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CONTENT

Editorial Policy

BJSHS is an international quarterly peer-reviewed scientific journal that keeps sports and health professionals up to date with advances in the fields of sports science, health education and promotion and physical rehabilitation. The journal publishes research articles in the following areas: *Social Sciences* (Physical Education, Sports Coaching, Sports Pedagogy, Sports Psychology, Sports Sociology, Research Methods in Sports, Sports Management, Recreation and Tourism), *Biomedical and Health Sciences* (Coaching Science, Sports Physiology, Motor Control and Learning, Sports Biochemistry, Sports Medicine, Physiotherapy and Occupational Therapy, Physical Activity and Health, Sports Biomechanics, Adapted Physical Activity) and *Humanities* (Sports History, Sports Philosophy, Sports Law, Sports Terminology).

The issues contain editorials, reviews of recent advances, original scientific articles, case studies. In all cases, it is vital that the journal's integrity, independence and academic reputation is not compromised in any way.

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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
URL www.lsu.lt/en/scientific-journals_BJSHS

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On January 15, 2015, **Jesus Bueno Pascual**, the NBA Vice-President for Europe, Africa and Middle East, was granted the title of LSU Honorary Doctor at the Senate Meeting of Lithuanian Sports University (LSU).

Jesus Bueno Pascual has made a great contribution to the University and the country. He is helping to strengthen ties with the NBA, promote the university's internationality and Lithuanian basketball. J. B. Pascual is helping to develop scientific research carried out by LSU students who investigate the NBA marketing.

EFFECT OF ELECTRICAL STIMULATION ON BLOOD FLOW IN CALF MUSCLES IN DIFFERENT BODY POSITIONS

Julius Dovydaitis, Albinas Grūnovas
University of Applied Sciences Kauno Kolegija, Kaunas, Lithuania

ABSTRACT

Background. In most studies on cardiovascular system, testing of subjects was performed in a horizontal position. With the change of the body position, certain functional changes occur in the cardiovascular system. The aim of this study was to analyze the effect of electrical muscle stimulation (EMS) on arterial and venous blood flows.

Methods. Eighteen athletes aged 19–23 performed two sessions of tests in horizontal and sitting positions. Changes in arterial and venous blood flows were recorded before and after EMS. In each session two occlusions were performed. In the horizontal position, the initial occlusion pressure of 20 mmHg was applied and as the balance in arterial and venous blood flow rates was reached, the additional pressure of 20 mmHg (40 mmHg in total). In the sitting position, the occlusion pressure of 40 and 20 mmHg was applied respectively (60 mmHg in total). In both sessions EMS was performed using the electrical stimulator *Mioritm 021*.

Results. In both horizontal and vertical positions, the effect of EMS on arterial blood flow, venous reserve capacity and venous elasticity was insignificant. Arterial and venous blood flows was affected significantly by the change of the body position. In the sitting position, arterial blood flow was significantly ($p < .05$) lower compared to the horizontal position. Similar results were recorded in venous reserve capacity.

Conclusion. The study suggests that blood flow in the calf muscles is affected by the body position and hydrostatic pressure; arterial blood flow increases in the horizontal body position.

Keywords: electrical muscle stimulation (EMS), arterial blood flow, venous reserve capacity, venous elasticity.

INTRODUCTION

During the training, different methods are used to improve functional capacities of muscles in athletes and one of these is electrical muscle stimulation (EMS). Muscles are affected by the intensity of stimulation and the duration of contraction and relaxation periods. The EMS exceeding threshold is often used to increase muscle strength and may vary even up to intolerable pain (Alon, Kantor, & Smith, 1999; Gondin, Guette, Jubeau, Ballay, & Martin, 2006)

The EMF method can be applied to develop muscle strength in healthy people (Bonerjee, Caulfield, Crowe, & Clark, 2005; Maffiuleti et al., 2006; Malatesta, Cattaneo, Dugnani, & Maffiuleti, 2003). The low intensity EMF increases maximal voluntary strength in sedentary and poorly performing people (Valli, Boldrini, Bianchedi, Brizzi, & Miserocchi, 2002). The EMF procedures have a specific effect on the athlete's body and can be used for the enhancement of muscle recovery and for the increase of muscle power (Maffiuleti et al., 2006) to decrease muscle atrophy and to accelerate restoration of muscle functions after injuries (Faghri, Votto, & Hovorka, 1998). Mild electrical stimulation of the calf muscle also known as electrical massage can be used to counteract venous stasis and to increase recovery of working muscles after the physical load (Kaplan, Czyrni, Fung, Unsworth, & Hirsh, 2002). Skeletal muscle contraction evoked by the artificial EMS signals bears physiological resemblance to real skeletal muscle contraction (Gregory & Bickel, 2005).

Blood flow in muscles during the physical load is an important factor influencing working capacity of muscles. Depending on the functional condition of skeletal muscles as well as environmental conditions, change in the intensity of skeletal muscle blood flow is observed even at rest (Wilmore, Costill, & Larry, 2008). The effect of recovery modalities is associated with an increase in blood volume and its distribution from less active muscles to more active muscles (Laughlin, 1999).

The skeletal muscle electrical stimulation is an effective method for accelerating the recovery processes of muscle working capacity after intense exercise (Кибиша, Подерис, & Грюновас, 1983). Any recovery method also has a certain effect as it requires an additional load on the body affecting its different systems (Платонов, 2004). EMS increases the velocity of venous blood flow in the calf muscles (Sochart & Hardinge, 1999) and increases the venous blood pump of the calf muscles (Daley, 1960). However, available evidence about the effect of EMS on arterial and venous blood flow is insufficient.

Venous blood stasis in the legs can be provoked by the immobility due to injuries or after long-haul air travel (Kaplan et al., 2002). After surgery, EMS possibly causes more effective evacuation of venous blood from lower extremities.

The majority of studies on human cardiovascular system present results from the tests where subjects were placed in a horizontal position (lying on the back), but only a few studies were performed testing subjects in a vertical position. The sitting position is considered one of the vertical positions and humans spend two-thirds of their lifetime in the vertical position. A number of functional changes occur to the human cardiovascular system due to the change of the body position. The aim of this study was to analyze the effect of EMS on arterial and venous blood flow in different body positions.

METHODS

The study included two sessions of tests that were performed in the horizontal and sitting positions with 18 subjects aged 19–23 and adapted to physical loads. Venous blood flow signals were recorded with the venous occlusion plethysmography (VOP). The subjects lied in a horizontal position on their back with knees bent (135°) at rest after 20 minutes of adaptation. The calf which was a segment under examination was positioned on heart level.

Two successive occlusions were performed: the initial occlusion pressure of 20 mmHg was applied and, as the balance in arterial and venous blood flow rates was reached, the additional occlusion pressure of 20 mmHg was applied constituting the total occlusion pressure of 40 mmHg.

In the second session, blood flow signals were recorded in the same way as in the first session, only the occlusion pressure and the position of the calf differed. The initial occlusion pressure of 40 mmHg was applied following by the additional occlusion pressure of 20 mmHg that constituted together 60 mmHg. The recording of vascular tones using the VOP features certain characteristics. When the pressure in the cuff increases above venous pressure, the VOP starts to rise, which indicates the increase of volume in a segment under examination. Venous filling occurs during cuff occlusion and venous outflow decreases. The increase of venous pressure and blood volume in the extremity occurs up to the point when plethysmography displays a horizontal line. The increased blood volume is determined by the distension of venous blood vessel walls. The higher the distension of the blood vessels, the larger amount of blood can be collected in the veins. When the plethysmogram is in a horizontal position with the initial occlusion pressure of 20 mmHg, the cuff occlusion pressure is increased by 20 mmHg and the total occlusion pressure constitutes 40 mmHg.

The study has been approved by Kaunas Regional Biomedical Research Ethics Committee. Both sessions of tests were performed using the electrical stimulator *Mioritm 021*. Previous studies on the effect of EMS on enduring physical loads showed that the optimal duration of the EMS application that helps to reach the highest working capacity is 10 min (Кибиша et al., 1983). The mode of an impulse was bipolar asymmetric with zero constant. The impulse formed a triangular shape. During continuous stimulation, the frequency of impulses was at 90 Hz. Depending on individual characteristics of the subjects, the intensity of electrical stimulus was around 10–15 mA. One electrode (20 × 3 cm) was placed on the calf muscle proximal and another electrode (14 × 3 cm) was placed on the distal area of the back. Finally, the data was analysed examining changes in arterial and venous blood flow in the horizontal and vertical positions.

The statistical analysis was performed using the statistical software *SPSS Version 17.0*. Student's *t*-test was used for the equality of the means in independent samples. Statistical significance of difference between two groups was determined using Student's *t*-test. The difference was considered statistically reliable if $p < .05$.

RESULTS

In the horizontal position, the arterial blood flow in subjects (2.42 ± 0.27 ml/100 ml/min) at rest was significantly higher ($p < .05$), compared to the vertical position (1.74 ± 0.12 ml/100 ml/min). The change in the arterial blood flow in subjects in the horizontal position before and after EMS was insignificant compared to the initial value. Similar indications were observed in the arterial blood flow measured in the vertical (sitting) position before and after EMS (Figure 1). These results suggest that the intensity of arterial blood flow is affected by the body position.

In the horizontal position before EMS at the occlusion cuff pressure of 20 mmHg, the venous reserve volume in subjects was 3.12 ± 0.6 ml/100 ml. After the additional occlusion pressure of 20 mmHg was applied, at the occlusion cuff pressure of 40 mmHg, the venous reserve volume was 4.0 ± 0.38 ml/100 ml. No significant change was observed in the venous reserve capacity in subjects before and after EMS (Figure 2).

In the vertical position before EMS at the occlusion cuff pressure of 40 mm Hg, the venous reserve volume was 1.7 ± 0.11 ml/100 ml. After the additional occlusion pressure of 20 mmHg was applied, at the occlusion cuff pressure of 60 mmHg, the venous reserve volume was 2.57 ± 0.38 ml/100 ml. Just like in the horizontal position, the venous

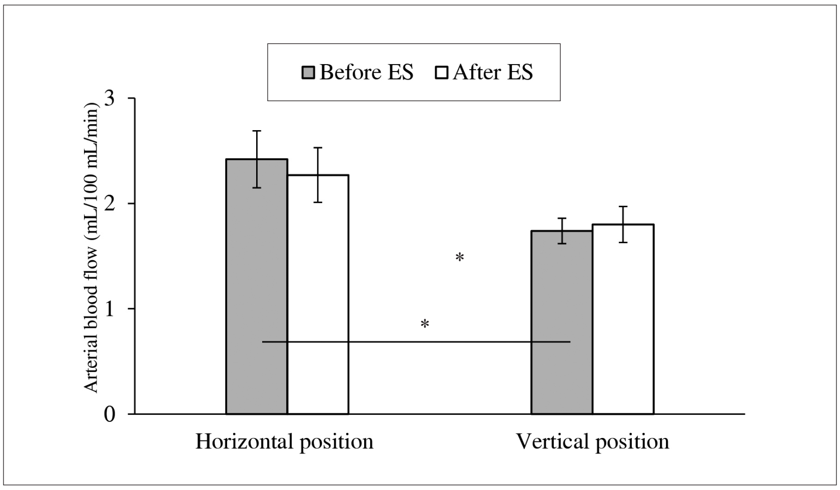


Figure 1. **Change in arterial blood flow in the horizontal and vertical positions before and after the EMS ($\bar{x} \pm S\bar{x}$)**

Note. * – $p < .05$.

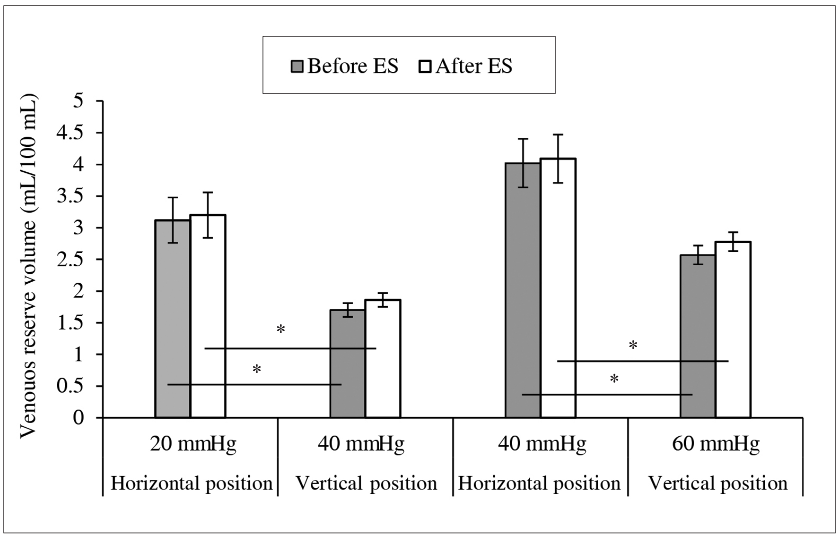


Figure 2. **Change in venous reserve volume in the horizontal and vertical positions ($\bar{x} \pm S\bar{x}$)**

Note. * – $p < .05$.

Figure 3. **Change in venous elasticity (ml/100 ml) in the horizontal and vertical positions ($\bar{x} \pm S\bar{x}$)**

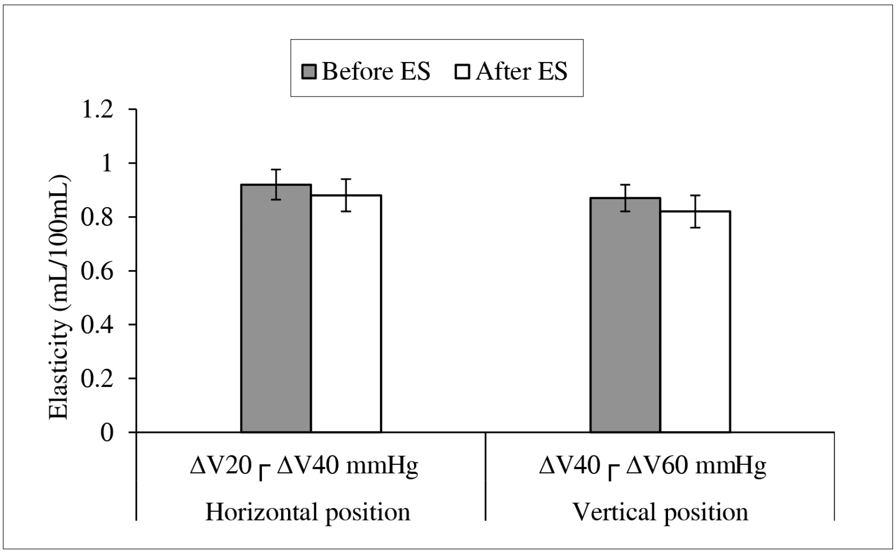
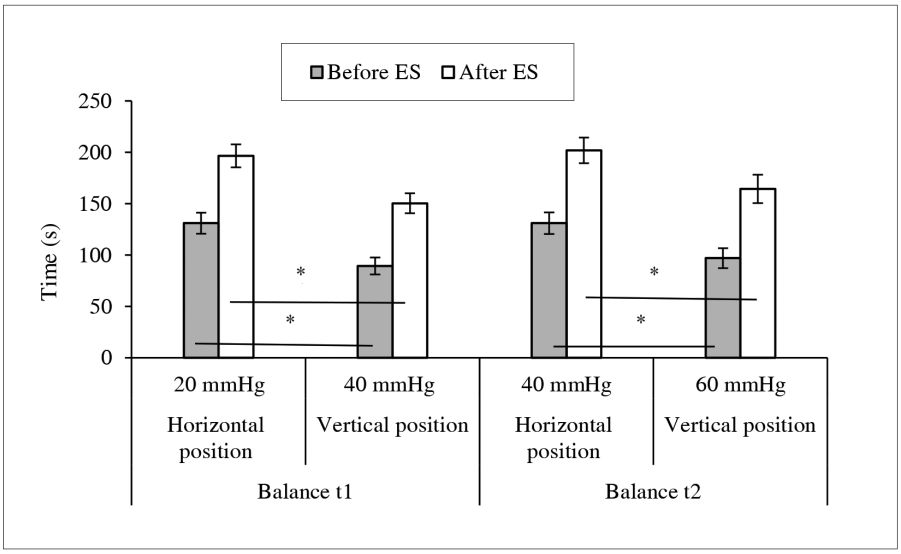


Figure 4. **Duration of time to reach balanced arterial and venous blood flow rates in the horizontal position before, during and after the EMS ($\bar{x} \pm S\bar{x}$)**



Note. * – $p < .05$.

reserve capacity in subjects in the vertical position before and after EMS did not differ (Figure 2).

In the horizontal position, venous elasticity (ΔV_{20} ┌ ΔV_{40} mmHg) in subjects was 0.92 ± 0.06 ml/100 ml before EMS and 0.88 ± 0.06 ml/100 ml after EMS.

In the vertical position, venous elasticity (ΔV_{40} ┌ ΔV_{60} mmHg) in subjects was 0.87 ± 0.05 ml/100 ml before EMS and 0.82 ± 0.06 ml/100 ml after EMS. No significant change was observed in venous elasticity in subjects between the horizontal and vertical positions (Figure 3).

