. +370 37 302663
Email diana.karanauskiene@lsu.lt

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Acknowledgements. On the Acknowledgement Page the authors are required to state all funding sources, and the names of companies, manufacturers, or outside organizations providing technical or equipment support (in case such support had been provided).

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