In the horizontal position before EMS at the occlusion cuff pressure of 20 mmHg, the balance in arterial and venous blood flow rates was reached in 131.4 ± 10.3 s. After the additional occlusion pressure of 20 mmHg was applied, at the occlusion cuff pressure of 40 mmHg, the balance in arterial and venous blood flow rates was reached in 196.6 ± 11.3 s.

In the vertical position before EMS at the occlusion cuff pressure of 40 mmHg, the balance in arterial and venous blood flow rates was reached in 89.4 ± 8.2 s. After the additional occlusion pressure of 20 mmHg was applied, at the occlusion cuff pressure of 60 mmHg, the balance in arterial and venous blood flow rates was reached in 92.6 ± 9.1 s (Figure 4). After EMS at the occlusion cuff pressure of 40 mmHg, balance in arterial and venous blood flow rates was reached during a longer period of time compared to the initial value than at the occlusion cuff pressure of 60 mmHg. No significant difference was observed in the duration of time required to reach balanced arterial and venous blood flow rates at different pressure levels (ΔV_{40} ┌ ΔV_{60} mmHg) before and after EMS.

DISCUSSION

When the body is in a horizontal position, the pressure of 6–9 mmHg is needed to retain a oval shape in the venous blood vessel. Even under high pressure, the distension of the veins is low due to rigid collagen elements in the structure of the blood vessel wall (Wilmore et al., 2008). Under very low pressure, the veins become elliptical in shape. When the blood vessel circumference is equal, the lumen of the blood vessel elliptical in shape is lower than the lumen of the blood vessel oval in shape. When the venous pressure increases from 0 to 6 mmHg, venous volume in a segment changes significantly. The increase of venous circumference and elasticity show the change in venous reserve volume. Venous elasticity, i.e. an increase of the venous circumference, increases the flexibility of blood vessels evoking an insignificant force as it was noticed in the change of venous reserve volume. If the venous pressure is less than 6-9 mmHg, the veins collapse (Folkow & Neil, 1971).

In both horizontal and vertical positions, EMS providing a mild massage had a small effect on the intensity of arterial blood flow. The strongest effect of EMS on venous reserve volume was when subjects were in a vertical position. The difference between values recorded in the study may be explained by the increased luminal diameter in the veins caused by the increase in hydrostatic pressure in the sitting position when venous blood vessels undergo transformation from elliptical to oval in shape. This change reduces the resistance of blood flow in venous blood vessels (Caro, Pedley, Schroter, & Seed, 1978). In both horizontal and vertical positions, even though EMS caused extension and relaxation of the calf muscles, mild EMS had a small effect on venous blood volume in the calf. This assumption is also supported by the substantially longer duration needed for the plethysmography curve (balance in arterial and venous blood flows) to reach a new level of dynamic balance which indicates the degree of venous outflow. The increase in venous reserve volume observed in this study suggests that the decreased amount of blood in the veins results from the vertical body position. It is very probable that due to the decreased venous pressure, the resistance to the venous blood flow increases (Neubauer, 1977). Venous flow velocity is also affected by the position of the foot. When the foot is lower to the body in the horizontal position, e.g. the calf is lowered 25 degrees, venous flow velocity increases significantly because of the effect of the venous foot pump (Fleming, Fitzgerald, Devitt, Rice, & Murray, 2000).

The results from this study may be applied in other studies when the optimum pressure should be selected for the occlusion of venous blood flow. Different conditions are created when the body is located in a different position (horizontal and vertical). In the horizontal body position, an optimum pressure for the partial occlusion of the veins would be 20 mmHg and at the occlusion pressure higher than 20 mmHg the restoration of balanced arterial and venous blood flow rates would be achieved in a long period of time. A similar situation would occur during the tests in the vertical body position. The occlusion pressure of 40 mmHg is optimum to record the parameters of venous reserve volume. The increase of hydrostatic pressure and other factors affect the restoration of balanced arterial and venous blood flow rates.

CONCLUSIONS

1. When the body is in the horizontal or sitting position, EMS has no significant effect on arterial blood flow in persons adapted to physical loads. In the sitting position under the influence of hydrostatic pressure, arterial blood pressure is significantly lower compared to the horizontal position.
2. In the sitting position when hydrostatic pressure is absent, venous reserve capacity is significantly higher compared to the sitting position. Venous elasticity in the horizontal and vertical position respectively did not differ.
3. In the sitting position, the balance between arterial blood inflow and venous blood outflow was reached significantly faster compared to the horizontal position.

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Corresponding author **Julius Dovydaitis**
University of Applied Sciences Kauno Kolegija
Petrausko str.15, LT-44221 Kaunas
Lithuania
Tel. +370 37 330149
E-mail julius.dovydaitis@go.kauko.lt

RELATIONSHIP BETWEEN WOMEN'S BODY DISSATISFACTION, SENSE OF COHERENCE AND PHYSICAL ACTIVITY

Audronė Dumčienė[1], Jolanta Gedvilienė[2], Vaidas Mickevičius[3]
Lithuanian Sports University[1], Kaunas, Lithuania
Mykolas Romeris University[2], Vilnius, Lithuania
Kaunas University of Applied Engineering Sciences[3], Kaunas, Lithuania

ABSTRACT

Background. Socio-cultural pressure exerted by the environment and the media makes the majority of women take care of their bodies. That is especially true in Western culture which promotes slimmer women in recent decades.

Methods. Two questionnaires were used in this research: Body Shape Questionnaire and Sense of Coherence scale. Research participants were 79 women aged 34.6 ± 3.76 years.

Results. After six months of regular fitness classes women's satisfaction of their body and their sense coherence level improved significantly. Relations between body shape dissatisfaction and sense of coherence, body shape dissatisfaction and manageability, comprehensibility and manageability were found.

Conclusions. Systematic fitness training positively affects women's satisfaction with their body. Understanding of the capability of controlling their body shape was improved. There was a significant relationship between dissatisfaction with their body shape and sense of coherence. The effect of physical activity improved the values of all three components of the sense of coherence construct. The values of comprehensibility, meaningfulness and manageability indicators show that respondents may already have a better control of their sense of coherence.

Keywords: women, body shape dissatisfaction, sense of coherence, physical activity.

INTRODUCTION

It is believed that satisfaction with one's own body causes positive emotions, positive approach to the body, and body dissatisfaction, vice versa, causes negative emotions, negative attitudes to the body (Dittmar, 2009).

Inadequate assessment of the body can occur due to both the body weight and the body shape, but it is often associated with the increasing dissatisfaction with the body (Greenleaf, 2005). Persons dissatisfied with their body shape have to take some steps to change their attitudes (McPherson & Turnbull, 2005).

It can be assumed that satisfaction or dissatisfaction with their bodies is more related to culture rather than body mass. It has been established (McPherson & Turnbull, 2005) that the overweight men of low socioeconomic status were satisfied with their body weight and body shape and were not likely to change their body weight. However, it was revealed that both men and women were similarly unhappy about their bodies, but women often did something about that while men did not anything (Greenleaf, 2005; McPherson & Turnbull, 2005).

The image of a woman in the media and even normal body composition can make a woman feel dissatisfied with her body. As a result of the influence of media, more and more girls and women seek to be slim as a possibility to escape from sadness, loneliness and failures (Paxton, 2007).

Research results show that 30 to 50% of women are dissatisfied with their bodies (Pasha &

Golshekoh, 2009). Researchers (Brown & Dittmar, 2005; Dohnt & Tiggemann, 2006) suggest that dissatisfaction with one's body might be associated with many factors – fashion, peers, media, and family influence. Studies have revealed that body dissatisfaction is associated with poorer physical health, smoking, and poorer psychological well-being (Bergeron & Tylka, 2007; Ganem, Heer, & Morera, 2009; Meland, Haugland, & Breidablik, 2007; Pomerleau & Saules, 2007).

Šivert and Sinanovic's (2008) study shows that younger women were more dissatisfied with their bodies than the older. Researchers believe that older women are in a better position than the younger ones because at their times body ideals were more realistic, they were easier to achieve.

Body dissatisfaction is associated with inadequate self-esteem, anxiety for social assessment (Gianini & Smith, 2008; Presnell, Bearman, & Madeley, 2007), depression, and worsening quality of life (Benas & Gibb, 2007). It has been established (Gilbert-Diamond, Bayle, Mora- Plazas, & Villamor, 2009) that body dissatisfaction is related to the body mass index – increasing body mass index increases body dissatisfaction. Engeln-Maddox (2005) investigated the influence of the media and found that advertising skinny women on TV increased body dissatisfaction among other women.

Choate (2005) has identified five factors that contribute to the formation of people's satisfaction with their bodies: family support, satisfaction of the sex role, positive assessment of physical condition, effective coping strategies, holistic balance and the sense of wellness. Body dissatisfaction has a negative impact on psychological well-being, the level of stress, anxiety, depression, life satisfaction and self-esteem in both girls and boys (Bergeron & Tylka, 2007; Bookwala & Boyar, 2008; Ganem, Heer, & Morena, 2009; Sujoldzic & De Lucia, 2007).

Physical activity is associated with body satisfaction. People start exercising to increase their body satisfaction thinking that it can help them to adapt more in the community. Others who are afraid to show their bodies in public can exercise less. It has been shown that physical activity is associated with body satisfaction (Greenleaf, 2005).

Studies have shown that among overweight girls and girls without it physical activity difference is statistically significant. Girls with overweight were more intensely active physically, but for a short time, and those without overweight were constantly active or inactive (Fonseca & De Matos, 2005).

According Antanovsky's (1987) salutogenic theory, every human has the generalized resistance resources, which, if necessary, help to deal with the difficulties of life. The volume of these resources is associated with personal qualities, intellect, and the provisions of the phenomenon of life, behavior and perception of reasoning, problem-solving strategies, financial capacity, social and cultural factors, enabling to control a stressful situation. The possibilities to use the general resistance resources depend on the person's sense of coherence level. Antanovsky (1987) proposed a scale Sense of Coherence (SOC) for the assessment of the sense of coherence level, which is widely used to search for coherence links with human health, well-being, mental health and other characteristics. Reviews of research on SOC concluded that significance of this relation was confirmed many times (Eriksson & Lindström, 2006, 2007).

The scale SOC is strongly and negatively associated with anxiety, anger, burnout, demoralization, hostility, hopelessness, perceived depression, perceived stressors, and post-traumatic stress disorder (Bothmer & Fridlund, 2003; Eriksson & Lindström, 2005; Skirka, 2000;)

SOC scale can serve for the prediction of staff burnout syndrome (Kalimo, Pahkin, Mutanen, & Topipinen-Tanner, 2003). According to the survey (Javtokas, 2001), 39.9% of Lithuanian population demonstrate a high sense of coherence level, while 60.1% – low.

METHODS

Research Participants. Research participants started attending regularly fitness classes twice a week in 2013–2014, and not less than half a year they attended group fitness classes. Research included 79 women aged 34.6 ± 3.76 years, their mean body mass index was 26.56 ± 2.84. All respondents participated in the survey voluntarily; they were informed about the purpose of the study and the anonymity. There were two questionnaires used for data collection – one for the assessment of the body shape and the second one – for the sense of coherence. The study participants' survey was carried out twice: the first one on admission to the fitness group and the second one was conducted after six months. Those who missed more than 15% of classes were not interviewed for the second time.

The Body Shape Questionnaire (Cooper, Taylor, Cooper, & Fairburn, 1986) was used for the assessment of women's dissatisfaction with their body shapes. The questionnaire consisted of 38 items. The items were rated using a 6-point Likert scale, with response options of 1 = *never*, 2 = *rarely*, 3 = s*ometimes*, 4 = *often*, 5 = *very often*, 6 = *always*. Replies estimates were summed. Higher total estimate indicated greater body dissatisfaction.

The scale was adapted for the use with Lithuanian populations using the back-translation procedure described by Hambleton, Merenda and Spielberger (2005).

Questionnaire translation from English into Lithuanian language and back was performed by two professional translators, both of whom had previous experience in adapting research instruments. One of them separately translated the original scale from English to Lithuanian and the second one translated from Lithuanian to English. The back-translated version and the original version were compared, and no lack of equivalence was found. Then the factor structure of the scale was examined using exploratory factor analysis. We performed a principal components factor analysis with orthogonal (varimax) rotation and Kaiser Normalization. Five factors with eigenvalues greater than 1.00 and item loadings greater than 0.45 for each factor emerged. These factors accounted for 61.72% of the total variance (Kaiser-Meyer-Olsen = .81, $p < .001$). The scale and component factors of the Lithuanian version scale corresponded to the original version of the scale. Estimation of the Cronbach's alpha demonstrated good levels of internal reliability for consistency scale (.918). The reliability estimated by questionnaire authors was .930 (Cooper, Taylor, Cooper & Fairburn, 1986).

The following factors were identified: *ashamed of their body* (ten items), *fear to become fat* (eighth items), *dissatisfaction with body shape compared with other women* (eighth items), *efforts to change the body shape* (five items) and *negative emotions about the body shape* (seven items). The estimation of the Cronbach's alpha demonstrated good levels of internal reliability, consistency for all five subscales (.938, .878, .901, .882 and .837).

For the assessment of the sense of coherence level we used Antonovsky (1987) 13 items scale. The scale distinguished three subscales: comprehensibility (cognitive component of the sense of coherence) (five items), meaningfulness (the motivational component of the sense of coherence) (four items) and manageability (the behavioural component of the sense of coherence) (four items). The items are rated using semantic difference 7-point Likert scales (*bad – good*), with response options from 1 = *very rarely or never* to 7 = *always*.

Some items had different response options (e.g. item number four, 1 – *did not have completely clear goals and objectives* and 7 – *had clear goals and targets*). While calculating estimates to certify the total values for five items (numbers 1, 2, 3, 7, 10) we needed to decode estimates of the 1–7 scale to 7–1 scale). Reply values were summed (Eriksson & Lindstrom, 2005), or calculated as averages of values. The total value of SOC-13 scale can be from 13 to 91. The rating was as follows: more points – a higher level of internal sense of coherence. The Lithuanian version of SOC-13 scale was prepared by Javtokas (2009).

Data Analysis. The analysis was performed using SPSS for Windows software (version 19.0). The methods of analysis included factor analysis, Cronbach's alpha coefficients, descriptive statistics, Pearson's correlations, and Student's *t*-test. Statistical significance was set at $p < .05$ for all tests.

RESULTS

Women's estimates of body dissatisfaction during the first and second surveys are presented in Table 1.

Data on the levels of internal sense of coherence of the respondents are presented in Table 2.

Correlation coefficients between the factors are presented in Table 3.

DISCUSSION

Based on the results given in Table 1, it can be said that physical activity (participation in regular fitness classes) has favourable influence on women's body satisfaction. The biggest change occurred with the estimates of the item "*Dissatisfaction with the body shape compared with other women*" (5.6 points) and the item "*Negative emotions about the body shape*" (5.22 points), and the smallest changes were observed in the item "*Efforts to change the body shape"* (3.06 points). It can be assumed that women realized their potential to improve satisfaction with their body shape. McLaren & Kuh's (2004) study showed that over 50% of normal weight (BMI < 25) women were dissatisfied with their body and women of higher social class were very unhappy about it. Women who smoked were more dissatisfied with their bodies than non-smokers (Pomerleau & Saules, 2007). Body dissatisfaction is associated and with other factors,

Table 1. **Estimates of women's body dissatisfaction**

Body dissatisfaction (factors)	First testing Mean ± *SD*	Second testing Mean ± *SD*	*t*-test	*p*
Ashamed of their body shape	37.67 ± 6.76	33.43 ± 4.92	4.51	< .0001
Fear to be heavier	27.56 ± 4.93	22.78 ± 2.98	7.38	< .0001
Dissatisfaction with body shape compared with other women	23.49 ± 2.84	17.89 ± 2.21	13.83	< .0001
Efforts to change their body shape	19.35 ± 2.92	16.29 ± 2.12	7.54	< .0001
Negative emotions about the body shape	20.11 ± 2.08	14.89 ± 1.96	16.23	< .0001
Total sum of mean values	128.36 ± 3.91	104.56 ± 2.84	43.77	< .0001

Table 2. **Levels of internal sense of coherence during the first and the second survey**

Inner sense of coherence (factors)	First survey Mean ± *SD*	Second survey Mean ± *SD*	*t*-test	*p*
Comprehensibility	27.56 ± 5.31	30.16 ± 3.24	–3.72	< .005
Meaningfulness	14.58 ± 2.32	21.65 ± 2.81	–17.24	< .0001
Manageability	19.39 ± 3.29	27.51 ± 1.47	–20.03	< .0001
Total values means sum	61.53 ± 3.64	79.23 ± 2.65	–34.94	< .0001

Table 3. **Correlation coefficients between the factors**

No.	Factors	1	2	3	4	5	6	7	8	9	10
1.	Ashamed of the body shape	1	.432*	.289	.228	.568*	.461*	.216	.095	.289	0.229
2.	Fear to become fat	.432*		.387*	.491*	.521*	.712*	.215	.098	.186	.168
3.	Dissatisfaction with the body shape compared with other women	.289	.387	1	.584*	.589*	.724*	.412*	.067	.193	.192
4.	Efforts to change the body shape	.228	.491*	.584*	1	.567*	.694*	.214	.211	.297	..443*
5.	Negative emotions about the body shape	.568*	.521*	.589*	.567*	1	.689*	.521*	.681*	.521*	.374*
6.	Dissatisfaction with the body shape	.461*	.712*	.724*	.694*	.689*	1	.252	.193	.646*	.733*
7.	Comprehensibility	.216	.216	.412*	.214	.521*	.252	1	.425*	.714*	.483*
8.	Meaningfulness	.095	.098	.067	.111	.681*	.193	.425*	1	.532*	.397*
9.	Manageability	.289	.186	.193	.197	.521*	.646*	.714*	.532*	1	.526*
10.	Sense of coherence	.229	.168	.192	.443*	.374*	.733*	.483*	.397*	.526*	1

although the study results are conflicting. Thus, Bergeron and Tylka (2007) found a significant correlation between the boys' dissatisfaction with their bodies and their psychological well-being. However, in their study Bookwala and Boyar (2008) found that dissatisfaction of body level predicted poorer psychological well-being only for women. However, Ganem, Heer, and Morera (2009) observed that dissatisfaction of body predicted poor psychological well-being for both girls and boys.

Body dissatisfaction manifests over the whole period of life. It is believed (Hrabosky, Masheb, White, & Grilo, 2007), that persons who are dissatisfied with their bodies overestimate this influence on their self-esteem as well.

Kater (2005) believes that body dissatisfaction is related to other people's approach and attitudes to the body, its beauty, diet and physical activity. It is believed (Greenleaf, 2005) that desired or perceived ideal body is highly dependent on the culture and society in which the person resides.

According to Mills, Fuller-Tyszkiewicz, and Holmes' (2014) research, body dissatisfaction predicted subsequent avoidance of social interactions. If women chose to avoid social interactions, their body dissatisfaction worsened, but when they did engage in active social interactions, their body satisfaction improved. In the study (Swami, Frederick, Aavik, & Alcalay, 2010), covering 10 regions of the world, shows that the media exposure predicted body dissatisfaction among women and desire for thinness was commonplace in high socioeconomic-status across settings world regions.

Interesting data on body satisfaction was obtained in C. Markey and P. Markey's (2014) study. It revealed that lesbian women preferred larger body ideals than heterosexual women and that women's ideal body preferences were not related to their partners' weight status.

The changes of sense of coherence values in fitness classes reflect the findings presented in Table 2. The estimates for all three factors in the overall internal sense of coherence level changes were significant ($p < .05$). Our study results on scale SOC-13 corresponded to the data of other researchers (Oosthuizen & Van Lill, 2008 – the assessment that they used on the scale SOC-29). Lithuanian internal sense of coherence research was conducted by Javtokas (2009), but he used a very concise modified version of the SOC questionnaire preferred for mass analysis. Sense of coherence is a very important factor in human life because as stated by Strumpfer and De Bruin (2009), an individual with a strong sense of coherence will put efforts and energy into live demands and see them as challenges.

Correlation links were found between the set of derived factors. The strongest correlation was found between comprehensibility and manageability (.814), body shape dissatisfaction and manageability (.746) and body shape dissatisfaction and sense of coherence (.833).

The relationships of the sense of coherence with most of the human condition indicators confirm the results of many researchers. Thus, the sense of coherence links with mental health was confirmed by Eriksson and Lindström (2006). Eriksson and Lindström (2007) analysed 32 articles that disclosed the relationship between the sense of coherence and the quality of live, which indicates that sense of coherence level predicts subjectively perceived level of the quality of live.

So, we have obtained results that are consistent with the findings of other researchers.

CONCLUSION

Systematic fitness training positively affects women's satisfaction with their body. We found a significant relationship between body shape dissatisfaction and the sense of coherence. The effect of physical activity improved all three components of the sense of coherence construct. The indicators as comprehensibility, meaningfulness and manageability show that respondents may already have better control of their sense of coherence.

Limitations and Direction for Future Research. First, a limitation in this study is that the sample was restricted to middle age women. Thus, it is unknown whether the results can be generalized to represent all women in Lithuania. Further research should be carried out with groups that are more representative of women and men. Second, the variables of interest in this study were restricted to women's body shape dissatisfaction and internal sense of coherence. In the future, researchers could extend our research design to examine other variables, such as the subjective quality of live, mental and physical health in relations with physical activity.

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Corresponding author **Audronė Dumčienė**
Lithuanian Sports University
Sporto str. 6, Kaunas LT-44221
Lithuania
Tel. +370 37 209050
E-mail audrone.dumciene@lsu.lt

OPTIMIZATION METHODS IN PHYSICAL EDUCATION LESSONS FOR GIRLS IN THE SECOND AND THE THIRD GRADES

Almagul Ilyasova, Valery Kovalenko, Zhanymmurat Erzhanov
Kazakh National Pedagogical University after Abay, Almaty, Kazakhstan

ABSTRACT

Background. Theoretical analysis of research papers allowed us to establish that physical preparation of pupils in elementary grades as an area of scientific and pedagogical knowledge was not investigated enough. Despite great efforts to cover a lot of questions and undoubted theoretical and practical significance of educational research, it should be noted that the problem of physical education for younger pupils using sports games in the lessons of physical education remains open to theoretical understanding and experimental study. There is a lack of specific studies that reveal the basic trends and ways to optimize the studied phenomenon. Worsening situation in the area of physical training in junior classes and individual indicators of health status in the country encourages looking for scientific solutions of the problem. *Research aim* was to define the most effective methods of physical education for 8–9-year-old girls, learners of the second and third grades, during physical education lessons including elements of sports games in a comprehensive school.

Methods. Research participants were 64 girls from the second and the third grades. They were divided into 4 groups – 3 experimental groups and one control group. During the experiment, group E1 was allotted 75% of the time of the lesson for training technical actions of sports, group E2 – 50% in E3 – 25%, for the development of physical skills – 25, 50 and 75% respectively. The effectiveness of the proposed program was estimated by the changes in the indicators of physical development and general physical fitness.

Results and conclusions. Physical development of girls during the school year changed considerably. The most clearly expressed change was noted in the results of the changes in the girls' body weight, from 20.32 to 23.24% in all groups. No significant differences between the experimental and control groups in terms of physical development were identified. Indicators of general physical fitness for the whole period of the experiment significantly increased in all the groups studied ($p < .05–.001$). They may be divided into two groups:

- The first group included indicators which were significantly higher in the experimental group E3, where more time was devoted to physical training (running at 30 m, the hand strength) during the physical education lessons;
- The second group included indicators which were significantly higher in the experimental group E1, where more time was devoted to sports (long jump, making a shot, running 3 x 10 m) during physical education lessons.

Thus, the lessons of physical education with elements of sports promoted more intensive development of the overall fitness of girls aged 8–9 years compared to those who attended physical education lessons conducted according to the general curriculum.

Keywords: girls in the second and the third grades, physical education class, physical development, physical fitness, sports and games.

INTRODUCTION

Physical training and sports as an important means of education performs a certain social function and becomes an element of lifestyle among the Kazakh people, thus creating favourable conditions for the harmonious personality development (Кульназарова, 2013).

Increasing importance of systematic physical training and sports for all students should be considered as a condition to prepare sports reserve and a solution of other problems of physical education for the younger generation (Yang, Telema, Laakgo, Keltikangas-Järvinen, & Pullli, 2007; Касымбекова, Кошаев, & Абишев, 2013; Синявский, Власов, & Сергеев, 2009).

Consideration of the questions of physical education in junior classes revealed the needs for special scientific and pedagogical consideration in developing specific proposals aimed at providing practical tasks related to physical training (Malina, Bouchard, & Bar-Or, 2004; Бервинова & Шарабакин, 2005; Минаев, 1989).

Consideration of the physical training problem for students in junior classes during physical training lessons is in accordance with the following scientific approaches:

- School-based physical training (Волков & Ромашев, 1998);
- Organization and planning of physical training in physical education classes and extra-curricular hours (Gudžinskienė, 2006; Гужаловский, 1987; Юревич & Мусатаев, 2013);
- Development of physical skills for school-aged children (Bar-Or, 1996; van Praag, 2000; Turley, 1997; Бальсевич, 2000).

Theoretical analysis of research papers allowed us to establish that physical preparation of pupils in elementary grades as an area of scientific and pedagogical knowledge was not investigated enough. Despite great efforts to cover a lot of questions and undoubted theoretical and practical significance of educational research, it should be noted that the problem of physical education for younger pupils using sports games in the lessons of physical education remains open to theoretical understanding and experimental study. There is a lack of specific studies that reveal the basic trends and ways to optimize the studied phenomenon. Worsening situation in the area of physical training in junior classes and individual indicators of health status in the country encourages looking for scientific solutions of the problem.

Thus, there is an objective contradiction between the demand prevailing in the necessity of organizing physical training for students in junior grades and insufficient development of this issue in pedagogical science and practice. Our research problem was the identification of the pedagogical conditions for physical development of students in junior grades during physical education lessons involving elements of sports, where the use of different exercises and the best outdoor sports games could contribute to the optimization of the investigated phenomenon (Ilyasova & Erzhanov, 2014).

The relevance of this problem, the lack of theoretical elaboration and practical requirements defined problem of our investigation – to theoretically substantiate and develop a technique of optimization for physical training of junior schoolchildren during physical education lessons.

Our research aim was to define the most effective methods of physical training for 8–9-year-old girls in the second and the third grades during physical education lessons which involve elements of sports games in a comprehensive school.

Research objectives were as follows:

- To prove the dependence of the dynamics of growth indicators and physical condition for female students in junior grades on the content and direction of physical education lessons;
- To justify the purposeful use of the elements of sports in the lessons of physical education which improve the physical condition of girls in junior grades and contributes to the engagement in sports.

METHODS

To obtain the research results we used the following methods: literature review, pedagogical experiment, testing, and mathematical statistics.

The research was conducted in the academic year of 2011–2012. Participants were 8–9-year-old students of the second and the third grades in the secondary school “Prestige” in Almaty. All participants were divided into four groups. In each of the three experimental (E1, E2, E3) and the control group (C) group included 16 girls. The pedagogical experiment involved 64 girls. The control group had physical education according to the programme of secondary schools twice a week for 45 minutes. The girls of the experimental groups E1, E2, E3 had physical education classes for one academic year involving specialized technical training exercises of sports (football, basketball, vigorous games), planned on the basis of the modified program CYSS which included: a blow on the ball in a range, making a shot, dribbling the ball kicked, dribbling hands, sending the ball between partners, a game with throws “Square”, “moving target”, “getting the ball”. The study was conducted in three stages, the first test was conducted in September, the second one – in February, and the third one – in June. During the experiment we examined the effectiveness of two factors:

- A different ratio of the time allotted for physical and technical training;
- Purposeful development of different physical skills.

During the experiment, the following indicators were tested:

- Physical development: body height, body weight, chest circumference, and chest excursion;
- General physical fitness: 30 m running with a high start, long jump from place, making a shot, running 3 x 10 m, hand grip strength;

During the experiment, group E1 had physical education lessons according to program A, i.e. 75% of the lesson time (34 min) was given to training technical elements of sport and 25% (11 min) – for the development of physical skills. Group E2 had physical education lessons according to program B, in which activities for technical skills were given 50% of the lesson time (22 min), and the development of physical skills – 50% of the time. Group E3 had education program C. Physical skills received 75% of the lesson time (34 min), and 25% of the lesson (11 min) was given to teaching vigorous games. The data obtained were processed applying the methods of mathematical statistics. We defined the arithmetic mean for each indicator (X) and their errors (Sx), as well as the percentage change in study data. Comparing the results of individual groups, as well as the increase of the indices for individual study period, when testing the hypothesis of equality of the individual and mean (X), the method of the analysis of variance ANOVA (F – Fisher's test) was used. Statistically significance of difference between the indicators assessed was set at $p < .05$ when $F = 3.20$).

RESULTS

Dynamics of physical development of 8–9-year-old girls is shown in Table 1.

The body height. In the first survey of the value of this indicator fluctuated from 120.6 (E2) to 126.0 (E1) cm. Statistically significant differences were not observed between the groups ($p > .05$). During the academic year, the value of the body height of the experimental groups and the control group increased by 5.92–9.82% ($p < .001$). It should be noted that during the experimental period there were statistically significant differences in the height of girls due to growth in the first and the third experimental groups as well as the control group ($p < .05$).

Body weight. In the first survey, the value of this indicator fluctuated from 21.8 (E2) to 26.4 (E1) kg. Statistically significant differences were observed between the groups ($p > .05$). During the second survey, an increase in body weight by 12.82–15.46% ($p < .05$, $p < .01$) was found. In the third survey, the value of the indicator for members in the experimental groups fluctuated from 28.4 to 34.1 kg. It was established that at the end of the experiment, the values of the body weight compared to baseline increased the greatest in group E2 – by 23.24%, and in group E1 – by 20.58%, whereas for the representatives of E3 the control group the increase was by 20.39 and 20.32%. Changes in body weight girls of all the researched groups were statistically significant ($p < .001$, $p < .01$).

The circumference of the thorax. At the beginning of the experiment, the value of this indicator fluctuated from 58.5 (E2) to 60.6 (E1) cm. However, between-group differences were not significant ($p > .05$). In the third testing, the values of this indicator fluctuated from 63.1 (E2) to 65.2 (E1) cm. However, again we did not observe intergroup differences. Overall growth indicators of the chest circumference were statistically significant ($p < .01$, $p < .001$) in all groups during the experiment.

Chest excursion. At the beginning of the experiment, the results of this indicator fluctuated from 1.9 (E2) to 2.4 (E3) cm. However, between-group differences at this stage of the survey were insignificant. In the third testing, the values of this indicator fluctuated from 2.7 (E2) to 3.3 (C) cm. Significant group differences in performance were observed only between the two experimental and control groups.

Results of changes in the general physical fitness are presented in Table 2.

*Running 30 m***.** The initial value of this indicator for girls fluctuated from 6.4 to 6.0 s (E3). During the second testing, significant group differences were found between the control, the second and third experimental groups ($p < .05$). It was established that during the third testing, the highest result was found for girls from the third group – 5.8 s. The average result of other experimental groups was equal to 5.9, and the control group – 6.1 s. A significant increase in the running speed between

Table 1. **Results of changes in the physical development of girls, students of the second and the third grades ($X \pm Sx$)**

Physical development	Stages	Groups			
		E1	E2	E3	C
Body height (cm)	1 2 3	126.0 ± 1.70 133.6 ± 1.86 139.1 ± 1.95	120.6 ± 1.87 128.2 ± 1.19 133.0 ± 1.27	123.4 ± 1.16 129.3 ± 1.17 134.4 ± 1.37	121.1 ± 0.79 128.3 ± 0.82 134.3 ± 0.82
Difference (%) and significance of changes	1–3	9.42 $p < .001$	5.92 $p < .05$	8.18 $p < .01$	9.82 $p < .001$
Body mass (kg)	1 2 3	26.4 ± 0.93 30.1 ± 0.87 34.1 ± 1.42	21.8 ± 0.82 25.5 ± 0.64 28.4 ± 0.66	24.2 ± 0.95 27.5 ± 0.95 30.4 ± 1.08	24.3 ± 0.79 28.2 ± 0.90 30.5 ± 1.21
Difference (%) and significance of changes	1–3	22.58 $p < .001$	23.24 $p < .001$	20.39 $p < .01$	20.32 $p < .01$
The chest circumference (cm)	1 2 3	60.6 ± 0.58 62.2 ± 0.75 65.2 ± 1.22	58.5 ± 0.71 60.3 ± 0.53 63.1 ± 0.63	59.3 ± 0.96 61.0 ± 0.14 64.1 ± 1.22	58.7 ± 0.82 62.7 ± 0.95 64.8 ± 1.05
Difference (%) and significance of changes	1–3	7.05 $p < .01$	7.29 $p < .01$	7.49 $p < .01$	9.41 $p < .001$
Chest excursion (cm)	1 2 3	2.2 ± 0.24 2.8 ± 0.28 2.9 ± 0.25	1.9 ± 0.17 2.3 ± 0.19 2.7 ± 0.16	2.4 ± 0.14 2.9 ± 0.26 3.0 ± 0.18	2.3 ± 0.16 2.9 ± 0.19 3.3 ± 0.21
Difference (%) and significance of changes	1–3	24.13 $p < .05$	29.62 $p < .01$	20.00 $p < .05$	30.30 $p < .001$

the first and the third testing was achieved only by the girls in the first experimental group ($p < .05$).

Long jump. In the first testing the result of this indicator fluctuated from 122.5 (E3) to 126.6 (E1) cm. However, between-group differences were not statistically significant. In the second testing, intergroup differences also remained almost unchanged. In the third testing, results of this indicator fluctuated from 133.0 (C) to 137.2 (E1) cm. However, significant differences in the results between the groups were observed. During the whole period of the experiment the most significant increase in the result of this exercise was observed in girls from group E1 – 9.91%.

Making a shot. The results of this indicator in the first examination fluctuated from an average of 2.4 (E3) to 3.4 (E1) results of 5 attempts. In the second testing, these indicators became almost identical in all groups. A similar pattern was observed in the third testing. However, it should be noted that the increase in this indicator during the experiment was the highest in girls in group E3 – 38.46% ($p < .001$).

Running 3 x 10 m. In the first examination, results of the indicator fluctuated from 10.8 (C) to 10.6 (E1, E3) s. In the second survey, results in running 3 x 10 m did not change. In the third testing, results of this indicator were almost equal in all groups. During the period of the experiment, results of this indicator in girls of all groups increased within the limits of 2.83–3.70%.

Hand grip strength. The results of this indicator in the first examination fluctuated from an average of 10.4 (E3) to 10.7 (E1) kg. In the second testing, the values of this indicator gradually increased, but between-group differences were statistically insignificant. In the third testing, the highest strength was demonstrated by girls in group E3, where this result increased from 10.4 to 12.9 kg (19.38%, $p < .001$) on average.

Table 2. **Result of changes in general physical fitness for girls, students in the second and the third grades (X ± *Sx*)**

Tests	Stages	Groups			
		E1	E2	E3	C
Running 30 m (s)	1 2 3	6.2 ± 0.08 6.1 ± 0.07 5.9 ± 0.06	6.1 ± 0.07 6.0 ± 0.06 5.9 ± 0.07	6.0 ± 0.05 5.9 ± 0.05 5.8 ± 0.05	6.4 ± 0.08 6.3 ± 0.08 6.1 ± 0.07
Difference (%) and significance of changes	1–3	4.83 $p < .05$	3.28 $p > .05$	3.33 $p > .05$	3.68 $p < .05$
Long jump (cm)	1 2 3	126.6 ± 2.88 132.3 ± 2.62 137.2 ± 2.52	123.4 ± 2.00 128.3 ± 1.97 133.3 ± 1.94	122.5 ± 1.61 128.2 ± 1.59 134.3 ± 1.52	122.8 ± 1.64 127.8 ± 1.69 133.0 ± 1.54
Difference (%) and significance of changes	1–3	9.91 $p < .001$	7.42 $p < .01$	8.78 $p < .01$	7.67 $p < .01$
Making a shot from the distance of 6 m, 5 attempts (number of shots)	1 2 3	3.4 ± 0.19 3.6 ± 0.13 4.3 ± 0.16	2.7 ± 0.25 3.3 ± 0.18 4.1 ± 0.21	2.4 ± 0.27 3.3 ± 0.19 3.9 ± 0.19	2.5 ± 0.23 3.3 ± 0.19 3.9 ± 0.17
Difference (%) and significance of changes	1–3	20.93 $p < .001$	34.14 $p < .001$	38.46 $p < .001$	35.90 $p < .001$
Running 3 x 10 m (s)	1 2 3	10.6 ± 0.18 10.4 ± 0.16 10.3 ± 0.15	10.7 ± 0.11 10.5 ± 0.10 10.3 ± 0.09	10.6 ± 0.11 10.5 ± 0.12 10.3 ± 0.10	10.8 ± 0.12 10.5 ± 0.11 10.4 ± 0.09
Difference (%) and significance of changes	1–3	2.83 $p > .05$	3.74 $p < .01$	2.83 $p < .05$	3.70 $p < .01$
Hand grip strength (kg)	1 2 3	10.7 ± 0.17 11.5 ± 0.20 12.5 ± 0.24	10.5 ± 0.25 11.3 ± 0.25 12.0 ± 0.28	10.4 ± 0.12 11.3 ± 0.1 12.9 ± 0.18	10.5 ± 0.11 11.2 ± 0.12 12.0 ± 0.15
Difference (%) and significance of changes	1–3	14.40 $p < .001$	12.50 $p < .001$	19.38 $p < .001$	12.50 $p < .001$

DISCUSSION

Analysing the dynamics of physical development of girls in primary school at the beginning of the experiment, we did not see much difference between the experimental and the control groups. Similar results of physical development of girls were found in the research by other authors (Baxter-Jones, 2001). During the period of the experiment, increase in indicators, was approximately equal in all groups, the special advantages of any group were not observed. This suggests that physical training in experimental and general education programs equally affected the growth of girls in the experimental groups and the control group. Comparing our data with those of several authors (Armstrong & Welsman, 2000; Bar-Or, 1996; Rowland, 2007; Telema, Yang, Hirvansalo, & Raitkari, 2006), we found that they corresponded to indicators characteristic of girls aged 8–9 years. It should be noted that the increase in the average physical development indicators of the girls during the experimental period was statistically significant ($p < .05– .001$) with some advantage of group E1 representatives who had the physical education lessons with 75% of time devoted to exercises in sports games. According to Baxter-Jones (2001), Rowland (2007), body height does not completely show the physical condition of a child. The main features of physical perfection for children is still considered as strength, speed, endurance, joint mobility, coordination and agility (Dencer, Thorsson, & Karlson, 2006; Malina et al., 2004; Синявский et al., 2009).

Analysis of the dynamics of the results of general physical fitness of girls shows that in all the surveyed groups there was a marked increase in the values of all indicators. This indicates a favourable age of 8–9-year-old girls for the development of basic impellent skills: speed and strength. A number of authors (Armstrong & Welsman, 2000; Chvicialovski, Wulf, de Medeiros, & Dencer, 2006; Kalfer, & Tani, 2008) are of the same opinion. Given dynamics of the results of general physical fitness over the study period suggests a different relationship between the indicators in the surveyed groups. For example, significant differences ($p > .05$) were observed in 30 m run and long jump. However, it should be noted that the increase of these indicators is somewhat higher in the experimental groups. As for exercise containing an element of technical training sports game – making a shot, the highest result was achieved by girls in group E1 in physical education lessons with 75% of the time allotted to sports games. At the same time the results of the strongest hand grip were demonstrated by girls in group E3, where 75% of time in physical education lessons was devoted to physical training. Physical development, the overall fitness of girls in primary school testify the advantages of the integrated programs with elements of sports games (experimental group) during physical education lessons without harming their health, and creating more favourable conditions for the manifestation of their capabilities to have more children in sports. The same opinion can be found in the research by Stepinski, Zwirko, Frolkiewicz, and Debieka (2003), Адамбеков and Боранбаев (1999).

Thus, the data obtained suggest that the experimental programs containing exercises in physical education lessons have a more significant effect on the physical development and physical fitness of girls 8–9 years of age.

CONCLUSIONS

1. Indicators of physical development of girls during the school year changed considerably. The most clearly expressed change was noted in the results of the changes in body weight of girls from 20.32 to 23.24% in all groups. Significant differences between the experimental and control groups were identified in terms of physical development.

2. Analysing the increase in overall physical fitness for the whole period of the experiment, we found a significant changes in all examined experimental groups ($p < .05–.001$). Indicators of overall physical fitness can be divided into two groups:

- The first group included indicators which were significantly higher in the experimental group E3, where more time was devoted to physical training (running at 30 m, the hand strength) during the physical education lessons;
- The second group included indicators which were significantly higher in the experimental group E1, where more time was devoted to sports (long jump, making a shot, running 3 x 10 m) during physical education lessons.

3. The study showed that the best option of physical training for girls of primary school age is an integrated program in physical education lessons with 75% of the total time of the lesson devoted to sports and 25% of the lesson time should be devoted to the development of physical skills (program A).

4. Physical education lessons with elements of sports games promote more intensive development dynamics in overall fitness of girls aged 8–9 years compared to physical education lessons conducted according to the general curriculum.

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Corresponding author **Almagul Ilyasova**
Kazakh National Pedagogical University after Abay
Spartak Stadium, Ormarova str., Almaty
Kazakhstan
Tel. +7(777) 571 71 80
E-mail timfk.2013@mail.ru

IMPACT OF SINGLE BOUT OF PHYSICAL EXERCISE ON ADOLESCENTS' STRENGTH AND BALANCE ABILITIES

Lina Kreivėnaitė, Vytautas Streckis, Sandra Raizgytė, Asta Lileikienė
Lithuanian Sports University, Kaunas, Lithuania

ABSTRACT

Background. There is evidence of physical exercise effect on the adolescents' balance and strength; however it is not known how aforementioned variables respond to physical exercise with different loads and intensities. Therefore, the aim of the study was to assess the impact of single bout of physical exercise of different intensity on adolescents' body balance and muscular strength.

Methods. Thirty healthy, physically active 11–13-year-old adolescents were randomly allocated to one of the two groups. Both groups performed single bout of physical exercise of high- or low-intensity climbing up and down-stairs. Postural sway and maximum voluntary contractions (MVC) were assessed before and after physical exercise.

Results. No statistically significant impact of low or high intensity exercise was found at adolescents' MVC. High intensity exercise influenced bigger postural sway with eyes closed compared to eyes open ($p < .05$). After high-intensity exercise there was a significantly greater postural sway with eyes closed than with eyes open ($p < .05$).

Conclusions. High and low intensity physical exercise had no impact on the adolescents' maximum voluntary contraction, whereas high intensity exercise deteriorated body balance with eyes closed.

Keywords: adolescence, physical exercise, MVC, balance.

INTRODUCTION

It is widely accepted that there is the direct benefit of regular physical activity on health (Bouchard & Rankinen, 2001; Doherty, 2003; Fitts, 2003). Lack of physical activity can lead to cardiovascular system disorders, obesity, diabetes and manifestations of other diseases (US Department of Health and Human Services, 1996). Insufficient physical activity is closely associated with the choice of a sedentary lifestyle in future as well (Malina, 2001; Telama et al., 2005), which can be responsible for the quickly resulting fatigue and may increase the risk of diseases related with low levels of physical activity as well as advance the manifestation of age-related diseases (US Department of Health and Human Services, 1996). There is much evidence that the family and environmental impact is a significant factor in choosing the level of physical activity (Bouchard & Rankinen, 2001). Moreover, the results of some studies have shown that participation in organized sport in childhood and adolescence is a good predictor of physical activity in adulthood (Barnekow-Bergkvist, Hedberg, Janlert, & Jansson, 1998; Engström, 1991; Malina, 2001; Tammelin, Näyhä, Hills, & Järvelin, 2003; Telama, Yang, Laakso, & Viikari, 1997). Significant reduction in human physical activity has been considered by many authors (Bouchard & Rankinen, 2001; Doherty, 2003; Fitts, 2003; Telama et al., 2005; Westerståhl, Barnekow-Bergkvist, & Jansson, 2005). It is also noted that more people are engaged in a monotonous manual activity at work, requiring repetitive muscle contractions or prolonged maintenance of unusual posture (Latash, 2008). Such activity increases local muscle fatigue and even the risk of injuries (Skurvydas, Brazaitis, Kamandulis,

& Sipaviciene, 2010; M. H. Stone, M. Stone, & Sands, 2007). In addition, adolescents also spend more time in activities with low level of dynamic movement (US Department of Health and Human Services, 1996; Bouchard & Rankinen, 2001; Doherty, 2003). It is not completely clear yet what effect age has on fatigue. Children often show a lower level of fatigue than adults (Kanehisa, Yata, Ikegawa, & Fukunaga, 1995; Streckis, Skurvydas, & Ratkevicius, 2007). Most fatigue tests are based on muscle strength or capacity measurements while performing high-intensity exercises. An ability to activate skeletal muscles can be of great importance to fatigue during this kind of exercises (Gandevia, 2001; Streckis et al., 2007; Skurvydas, Brazaitis, Venckunas, & Kamandulis, 2011a). The research investigation discovered that voluntary activation results of adolescents are controversial, additionally, it is known that adolescents show different response to central fatigue compared to adults (Blimkie, Sale, & Bar-Or, 1990; Stackhouse, Binder-Macleod, & Lee, 2005; Streckis et al., 2007; Skurvydas et al., 2011b). For these reasons, the problem remains relevant in the international scientific literature about human physical fatigue, otherwise known as muscle fatigue. Although the world literature studies target to establish guidelines for health and adequate physical loads for children and adolescents, these studies have limiting factors due to different methodologies (Brener et al., 2004; Department of Health, 1997; Gregory et al., 2000; Grunbaum et al., 2004). Moreover, what nature, intensity and duration of physical exercise are sufficient for adolescents to ensure the adequate development of their body and good health, and what exercise may result in the occurrence of fatigue has not been determined yet. On the basis of the above-mentioned findings we set the aim of the study – to assess the impact of single bout of physical exercising of different intensity on adolescents' body balance and muscular strength.

METHODS

Research sample. Thirty healthy and physically active adolescents voluntarily agreed to participate in our study. The age of research sample was between 11 and 13 years. The study included 14 boys (height 171.6 ± 6.2 cm, weight 59.2 ± 4.3 kg) and 16 girls (height 169.0 ± 6.6 cm, weight 50.6 ± 6.4 kg). The participating adolescents were physically active and attended physical education lessons twice a week.

Body Balance. For the assessment of the research subjects' balance, the tenzoplatform "KISTLER" and computer equipment for signal records were used (Cesnaitiene et al., 2010). Balance was recorded during quiet stance of 30 s with eyes open, looking straight to the selected point at the eye level at a 2-meter distance, arms at sides. After that, the same procedure was performed with eyes closed. Balance assessment tests of the research participants were carried out before and after physical exercise.

Assessment of Maximal Voluntary Contraction (MVC). The maximum voluntary contraction (MVC) of quadriceps femoris was assessed using the *Biodex* isokinetic dynamometer performing two repetitions of 3 s, with a two-minute rest between them. Lower limb bending angle was 120 °.

Measuring of heart rate. During exercise, the pulse frequency of the subjects was strictly controlled using the "Polar RS800CX" heart rate monitor. Heart rate (HR) limits of each participant were determined individually and not exceeded during the physical exercise.

Physical Exercise. The research subjects were divided into two groups. The first group of the subjects performed a high-intensity continuous 30 min exercise. Heart rate (HR) was over 70% (no less than 150 beats/min) of maximum individual pulse rate. The second group of the subjects performed a low-intensity 30-minute exercise. Their HR did not exceed 70% (up to 150 beats/min) of the maximum heart rate of an individual. The single bout of physical exercising was carried out by climbing up and going downstairs continuously. The subjects were strictly monitored; each had to climb the stairs meeting HR standards.

Experimental protocol. The measurements were carried out at the same time of day. The anthropometric measurements were performed at the beginning of the research. Later, balance test, using the Kistler's tenzoplatform, was carried out. After the warm up with the veloergometer (20–30 W power for 10 minutes, HR – 120 to 145 beats/min), the maximum voluntary contraction (MVC) was estimated using the dynamometer. After the initial measurements, the physical exercises of the required duration and intensity were carried out (see section „physical exercise"). After the exercise, when the HR recovered to the resting level, the balance and MVC tests of the subjects were performed repeatedly.

Analysis of Statistical Data. Data analysis was performed using the Statistical Package for Social

Sciences (SPSS), program 17 version. The study data was processed determining the arithmetic means of the research group (*x*), the dispersion was evaluated in association with standard deviations (*S*). The significance of the group mean differences (*p*) was evaluated using the Student (*t*) criterion. The differences between the means were considered statistically significant when $p < .05$.

RESULTS

Dynamics of MVC. Prior to the high-intensity physical exercise, it was found that the MVC of girls was 160.7 ± 50.8 N · m. After the MVC test the girls performed the high-intensity continuous 30 min exercise. The exercise intensity was 70–89% of the individual maximal heart rate (HR). The analysis of heart rate indicators showed that the girls' average HR was 169.6 ± 10.2 beats/min. It was also found that the girls climbed stairs (up and down) 13.9 ± 1.9 times on average, and one rise-descent took an average of 2.15 ± 0.45 min. After the exercise the subjects performed MVC test repeatedly. It was discovered that after the high-intensity exercise the girls' MVC slightly increased to 169.1 ± 50.9 N · m, but no statistically significant difference was observed ($p > .05$).

The analysis of 11 to 13-year-old girls' MVC test results before the low-intensity physical activity determined that the girls' MVC was 171.1 ± 47.9 N · m. After the MVC test the girls performed the continuous 30 min exercise of low-intensity. The exercise intensity was not more than 70% of the individual maximal heart rate. The analysis of HR indicators showed that girls' average HR was 146.3 ± 9.5 beats/min. It was also identified that during exercise the girls climbed the stairs (up-down) 7.5 ± 2.2 times on average. One rise-descent took an average of 4.09 ± 0.35 min. After the low-intensity continuous exercise the subjects' MVC test was re-done. The evaluation of MVC test results of the participants after the exercise demonstrated no statistically significant change in the force 172.9 ± 49.9 N · m (Figure 1).

The analysis of 11–13- year-old boys' MVC test results prior to the high-intensity exercise showed that the boys' MVC was 238.9 ± 47.5 N · m. After the MVC test performance the boys performed the high-intensity continuous 30 min exercise. The exercise intensity was 70–89% of the individual maximal heart rate. The analysis of HR indicators showed that the boys mean HR after the high-intensity exercise was 165.9 ± 11.4 beats/min. It was also found that the boys climbed the stairs up and down an average of 14.3 ± 2.1 times during the 30 min exercise. One rise-descent took an average of 2.09 ± 0.37 min. After the intense continuous exercise the subjects' MVC test was re-done. It was identified that after exercise the boys' MVC rose to 239.6 ± 49.8 N · m, with no statistically significant difference between the loads.

Before carrying out the low-intensity physical exercise, it was found that boys' MVC was 247.4 ± 50.1 N · m. After the MVC test the boys performed the continuous 30 min exercise of low-intensity. The exercise intensity was not more than 70% of the individual maximal heart rate. The analysis of HR indicators showed that the boys' average HR

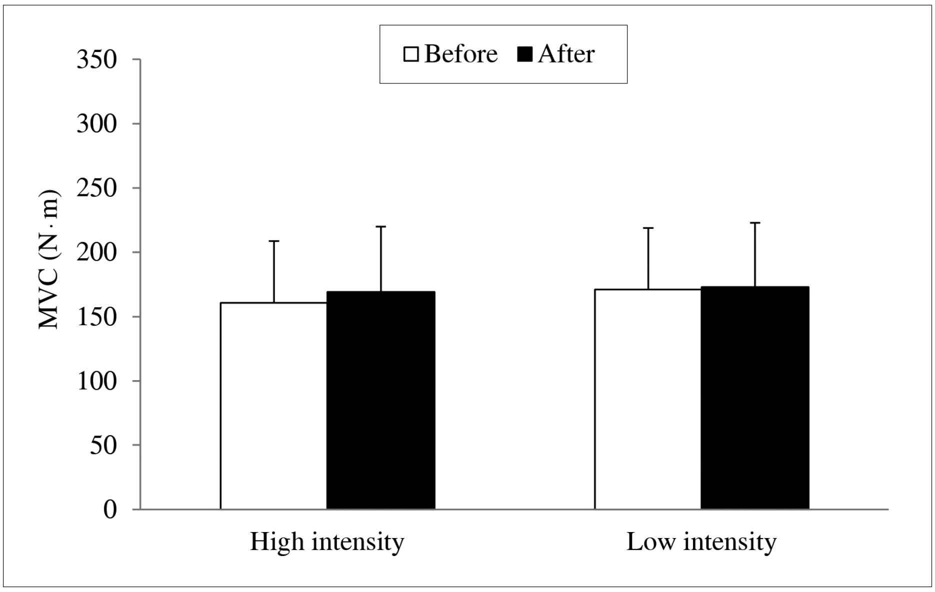


Figure 1. **Girls' MVC test results before and after high and low intensity exercise**

was 143.4 ± 9.8 beats/min during the low-intensity exercise. It was also discovered that during exercise the boys climbed the stairs up and down an average of 7.9 ± 1.9 times, and a rise-descent took an average of 3.8 ± 0.29 min. After the exercise the MVC test was re-done. The evaluation of the MVC of the subjects after the low-intensity exercise showed that the force did not change statistically significantly – 255.9 ± 50.2 N·m (Figure 2).

Dynamics of balance abilities. The body balance test was performed while the subjects were standing on both legs for 30 s with eyes open and 30 s with eyes closed before and immediately after the performed exercise. Eyes open and eyes closed test results were compared with the results before and after the exercise, the difference between the postural body sway with eyes open and eyes closed was also examined. The research results are presented in the graphs (Figure 3, Figure 4) below.

After analysing the girls' body balance results before and after the low-intensity exercise it was found that the postural sway with eyes open before the exercise was equal to 0.81 ± 0.29 mm/s, and after exercise it was 1.35 ± 0.42 mm/s. During the test with closed eyes the girls' postural sway before the exercise was 1.3 ± 0.55 mm/s and after the exercise the result changed to 1.38 ± 0.56 mm/s. However, these variations were not statistically significant (Figure 3). Comparing the girls' postural sway difference between the test with eyes open

Figure 2. **Boys' MVC test results before and after high and low intensity exercise**

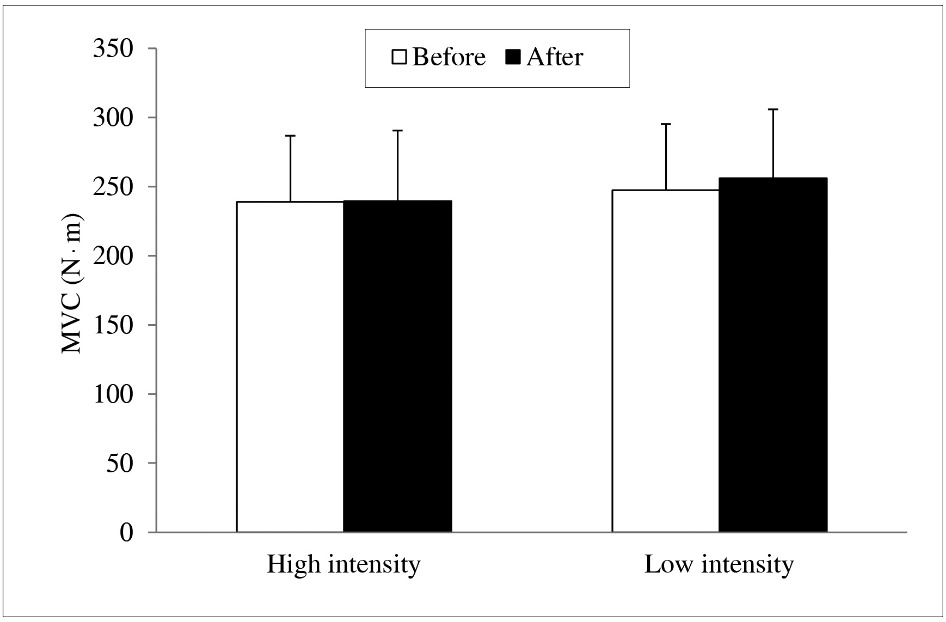
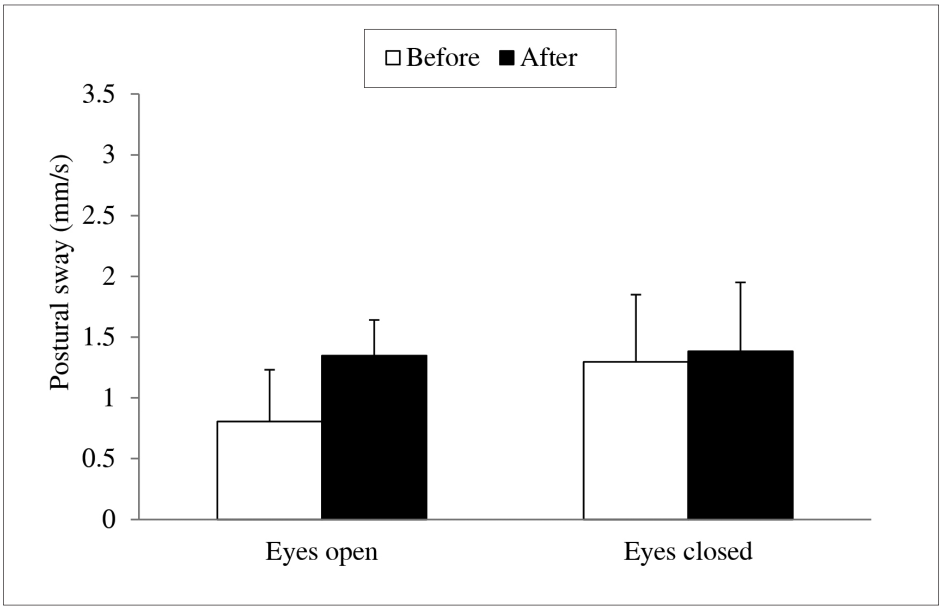


Figure 3. **Girls' body balance test results with eyes open and eyes closed before and after low-intensity exercise**



and with eyes closed it was determined that before the low-intensity physical exercise the difference between these tests was equal to 0.53 mm/s. After the exercise, the difference between the eyes open test and eyes closed test changed to 0.09 mm/s, but it is not statistically significant as well.

The analysis of the girls' body balance test results before and after the high-intensity physical exercise showed that the postural sway with eyes open changed from 1.02 ± 0.35 to 1.19 ± 0.43 mm/s. Meanwhile, the girls' postural sway with eyes closed after the high-intensity exercise significantly increased from 1.29 ± 0.65 to 2.75 ± 0.58 mm/s ($p < .05$). The comparison of the girls' body balance test results with eyes open and eyes closed showed that prior to the high-intensity physical activity the difference between the girls' postural sway with eyes open and eyes closed was only 0.17 mm/s (Figure 4). However, after the high-intensity exercise a significantly higher postural sway was identified – 1.46 mm/s performing the eyes closed test ($p < .05$).

The analysis of the boys' body balance test results before and after low-intensity exercise showed that the postural sway with eyes open was equal to 1.05 ± 0.57 mm/s before the load, and after the exercise the fluctuation changed to 1.64 ± 0.59 mm/s. Meanwhile, the boys' postural sway with eyes closed before the load was 1.42 ± 0.65 mm/s and after the physical exercise the result altered

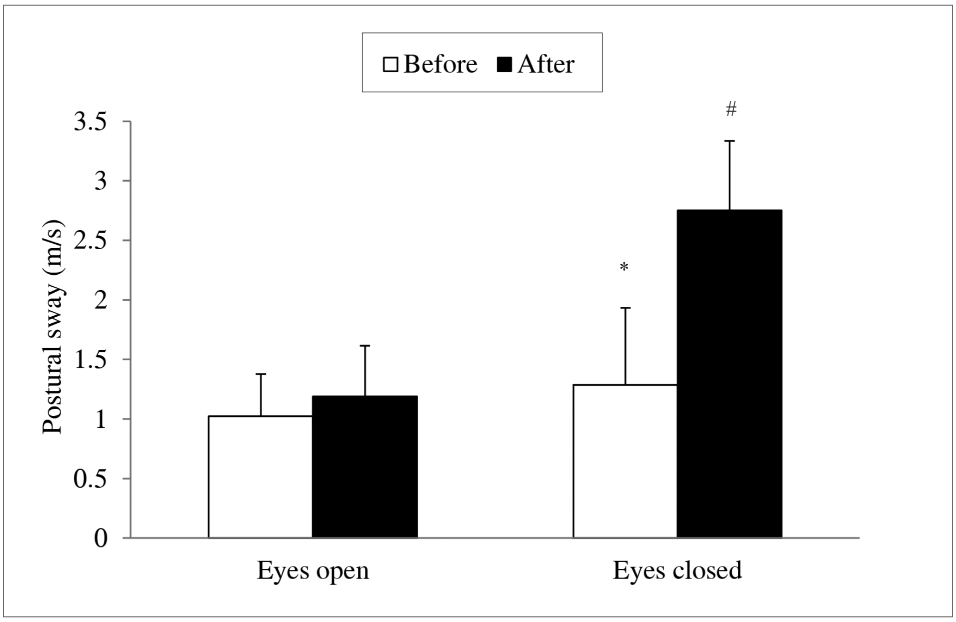


Figure 4. **Girls' body balance test results with eyes open and eyes closed before and after high-intensity exercise**

Note. * – $p < .05$, comparing tests before and after exercise; # – $p < .05$, comparing eyes open and eyes closed tests.

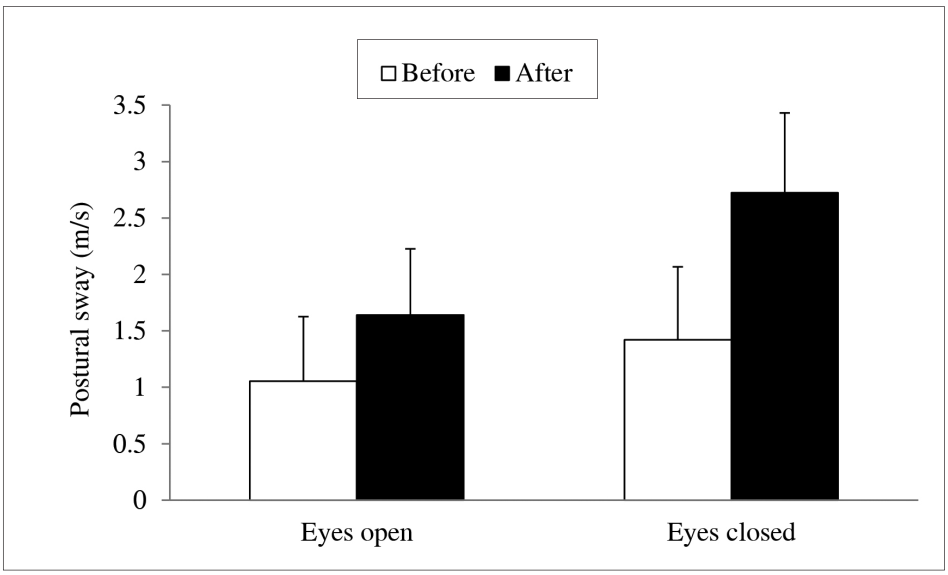
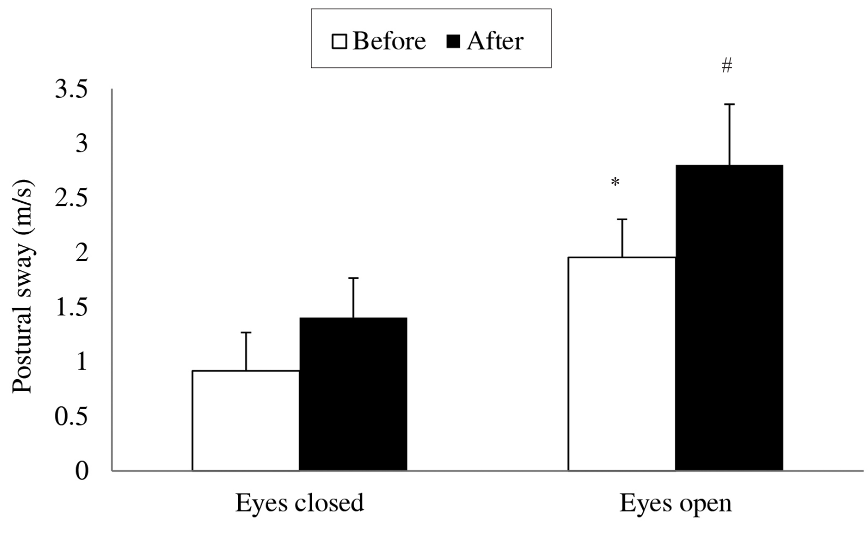


Figure 5. **Boys' body balance test results with eyes open and eyes closed before and after low-intensity exercise**

Figure 6. **Boys' body balance test results with eyes open and eyes closed before and after high-intensity exercise**



Note. * – $p < .05$, comparing tests before and after exercise; # – $p < .05$, comparing eyes open and eyes closed tests.

to 2.72 ± 0.70 mm/s. However, these variations were not statistically significant. Comparing the difference between the boys' postural sway test with eyes open and eyes closed provides that before a low intensity physical exercise the difference between these tests was equal to 0.37 mm/s. After the exercise, the difference between eyes open and eyes closed tests increased to 1.08 mm/s, but this is not statistically reliable as well (Figure 5).

Comparing the boys' body balance before and after high-intensity physical exercise (Figure 6) it was determined that the postural sway with eyes open did not change significantly from 0.92 ± 0.49 to 1.40 ± 0.36 mm/s. Meanwhile, the boys' postural sway with eyes closed after high-intensity exercise increased statistically significantly from 1.95 ± 0.56 to 2.80 ± 0.61 mm/s, ($p < .05$). The comparison of the body balance test results with eyes open and eyes closed showed that prior to high-intensity exercise the postural sway with eyes closed was 1.04 mm/s, significantly higher than in the eyes open test ($p < .05$). Moreover, after high-intensity exercise, the girls alike, and a significantly higher postural sway in the eyes closed test was determined – 0.68 mm/s, ($p < .05$).

DISCUSSION

Our research aim was to investigate the impact of one-time continuous physical exercise of different intensity on adolescents' body balance and force. The main finding of this study was that one-time low and high intensity continuous 30-minute physical exercise had no impact to the adolescents' maximum voluntary contraction, but it influenced their body balance with eyes closed.

Jansen and LeBlanc (2010) argue that the benefits of physical activity in adolescents' health can be achieved by actively moving 30 minutes a day on average. However, according to the recommendations of the World Health Organization (WHO) (2010) children and adolescents should be physically active for at least 60 minutes a day. The activity rate for children and adolescents can be achieved by accumulating and summing the different duration and type of physical activities. Even so, physical activity is recommended in no shorter than 5-minute intervals, but high-intensity physical exercise may be too strenuous for less active children and adolescents (Jansen & LeBlanc, 2010).

As we have noted above, there is a relevant problem of significant reduction in human physical activity (Bouchard & Rankinen, 2001; Doherty, 2003; Fitts, 2003; Telama et al., 2005; Westerståhl et al., 2005), which leads to large decreases in muscle mass and strength, as well as increased fatigability due to changes in muscle metabolism (Bloomfield, 1997; Rimmer, Schiller, & Chen, 2012). For this reason, we expected that the exercise intensity and duration would cause motor system fatigue which will lead to a fall in MVC and increased body sway. As the adolescents' MVC did not change after low-intensity exercise, we can assume that the low-intensity exercise assigned to the subjects was insufficient in its duration and intensity to affect their MVC. It would be informative to examine the adolescents' MVC after the longer-term continuous low-intensity physical load to assess the appearance of motor fatigue.

Nevertheless, the high-intensity physical activity did not affect the MVC results of adolescents either. Although Baker, Kostov, Miller, and Weiner (1993) state that the 15- to 20-minute exercise with intervals results in the adults' MVC reduction and slow force recovery, we can assume that 30 minutes of high-intensity physical activity was not sufficient to induce a decrease of MVC in physically active adolescents. It is also likely that fatigue could occur after a while, as the eccentric exercise can delay muscle pain, fibre injuries and reduce muscular functional capacities (Clarkson & Hubal, 2002; Streckis, Skurvydas, & Ratkevicius, 2005; Streckis et al., 2007). According to the WHO recommendations, the high-intensity physical activity for children and adolescents should not exceed 30 minutes per day, for this reason we could not evaluate the MVC after the longer-term continuous high-intensity physical load.

The result analysis after low-intensity exercise, the body balance results of adolescents with open and closed eyes remained unchanged in comparison with the testing carried out before the load. We believe that low-intensity 30-minute physical activity was insufficient to impact the amplitude of postural sway as well as the MVC of physically active adolescents. It is known that lower extremities are commonly used for locomotion and posture control – tasks that do not normally require fast contractions (Hirschfeld, 2007). There is no occurrence of motor fatigue testing the adolescents' MVC variations after low and high-intensity exercise, so absence of body balance alterations is not surprising.

However, the question remains why increased adolescents' postural sway in test with closed eyes after high-intensity physical load. While the body balance with eyes open after the 30-minute high-intensity exercise did not change, but an increased postural sway was observed during the test with eyes closed. Similar results were recorded by other scientists (Cesnaitienė et al., 2010; Skurvydas et al., 2010). Katayama et al., (2004) found that the lack of visual information while standing with both legs together leads to the 1.5-time increase in the amplitude of sway. Diener, Dichgans, Bruzek, and Selinka (1982) also discovered that vision was an important factor in the most effective stabilization of balance. The increased postural sway after high-intensity exercise can be influenced by the onset of motor system fatigue (Cesnaitienė et al., 2010; Skurvydas et al., 2010), decreased concentration and increased muscle activation (Streckis et al., 2005; Streckis et al., 2007). Moreover, there is a possibility that high-intensity physical activity affected the ear vestibular apparatus, which changed the balance results with eyes closed (Skurvydas et al., 2010).

CONCLUSIONS

Acute effect to continuous exercising of low or high intensities did not affect the muscular strength of adolescents but deteriorated their body balance. The greater effect on balance was found out while performing the balance task with closed eyes.

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Corresponding author **Lina Kreivėnaitė**
Lithuanian Sports University
Sporto str. 6, LT-44221 Kaunas
Lithuania
Tel. +370 619 62454
E-mail lina.kreivenaite@lsu.lt

INDICATORS OF BODY RESERVE OPPORTUNITIES FOR YOUNG GYMNASTS AS ONE OF THE FACTORS FOR SUCCESSFUL DEVELOPMENT OF INITIAL SPECIALIZED TRAINING

Zinaida Kuznetsova, Ilshat Dauletshin, Stanislav Kuznetsov
Povolzhskaya State Academy of Physical Culture, Sport and Tourism, Naberezhnye Chelny, Russia

ABSTRACT

Background. The article deals with the problem of selection in gymnastics and the reasons why it is necessary to research that. Artistic gymnastics carries the heaviest losses on the initial stages of specialized training, which explains the lack of science-based regulatory requirements in the gymnastics system, allowing diagnosing, assessing and predicting the development of the main indicators of physical condition and fitness of athletes in complex.

Research aim was to develop additional criteria of young gymnasts' selection at the initial stage of specialized training on the basis of the indicators of human body reserve opportunities.

Methods. Experimental work was carried out with gymnasts aged 9 years (n = 15) and 10 years (n = 16) in the research laboratory of Povolzhskaya State Academy of Physical Culture, Sport and Tourism and sports complex "Yar Chally" in Naberezhnye Chelny, Republic of Tatarstan (Russia).

Results. Gymnasts aged 9–10 years had a harmonious type of power supply of the body: more gymnasts had aerobic-anaerobic type of muscular activity power supply. Gymnasts who qualified in the obligatory program of category 3 on pommel horse equally represented only the second and the third biological groups.

The results of correlation analysis suggest that for gymnasts aged 9 years, the most significant factors affecting their special physical and technical fitness included aerobic capacity source of muscle activity energy supply and general metabolic capacity and for gymnasts aged 10 years – capacity and anaerobic power glycolytic sources of energy and muscular activity.

Discussion and conclusions. Obtained information on the preferred for gymnastics bioenergy groups can help coaches in predicting abilities of young gymnasts.

Keywords: sportspeople, gymnasts, selection, model descriptions, indicators of reserve opportunities.

INTRODUCTION

The problem of the scientific substantiation of selection and orientation in sports has always existed in our country and abroad (Melikhova, 2007; Rozin & Mukambetov, 1980; Rozin, 2001; Shlemin & Bril, 1978; Smolevsky, 2005). The solution of this problem allows reducing the time of high-class athlete training, giving them thus a longer period for performance in the international arena (Lebedev & Rozin, 1981; Melikhova, 2007; Vasilchuk & Gaverdovskiy, 1985).

Prevailing training and technology in Russian gymnastics should be improved in line with the trends of gymnastics (Arkaev & Rozin, 1999). It should be noted that this provision applies fully to the technology of selection and sports orientation in the gym. We suggest the following main reasons for the need to improve methods of selection and sports orientation of young gymnasts.

First, at present almost all competitions in gymnastics among children are conducted following the mandatory programs approved by the Russian Federation of Gymnastics, which is a set of required elements for each type of all-around gymnastics and gymnasts (Grigoryants, 2005).

Secondly, the recently adopted rules allow gymnasts to compete specializing in individual events (Green, 2006; Kirk Seeley & Bressel, 2005; Marinšek & Čuk, 2010). Results of the 2004 Olympic Games in Athens showed that most successful among men were gymnasts-“specialists”. Smolevsky (2005) claims that the rules can be criticized from the standpoint of events and overall achievements of prestigious teams, but among the winners there were athletes over 25 years of age, and the gold medals for men were won by representatives from eight out of eight different countries. According to the scientist, position of the International Gymnastics Federation (FIG) is unlikely to change in the foreseeable future and this fact should be considered when developing a strategy and tactics for gymnasts’ long-term training.

Aforementioned facts prove the relevance of the problem and the need for additional selection criteria in gymnastics.

Research aim was to develop additional criteria of young gymnasts’ selection at the initial stage of specialized training on the basis of the indicators of the body reserve opportunities.

Research objectives were as follows:

1. To study the indicators of body reserve opportunities for gymnasts qualified in junior categories I and III.
2. To identify the features of body reserve opportunities typical of young gymnasts.

METHODS

Methods of research chosen were theoretical analysis and synthesis of research literature, pedagogical experiment, medical and biological methods (computer technique “D&K-TEST”), testing of specific physical (SPF) and technical fitness (STF), and methods of mathematical-statistical data processing.

Experimental work was carried out with gymnasts aged 9 years (n = 15) and 10 years (n = 16) in the research laboratory of Povolzhskaya State Academy of Physical Culture, Sport and Tourism and sports complex “Yar Chally” Naberezhnye Chelny, Republic of Tatarstan, Russia.

Computer technique “D&K–TEST” was used to analyse the following indicators: the ANAMV – anaerobic metabolic volume; AMV – aerobic metabolic volume; GMV – general metabolic volume; PCP – the power creatine phosphate source of energy supply; PGL – the power glycolytic source of energy supply; MASES – the power aerobic source of energy supply (maximum oxygen consumption); W ANMT – anaerobic metabolism threshold; heart rate ANMT – criterion of efficiency of the use of aerobic source.

The percentage of the ANAMV and AMV indicates five bioenergy types: aerobic type of power supply for muscular activity, aerobic-glycolytic type of power supply for muscular activity, aerobic-anaerobic (mixed) energy supply for the optimal level of muscle activitiy, anaerobic-aerobic type with a high level of anaerobic energy for muscle activity, anaerobic type with the highest level of anaerobic energy for muscle activity.

The first group includes athletes with ANAMV (1–11%) and AMV (89–99%), the second group – with ANAMV (12–20%) and AMV (80–88 %), the third group – with ANAMV (21–29%) and AMV (71–79%), the fourth group includes athletes with ANAMV (30–38%) and AMV (62–70%) and to the fifth group – athletes with ANAMV (39–83%) and AMV (17–61%) (Dushanin, 1986; Gibadullin, 2009; V. P Karlenko & N. V. Karlenko, 2003).

RESULTS

The study of reserve opportunities in gymnasts’ bodies revealed that among 9-year-olds, 20% of them belong to the second bioenergy group with a predisposition for aerobic work, 66.7% belong to the third bioenergy group with a predisposition equal to both aerobic and anaerobic work, and 13.3 % belong to the fourth bioenergy group with a predisposition to anaerobic work. As for 10-year-old gymnasts, 25% of them belong to the second group, 56.2% – the third group, and 18.8% – the fourth group. Summarizing the data for all ages, we identified 22.6% of the research participants who belong to the second group, 61.3% of them in the third group, and 16.1% – in the fourth group. Among the young gymnasts, there were no representatives in the first and the fifth biogroups (Figure 1).

Table. **Indicators (X ± σ) of body reserve opportunities for young gymnasts**

Age	ANAMV	AMV	GMV	PCP	PGL	MASES	W ANMT	Heart rate ANMT
9 years	89.8 ± 20.6	268.9 ± 18.7	358.7 ± 17.7	29.1 ± 5.5	35.8 ± 4.3	75.0 ± 3.9	67.7 ± 3.0	178.6 ± 5.2
10 years	75.4 ± 18.5	246.5 ± 23.7	321.9 ± 28.1	30.9 ± 3.9	31.8 ± 7.5	69.8 ± 4.1	68.9 ± 5.0	170.6 ± 5.2

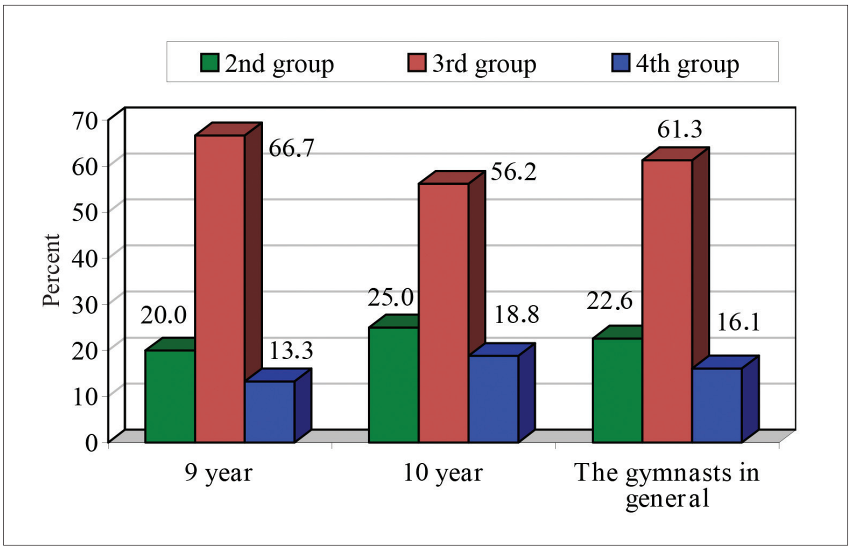

Figure. **The distribution of bioenergy groups among 9–10-year-old gymnasts**

Our research data obtained indicate that 9-year-old gymnasts in the third biogroup can more easily meet the special requirements for the types of all-around gymnastics. Among the 10-year-old gymnasts in all kinds of Multi-Athlon, except exercises on pommel horse, there is a dominance of the third biogroup compared to the second biogroup. Gymnasts who were in compliance with the mandatory requirements of the program on the pommel horse equally represented the second and the third biogroups.

The total analysis of the data for all ages showed that among the young gymnasts mandatory program for all kinds of gymnastics was more accessible by members in the third biogroup.

Next, we consider the results of the correlation analysis between indicators of body reserve opportunities and SPP and STP indicators among the gymnasts aged 9–10 years.

Among 9-year-old gymnasts, reliable correlation values were found in the following pairs:

- ANAMV in combination with the results of the test "circles" ($r = -.66$);
- AMV in combination with "Swiss press to handstand" test results ($r = -.63$);
- GMV in combination with "Swiss press to handstand" test results ($r = -.54$), "hanging scale rearways (back lever)" ($r = -.62$), "circles" ($r = -.63$); "handstand" ($r = .67$), STP on the pommel horse ($r = -.58$);
- MASES in combination with "climbing on a rope" test results ($r = .77$), "V-sit" ($r = -.60$), "Swiss press to handstand" ($r = -.66$), "lifting force" ($r = -.52$), "hanging scale rearways (back lever)" ($r = -.75$), "handstand" ($r = -.57$).

For 10-year-old gymnasts, significant correlation values were found in the following pairs:

- ANAMV in combination with the "jump" test results ($r = -.51$), "climbing on a rope" ($r = .62$), "V-sit" ($r = -.68$), "Swiss press to handstand" ($r = -.54$), "lifting force" ($r = -.60$), "hanging scale rearways (back lever)" ($r = .89$), "circles" ($r = -.56$), "handstand" ($r = -.66$), STP on the floor exercises ($r = .59$), pommel horse ($r = -.54$), rings ($r = -.65$), parallel bars ($r = -.66$), the horizontal bar ($r = -.65$), and total STP ($r = -.69$);

- AM, combined with the results of the test "20 m run" ($r = -.57$);
- PCP combined with the "Swiss press to handstand" test results ($r = -.53$);
- PGL in combination with the results of the tests "20 m run" ($r = .53$), "Swiss press to handstand" ($r = -.56$), "hanging scale rearways (back lever)" ($r = -.56$), "handstand" ($r = -.56$), STP on the floor exercises ($r = -.56$), horizontal bar ($r = .61$) and total STP ($r = -.52$);
- W ANMT in combination with the results of the tests "20 m run" ($r = -.56$), "handstand" ($r = .53$), STP on the floor exercises ($r = .55$) and horizontal bar ($r = .60$).

DISCUSSION

Numerous studies of the authors (Dushanin, 1986; Gibadullin, 2009; V. P. Karlenko & N. V. Karlenko, 2003) allowed us to develop a new method for determining the functional capacity of aerobic and anaerobic components without the use of load tests. It was found that between the permeability of cell membranes of the myocardium, the slew rate of the transmembrane action potential in ventricular depolarization of the heart was recorded in a state of rest and the values of aerobic and anaerobic metabolism - in muscle activity of any orientation, length and intensity.

The basis for quick diagnosis of chest electrocardiogram in such leads as V_{3R}, V_1 and V_2, V_4, V_5, and V_6 in muscle at rest is registered. In each of them, R-wave amplitude (in mm) and S are measured and their percentages (R × 100) / (R + S) which allow defining various aspects of athlete functional performance are calculated.

This method of quick diagnosis enables to determine various aspects of functional and reserve capacity of athletes' bodies without complicated procedures and to keep records and control of the current operational status of athletes. During the diagnosis and mathematical calculations of adjustment of R and S electrocardiogram waves, researchers (Dushanin, 1986; V. P. Karlenko & N. V. Karlenko, 2003) have identified various functional parameters:

- The general metabolic capacity (GMV) shows a certain amount of aerobic (AMV) and anaerobic (ANAMV) metabolic volumes during muscular work with the intensity level of maximum oxygen consumption. The indicator shows a certain level of performance.
- Power creatine phosphate source of energy (PCP) is the fastest source of energy used by muscle cells from the beginning of muscle contraction. It occurs due to the high-energy phosphate compounds – creatine phosphate. This source of energy is characterized by the maximum possible rate movements. An athlete cannot perform such movements for more than 10 seconds. The creatine phosphate source has a maximum capacity in comparison with other systems. Maximum speed of energy production exceeds the capacity of the glycolytic system three times and the aerobic capacity of the system 4–10 times. Capacity creatine phosphate system is small and many times less than other systems. In the operation of this power, request of the total oxygen is small, but oxygen qcquisition time is significantly longer. Therefore, the work in this capacity is also anaerobic because re-synthesis of ATP oxygen is not involved. These indicators of power creatine phosphate source of energy prove the effectiveness of the use of tools and methods in the training process in the development of power as well as explosive speed and power abilities (Sandbakk, Holmberg, & Leirdal, 2010).
- The power glycolytic energy source (PGL) is characterized by anaerobic degradation reaction of glycogen. As a result of such reactions, lactic acid – lactate is formed. The totality of these reactions is called anaerobic glycolysis. This system is characterized by high energy capacity, i.e. a high rate of energy production. Power anaerobic-glycolytic energy source reaches a maximum only at work that lasts longer than 10–20 seconds. This system plays a crucial role in energy supply works very large capacity, which can last from 10 seconds to 2–3 minutes and is associated with strong muscle contractions. Power-anaerobic glycolytic power 1,5 times higher than that of aerobic, but 3 times lower than power creatine phosphate source. However, if to compare data capacity systems, the capacity of the glycolytic source is still above creatine phosphate source which is 2.5 times higher. The indicator assesses the effectiveness of the use of means and

methods for a certain period of training in the development of speed endurance.

- The power of aerobic energy source (MASES) depends on the level of maximal oxygen consumption (MOC) in the human organism as a whole. Maximum oxygen consumption is an indicator of aerobic performance of the body which is able to perform heavy work providing energy costs due to oxygen absorbed during operation. Therefore, in exercise endurance athletic performance is largely determined by aerobic capacity of an athlete that is largely dependent on the level of maximum oxygen consumption. This indicator is an expression of the community of many body systems (respiratory, cardiovascular, circulatory), and depends on factors such as partial pressure of oxygen in the inhaled air, ventilation, the rate of diffusion of gases from the lungs into the blood, the oxygen capacity of the blood, the volume rate of flow, arterial-venous difference, and the activity of oxidative enzymes (Mahood, Kenefick, Kertzer, & Quinn, 2001; Wagner, 1996).
- Efficient and economical use of aerobic source of energy is determined by indicators such as the threshold of anaerobic metabolism (W ANMT) and heart rate at the level of the threshold of anaerobic metabolism (heart rate ANMT). Anaerobic threshold characterizes the level of fitness of the body and the relationship between aerobic and anaerobic energy pathways of exercise. Its anaerobic threshold determines the quality and efficiency of aerobic system. Therefore, the higher the anaerobic threshold, the higher the fitness of the athlete is. The most informative determinant of the anaerobic threshold is heart rate ANMT. That is, the heart rate of the anaerobic threshold demonstrates the level of the aerobic capacity of athletes involved in cyclic sports. Most authors consider heart rate ANMT as most effective in the evaluation and planning of the intensity of training loads as it can be determined by heart rate ANMT transition boundary between aerobic and anaerobic processes. The higher the heart rate ANMT, the higher training intensity can be maintained according to the athlete. Therefore, knowing heart rate ANMT can most effectively allocate zone intensity training loads (Kachouri, Vandewalle, & Huet, 1996).

On the basis of numerous studies on this procedure, Dushanin (1986), V. P. Karlenko and N. V. Karlenko (2003) concluded that aerobic and anaerobic organism genotypes of athletes of all ages and specialties virtually are unchanged for a long time and are determined by metabolizer genotype. The results of years of research by the method of fast diagnosis "D&K-TEST" practice in training athletes showed that most high results were achieved by athletes who belonged to the fifth and the fourth bioenergy groups. Their best achievements were shown in individual programs. High achieving first, second and third groups are primarily part of the functional declines and breakdowns in crucial moments according to the statostics.

According to test results of "D&K-TEST", researchers (Gibadullin, 2009; Gibadullin & Kozhevnikov, 2010; Gizatullina, 2013; Khalikov, 2014; Kozhevnikov, 2010, 2011; Kugaevsky, 2009; Morozov, 2014) provided recommendations on the structure and content of sports training, on the basis of bioenergy groups of athletes. For the first bioenergy group, the authors recommended the optimal ratio of exercise on the stages of sports perfection and the annual cycle in the zones of intensity which were 90–95% (zones 1–3), and 5–10% (zones 4–5). For the second bioenergy group, the intensity of 75–80% in zones 1–3 and 20–25% in zones 4–5 was recommended. Athletes of the third bioenergy group were recommended the intensity of 70–75% in zones 1–3 and 25–30% in zones 4–5. The fourth bioenergy group was recommended the ratio of the intensity of 65–70% in zones 1–3 and 30–35% in zones 4–5. Athletes of the fifth group were recommended the intensity of 60–65% in zones 1–3 and 35–40% in the zones 4–5.

The selection system is shown as one of the contradictions of modern gymnastics: the struggle for mass sports, bringing to sport a number of studies dealing with them and, along with it, the professional selection of promising gifted athletes in the inevitable classifying contingent (Chernukhina, 2004; Čuk & Marinšek, 2013; Dauletshin, 2013; Rozin, 2001). Rozin (2001) emphasizes that gymnastics carries the heaviest losses in the initial stages of specialized training, which explains the lack of scientific-based regulatory requirements in the gymnastics system allowing diagnosing, assessing and predicting the development of the main indicators of physical condition and fitness of athletes in complex.

Gibadullin and Kozhevnikov (2010) emphasize that the existing methods of selection and control of the training process are the most efficient methods of Dushanin and Karlenko in the “Assessment and functional reserve capacity of the organism” – “D&K-TEST”. Further research is needed in this direction.

CONCLUSIONS

1. Gymnasts aged 9–10 years have a harmonious type of power supply to the body: more gymnasts have aerobic-anaerobic type of muscular activity power supply. Gymnasts who qualified in the obligatory program in category 3 on pommel horse equally represented only the second and the third biological groups.

2. The results of correlation analysis suggest that gymnasts aged 9 years employ the aerobic capacity source of muscle activity energy supply and general metabolic capacity, and gymnasts aged 10 years – the capacity and anaerobic power glycolytic sources of energy for their muscular activity.

The information obtained on the bioenergy groups preferred in gymnastics can help coaches in predicting the abilities of young gymnasts. Further research is needed in this direction.

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Corresponding author **Zinaida Kuznetsova**
Povolzhskaya State Academy of Physical Culture, Sport and Tourism
Naberezhnye Chelny, Batenchuk E. N. str. 21
423807, Russia, Republic of Tatarstan
Tel. (8552) 703645, 712422
E-mail kzm_diss@mail.ru

RATE OF INCREASE IN WORKLOAD DETERMINES THE MOBILIZATION RATE BUT NOT THE DEGREE OF INCREASE IN ECG PARAMETERS

Kristina Poderienė, Alfonsas Buliuolis, Vilma Papievienė, Jonas Poderys
Lithuanian Sports University, Kaunas. Lithuania

ABSTRACT

Background. The aim of this study was to compare the peculiarities of the dynamics of cardiovascular functional state indices during bicycle ergometry by applying the steep or slow increase in workload.

Methods. Twenty five males attending health promotion sport clubs took part in two cardiovascular testing procedures by performing graded exercise stress, i.e. increase in workload every 1 min, and increase in workload every 6 min, and they exercised till the inability to continue the task or unless distressing cardiovascular symptoms supervened; 12 lead ECG was recorded and analysed.

Results. The steep increase of registered cardiovascular parameters was observed at onset of exercising and the rate of was in dependence on the rate of the increase in workload. Registered maximal changes of heart rate, JT interval, and the ratio JT/RR as functional state indices at the moment of refusing to continue the graded exercise test were at the same level while applying the steep or slow increase in workload.

Conclusions. The rate of increase in workload determines the mobilization rate but not the degree of increase of ECG parameters. Maximal changes of heart rate, JT interval, and the ratio JT/RR as functional state indices at the moment of refusing to continue the graded exercise test were at the same level while applying the steep or slow increase in workload.

Keywords: cardiovascular system, graded exercise stress, functional state.

INTRODUCTION

At the onset of exercise a lot of body systems adapt to the variations of load. Consequently, a number of indices exist for the measurement of response of body functions to workload. In practice, the response to exercise can be evaluated by measuring the changes in the performance of one or another system (Cao et al., 2015; Giardini, Odendaal, Khambadkone, & Derrick, 2011; Hettinga, Monden, van Meeteren, & Daanen, 2014; Hughson & Tschakovsky, 1999; Roberts, 2014; Vainoras, 2002).

There are a lot of studies presenting the dynamics of cardiovascular indices during graded exercise stress (Alihanoglu et al., 2015; Ceci et al., 2013; Olson et al., 2012; Shin, J. I. Park, S. K. Park, & Barrett-Connor, 2014; Vainoras, 2002). Concerning the problem of evaluation of the peculiarities in mobilization of body functioning during exercising, the two factors are important: first, the velocity of adaptation at onset of exercise, and second, to what extent the body function was mobilised.

The various protocols for increase in workload during the graded exercise stress could be used. The steep increase in workload induces the faster development of fatigue while the slow increase in workload allows slow adaptation to exercising and demonstration of the best results of muscular performance (Dawson et al., 2005; Munch et al., 2014; Poderys, Buliuolis, Poderytė, & Sadzevičienė, 2005). The aim of this study was to compare the peculiarities in dynamics of cardiovascular functional state indices during bicycle ergometry by applying the steep or slow increase in workload.

METHODS

The participants of the study (males attending health promotion sport, $n = 25$) had spent 20 min seated and after registration the base-line values of cardiovascular indices underwent a 50 W increase in workload, i.e. graded exercise test (*bycicle ergometry*) and they exercised till the inability to continue the task or unless distressing cardiovascular symptoms supervened. The subjects underwent a 50W increase in workload every 60 seconds (60 revolutions/min). Two protocols for increase in workload were applied. First, increase in workload every 1 min, and the second, increase in workload every 6 min.

A computerized ECG analysis system "Kaunas-load" was applied for 12 lead ECG recording and analysis. The changes in heart rate (HR), JT interval, and in the ratio of intervals JT/RR were analysed. Standard ABP measurement was performed with pneumatic cuff by listening to "Korotkoff tones".

The significance of the difference between the values was evaluated by computing *t* criterion; the paired *t*-test was used. The difference has been considered statistically significant at $p < .05$ (95 CI).

RESULTS

Working capacity. The task for the participants of this study was to continue exercising as much as they can, i.e. till the inability to continue it. Table 1 presents the data of working capacity while the two incremental protocols were used. All the participants of this study were able to continue the task, i.e. to perform the exercise up to 250 W (5 min), some of them were able to perform the exercise at the stage of 350 W (up to 7 min) while the new stage of increased workload was 1 minute. While the new stage of increased workload was 6 minutes, all participants were able to perform the exercise up to 150 W (18 min), some of them were able to perform it at the stage of 350 W (up to 32 min).

Dynamics of cardiovascular indices. Figure 1 presents the dynamics of HR during the graded exercise test applying two protocols of the increase in workload. There were no significant differences ($p > .05$) between the initial values before exercising. The steep increase in HR was observed at onset of exercising and the rate of was in dependence on the rate of increase in workload. There were no statistically significant differences ($p > .05$) between maximal HR values registered at the end of the exercising (176.7 ± 3.9 beats/min while the increase in workload every 1 min was applied and 169.5 ± 4.6 beats/min while the increase in workload every 6 min was applied).

Table 1. **Working capacity while two different protocols for increase in workload was applied**

Indices	**Increase in workload every 1 min**								
Workload	50 W	100 W	150 W	200 W	250 W	300 W	350 W		
Total duration of exercising	1 min	2 min	3 min	4 min	5 min	6 min	7 min		
Number of participants	25	25	25	25	25	16	4		
	Increase in workload every 6 min								
Workload	50 W			100 W			150 W		
Total duration of exercising	2 min	4 min	6 min	8 min	10 min	12 min	14 min	16 min	18 min
Number of participants	25	25	25	25	25	25	25	25	25
Workload	200 W			250 W			300 W		
Total duration of exercising	20 min	22 min	24 min	26 min	28 min	30 min	32 min		
Number of participants	16	11	8	6	4	4	2		

Figure 2 presents the dynamics of JT interval of ECG during the graded exercise test applying two protocols of increase in workload. There were no significant differences ($p > .05$) between durations of JT intervals registered before exercising. At onset of exercising and the rate of changes was in dependence on the rate increase in workload. There were no statistically significant differences ($p > .05$) between the shortest JT interval values registered at the end of the exercising (0.162 ± 0.005 s while the increase in workload every 1 min was applied and 0.164 ± 0.004 s while the increase in workload every 6 min was applied).

Similar changes as a HR changes were find in comparison with the dynamics of the ratio of ECG intervals JT/RR during the graded exercise test applying two protocols of increase in workload. There were no statistically significant differences

Figure 1. **HR dynamics during the graded exercise test applying two protocols of increase in workload**

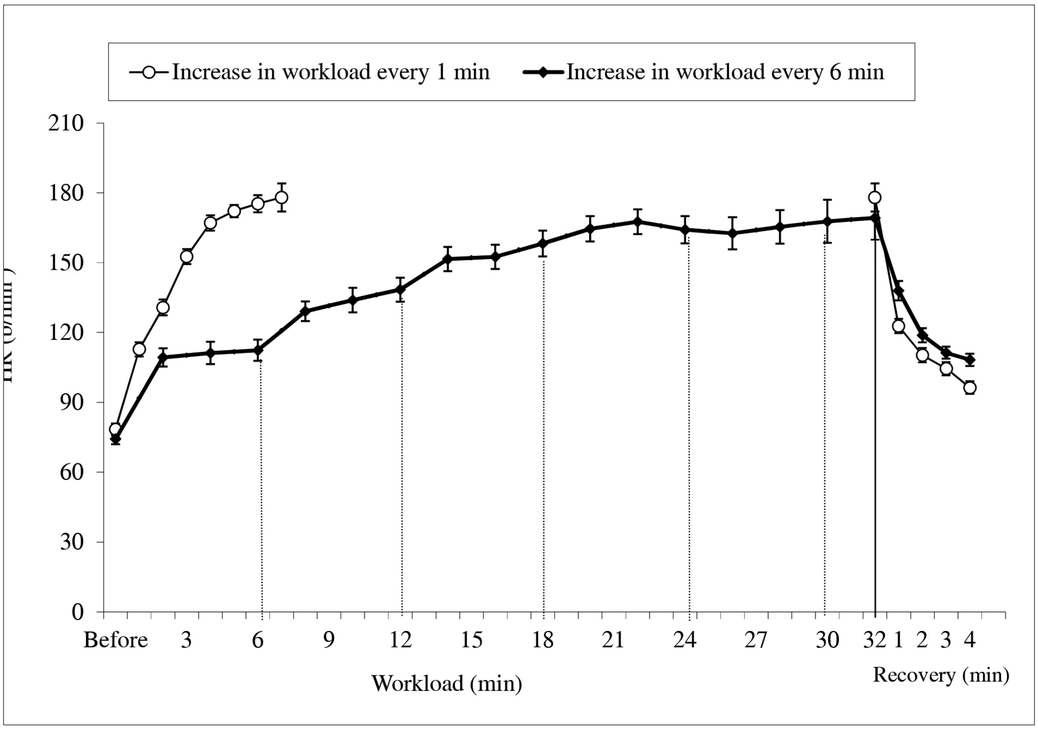
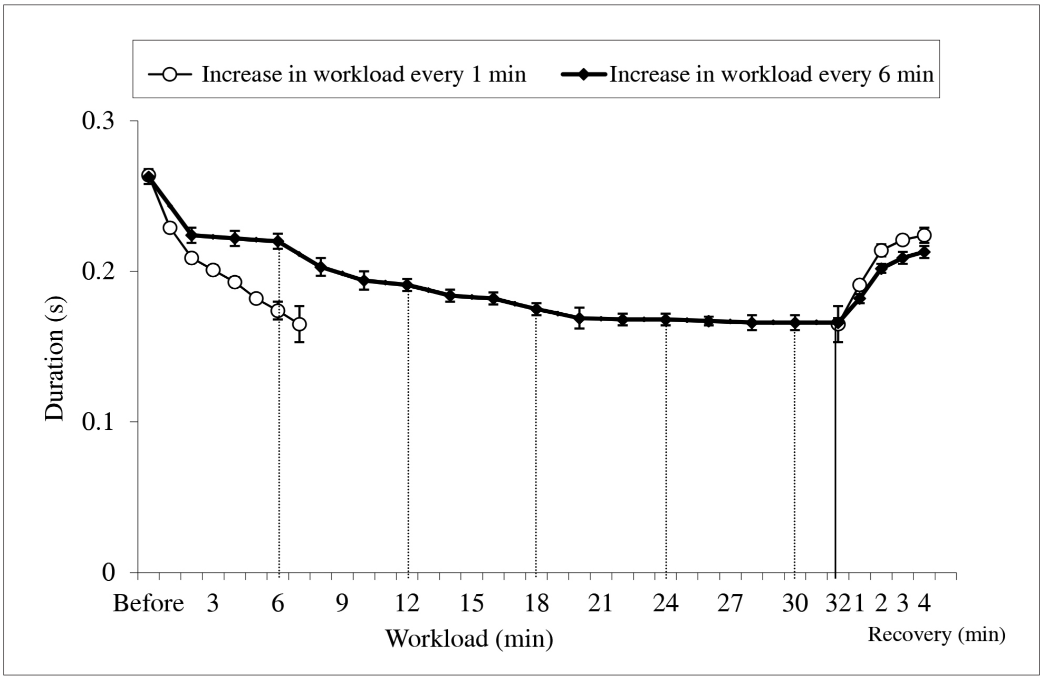


Figure 2. **JT interval dynamics during the graded exercise test applying two protocols of increase in workload**



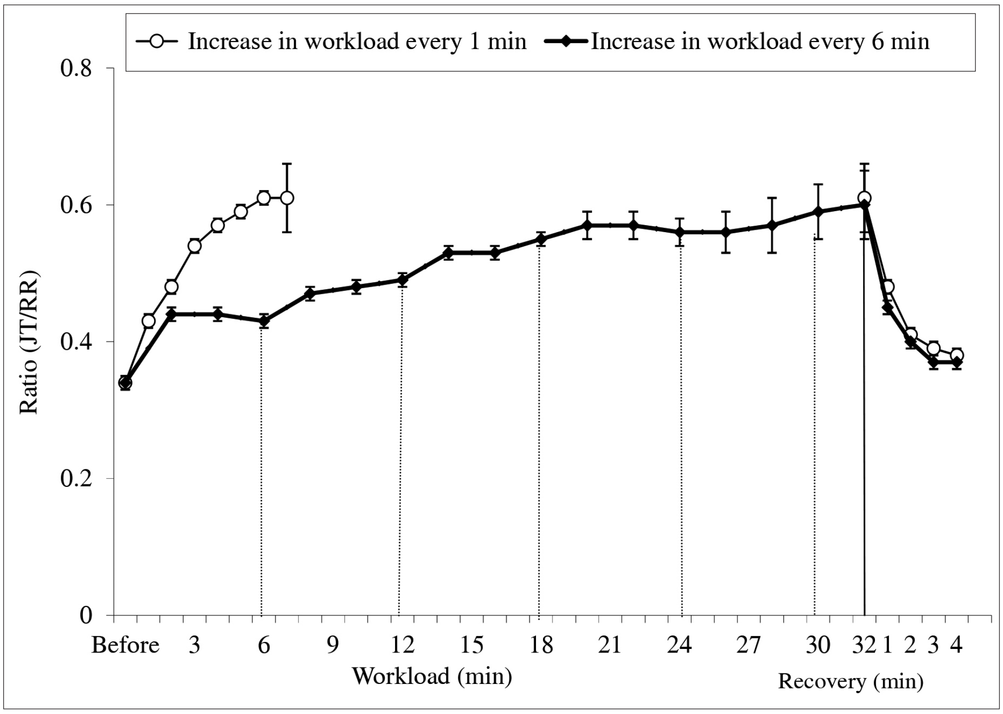


Figure 3. **Dynamics of ratio of ECG intervals JT/RR during the graded exercise test applying two protocols of increase in workload**

Table 2. **Values of ECG indices registered during the graded exercise stress while two different protocols were applied**

Indices	Before workload		At the end of workload	
	Increase in workload every 1 min	Increase in workload every 6 min	Increase in workload every 1 min	Increase in workload every 6 min
HR (beats/min)	78.5 ± 2.5	74.3 ± 2.2	176.7 ± 3.9	169.5 ± 4.6
JT interval (s)	0.264 ± 0.003	0.263 ± 0.005	0.162 ± 0.005	0.164 ± 0.004
JT/RR	0.342 ± 0.01	0.34 ± 0.01	0.610 ± 0.01	0.616 ± 0.04
Systolic ABP (mmHg)	124.0 ± 2.1	126.2 ± 2.1	185.8 ± 6.8	204.2 ± 6.3
Diastolic ABP (mmHg)	75.6 ± 1.5	77.6 ± 1.3	23.3 ± 5.6	29.2 ± 6.7
Total peripheral resistance (mmHg/l/min)	16.8 ± 1.3	16.0 ±1.4	3.8 ± 0.7	2.7 ±1.0

(p >.05) between the JT/RR values registered at the end of the exercising (0.610 ± 0.01 while the increase in workload every 1 min was applied and 0.616 ± 0.04 while the increase in workload every 6 min was applied).

In general, the dynamics of cardiovascular parameters while performing the graded exercise stress has the same tendency of stepwise changes with each new stage of workload. This tendency was strongly expressed during the first stages of workout and weakened when exercising became subjectively hard, i.e. during the last stages of workout. The values of cardiovascular indices registered at rest and at the moment of their maximal change, usually at the end of exercising, are presented in Table 2. As it was established during the analysis of figures presented in Table 2, a statistically significant difference was found (p < .05) while the values of systolic ABP at the end of exercising were compared. There were no significant differences observed between other registered ECG indices at the end of exercising.

DISCUSSION

Various indices for outlying cardiovascular response to exercising and physical exertion have been suggested; their applicability and value are widely discussed and analyzed in research literature (Boettger et al., 2010). Dynamics of HR during exercising is a commonly accepted measure of intensity of exercising and provides the clear understanding of the dynamics of functional state. HR is easily measurable index and various types of heart rate monitors have been widely used in sports for over 30 years (Achten & Jeukendrup, 2003). Some authors consider the HR response measurement as a convenient non-invasive evaluation tool to monitor and analyze individual workouts (Dellal et al., 2012; Hettinga et al., 2014; Jeukendrup & VanDiemen, 1998). Increases in the severity of exercise leads to increases in HR until it reaches its maximum, which is relatively constant in a particular person.

JT interval is not independent of the ventricular repolarisation pattern and can be used as an accurate means of estimating the duration of ventricular depolarisation (Banker, Dizon, & Reiffel, 1997; Chiladakis et al., 2012) and its changes interrelate with the intensity of heart metabolism (Vainoras, 2002). In some studies it was shown that the change in the ratio of JR/RR intervals of ECG allows assessing the dynamics of mobilization of cardiovascular system during the exercise tests or workouts (Ežerskis, 2005; Poderys et al., 2005; Žumbakytė-Šermukšnienė, Kajenienė, Vainoras, Berškienė, & Augutienė, 2010). The results obtained in this study confirm the same idea, i.e. the ratio of JT/RR can be useful for outlining to what extent the cardiovascular function was mobilised. As it was found during the incremental increase in workload (till the inability to continue the task), the ratio in JT/RR has varied very closely or even coincided with what was established by Boshkow (Бочков, 1986). According to Boshkow (Бочков, 1986), these biological constants can be expressed mathematically ($1/e = 0.368$ *and* $1–1/e = 0.632$). When performing dosed workloads (*Roufier test* – aerobic workout) and during 30-second all-out test in jumping (anaerobic workout), the changes in ratio of JT/RR were in dependence on the performance abilities (training experience) and functional state. This is evidence that the ratio of JT and RR intervals (JT/RR) of ECG provides the information concerning the dynamics of mobilization of cardiovascular system.

Changes of various cardiovascular indices during graded exercise stress could be useful for outlying the peculiarities of functioning and personal features of cardiovascular system (Alihanoglu et al., 2015; Ceci et al., 2013; Olson et al., 2012; Shin et al., 2014;Vainoras, 2002). The results obtained during this study showed that maximal changes of HR, JT interval, and the ratio of JT/RR as functional state indices at the moment of refusing to continue the graded exercise test were of the same level while applying the steep or slow increase in workload.

CONCLUSION

The rate of increase in workload determines the mobilization rate but not the degree of increase of ECG parameters.

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Corresponding author **Kristina Poderienė**
Lithuanian Sports University
Aušros str. 42, LT-44221 Kaunas
Lithuania
Tel. +370 30 26 74
E-mail k.poderiene@gmail.com

DOES SIMILAR WHOLE BODY COOLING INDUCE GENDER-SPECIFIC ATTENTION STABILITY DETERIORATION?

Rima Solianik, Albertas Skurvydas, Marius Brazaitis
Lithuanian Sports University, Kaunas, Lithuania

ABSTRACT

Background. There is evidence of greater whole body cooling induced unpredictable task switching and memory deterioration in men than in women; however, it is not known how whole body cooling affects attention stability. This study aimed at identifying if there are any gender-specific differences in the effect of cold water immersion-induced stress on attention stability.

Methods. Thirteen men and thirteen women were exposed to acute cold stress by immersion in 14°C water until rectal temperature reached 35.5°C or for a maximum of 170 min. Thermoregulatory response (i.e. changes of body temperature and metabolic heat production) and attention stability response (i.e. Schulte table (less cognitively demanding task) and Schulte-Gorbov table (more cognitively demanding task)) were monitored.

Results. During cold stress, body temperature variables decreased ($p < .05$) and did not differ between genders. Metabolic heat production was greater ($p < .05$) in men than in women. Body cooling significantly increased ($p < .05$) the duration of Schulte table performance for both genders, whereas an increase ($p < .05$) of the duration of Schulte-Gorbov table performance was observed only in men.

Conclusion. This is the first study to find the evidence supporting the idea of gender-specific and task-dependent attention stability response after whole body cooling. Whole body cooling induced stress had similar influence on simple attention stability task in men and women, whereas more complex task was adversely affected only in men. This greater men's decrement of complex task performance can be associated with their greater catecholamines-induced metabolic heat production.

Keywords: men, women, cognitive performance, metabolic heat production, shivering.

INTRODUCTION

It is well established that exposure to a whole body (peripheral and central) cooling induced stress impairs cognitive performance and shows a dose-response relationship between decreased cognitive performance and core body temperature (Palinkas, 2001). The adverse effect of marked core cooling as a decreased vigilance, attention and memory can be observed (Brazaitis et al., 2014b; Coleshaw, van Someren, Wolff, Davis, & Keatinge, 1983; Giesbrecht, Arnett, Vela, & Bristow, 1993; Lockhart, Jamieson, Steinman, & Giesbrecht, 2005; Mäkinen et al., 2006; Palinkas, 2001; Solianik, Skurvydas, Vitkauskienė, & Brazaitis, 2014b). Furthermore, it is suggested that cold-induced cognitive perturbations are task-dependent (Giesbrecht et al. 1993; Mäkinen, 2007). It seems that especially simple cognitive tasks are adversely affected by cold, while more complex tasks performance may even improve upon short-term exposure (Giesbrecht et al., 1993; Mäkinen, 2007) and decline following central body cooling of 2–4˚C (Giesbrecht et al., 1993).

A recent study showed that during whole body cooling strategies of physiological adjustments to cold stress differ between men and women, i.e. men are more reliant on metabolic strategy, including shivering thermogenesis (Solianik et al., 2014b). It is well established that metabolic heat production (MHP) and shivering is aided by catecholamines (Banet, Hensel, & Liebermann, 1978; Maggs, Gallen, Fone, & Macdonald, 1994), whose response is greater during cold exposure in men than in women (Solianik et al., 2014b; Wagner, Horvath, Kitagawa, & Bolduan, 1987). It is suggested that cold-induced catecholamines dysregulation reduces cognitive function; particularly, catecholamines are important for tests involving complex attentional functions (Hyafil, Summerfield, & Koechlin, 2009). According to previously mentioned MHP and shivering differences between men and women, we hypothesized that men would have greater cognitive function alteration then women, especially during more complex task performance.

Shansky and Lipps (2013) stated that most research is conducted in men, and thus our general understanding of the effects of stress on cognitive function is in the context of the men's brain. There is evidence of greater whole body cooling induced unpredictable task switching and memory deterioration in men than in women (Solianik, Skurvydas, Mickevičienė, & Brazaitis, 2014a), however it is not known how whole body cooling affects attention stability in men and women. Thus, the aim of the research was to identify if there are any gender-specific differences in the effect of cold water immersion-induced stress on attention stability.

METHODS

Participants. The criteria for inclusion were: age 18–25 years; no excessive sport activities, i.e. < 3 times per week; no involvement in any temperature-manipulation program or extreme temperature exposure for ≥ 3 months; non-smokers; and no medications (including oral contraceptives) that could affect natural thermoregulation. Participants were excluded from the study if they had Raynaud's syndrome, asthma, neurological pathology, or conditions that could be worsened by exposure to cold water. Finally, 26 volunteers (13 men and 13 women) met the inclusion criteria and agreed to participate in this study. Their physical characteristics are presented in Table 1. Written informed consent was obtained from all participants after the explanation of all details of the experimental procedures and the associated discomforts and risks. All procedures were conducted according to the guidelines of the Declaration of Helsinki. The Kaunas Regional Research Committee approved this study (2011-10-12 No. BE-2-41). Participants were in self-reported good health, as confirmed by medical history and physical examination. Women were in the follicular phase of their menstrual cycle.

Experimental design. Before the experimental trial, the participants attended a familiarization session. On arrival at the laboratory, anthropometric variables were measured, and the participants were introduced to the experimental procedures for cognitive testing. Each participant performed all cognitive tests for three days continuously. The participants were instructed to refrain from consuming any food for at least 12 h and alcohol, heavy exercise, and caffeine for at least 24 hours before the experiment, and they were instructed to sleep at least 8 hours the night before the experiment.

One week after the familiarization trial, the participants attended an experimental session. To control for circadian fluctuations in body temperature, the experimental trial began at 7.00. On arrival at the laboratory, the participant was asked to lie down in a semirecumbent position for 30 min at an ambient temperature of 22°C and 60% relative humidity. Resting pulmonary gas exchange was recorded during the last 20 min. After body temperature stabilization, control measurements of skin (T_{SK}) and rectal (T_{RE}) temperature were made. The participant was then seated at a table, and cognitive testing was performed. After the cognitive testing, the participant began the cooling protocol. Participants were immersed in a semirecumbent position up to the level of the manubrium in the 14°C water bath. During cooling, every 20 min, the participant was asked to step out of the bath and rest for 10 min in the room environment, and then to return to the water bath for the next 20 min of immersion. This process continued until the T_{RE} decreased to 35.5°C or until 170 min in total, at which time the cooling ended regardless of the T_{RE}. The exposure time until the T_{RE} was achieved was recorded. T_{RE} was recorded every 5 min throughout the cooling experiment. Pulmonary gas exchange was recorded only during each 20 min water immersion. Immediately after the experimental cooling, the participant was towel dried, the T_{SK} and T_{RE} were measured, and cognitive tests were performed.

Experimental measurements

Anthropometric measurements. The participant's weight (in kg) (TBF-300 body composition scale; Tanita, UK Ltd., West Drayton, UK) and height (in cm) were estimated, and body mass index (in kg/m^2) was calculated during the familiarization trial. The participant's body surface area (BSA) (in m^2) was estimated using the following best-fit equations: BSA = 128.1 × $weight^{0.44}$ × $height^{0.60}$ for men and BSA = 147.4 × $weight^{0.47}$ × $height^{0.55}$ for women (Tikuisis, Jacobs, Moroz, Vallerand, & Martineau, 2000).

Temperature recording. The T_{RE} (in °C) was monitored with a thermocouple (Rectal Probe, Ellab, Hvidovre, Denmark) inserted to a minimum of 12 cm past the anal sphincter. Back, thigh, and forearm skin temperatures were monitored by surface thermistors (DM852, Ellab, Hvidovre, Denmark). The mean skin temperature (T_{SK}) and body temperature (T_B) (in °C) were estimated by the following equations: $T_{SK} = 0.5_{Back} + 0.36_{Thigh} + 0.14_{Forearm}$ (Burton, 1935) and $T_B = 0.65T_{RE} + 0.35T_{SK}$ (Mermier, Schneider, Gurney, Weingart, & Wilmerding, 2006), respectively. The T_{RE} and T_{SK} gradient ($T_{RE} - T_{SK}$), as a measure of insulation, were also calculated.

Pulmonary gas exchange measurement. A mobile spirometry system (Oxycon Mobile, Jaeger/ VIASYS Healthcare, Hoechberg, Germany) was used to measure pulmonary gas exchange at rest and during cold-water immersion. This system uses a tightly fitting face mask covering the nose and mouth with a lightweight integrated flow meter (Triple V volume sensor, 45 g) with a dead space of 30 ml. It monitors oxygen consumption (VO_2) and carbon dioxide production (VCO_2) every 5 s on a breath-by-breath basis. The processing, recording, and battery system comprises two units attached to a belt, which was kept as close as possible to the participant's nose and mouth during immersion. The data were stored on a memory card and PC hardware. Calibration of this instrument was performed before recording according to the manufacturer's instructions. Resting VO_2 and VCO_2 were calculated as average from the last 20 min of the baseline recording. Because the total water-immersion time differed between participants, the mean values for stress VO_2 (an index of shivering (Muller et al., 2012)), and VCO_2 were calculated as the average during the cold-water immersion sessions. The data collected during the first 5 min of each 20 min immersion were not used in any calculations because of reflex hyperventilation caused by cold-water immersion. The MHP was calculated from the respiratory gas exchange measurements of VO_2 and the respiratory exchange ratio (RER = VCO_2 / VO_2) according to Péronnet and Massicotte (1991) as follows: MHP = (281.65 + 80.65 × RER) × VO_2. For comparative purposes, MHP (in W) and VO_2 (in ml/min) were normalized against weight and BSA. Furthermore, the function of shivering was expressed relatively to baseline MHP, where low shivering intensity corresponds to < 2.5 of baseline MHP, moderate shivering intensity corresponds to 2.5 – 3.8 of baseline MHP, and high shivering intensity corresponds to 3.8 – 5 of baseline MHP (Haman, 2006).

Measurement of cognitive performance. A programmed cognitive test battery was used to assess attention stability. As reported previously (Berneckė et al., 2012), the reliability of chosen tests was considered acceptable because the intra-class correlations were $R > .90$ and the coefficient of variation for repeated tests was < 4%. All tasks were computer controlled, and the information was presented on the screen of a laptop (HP Compaq 6730b). All tests were performed in a quiet and semi-darkened laboratory with a laptop screen ~40 cm in front of the participant. The test battery took ~5 min to perform and included the following tasks in random order.

The Schulte table assesses attention stability and is a validated technique for the estimation of concentration and switching of attention (Gordeev, 2008; Prokopenko et al., 2013). Standard values of full one table completion correspond to 40–45 s (Prokopenko et al., 2013). In the middle of the screen there appeared a five-by-five square table in which the numbers from 1 to 25 were displayed in random order. Participants had to find and click the mouse button on figures in an increasing order from 1 to 25 without omission. After one table was accomplished, the next table appeared on the screen. Participants had to accomplish 5 tables as fast as possible and the mean test duration (in s) was calculated.

The modified Schulte table (i.e. Schulte-Gorbov table (Mashin, 2006)) estimates fourfold-switching of attention according to two different colours and two different sequence orders. In the middle of the screen there appeared a square table which contained random red numbers from 1 to 25 and black numbers from 1 to 24. The participant was asked to mark red numbers in ascending order and black numbers in descending order as fast and as accurately as possible. Besides, every time they had to switch the colour and order of numbers in the following sequence: 1 – a red number, 24 – a black number, 2 – a red number, 23 – a black number, etc. The maximum allowed task duration was 5 minutes. Test duration (in s) was calculated.

Statistical analysis. The data were tested for normal distribution using the Kolmogorov–Smirnov test. To compare differences between men and women, *t* tests for independent samples were used for data with a normal distribution (height, weight, body mass index and BSA), and the Mann–Whitney *U* test was used for age, which was not normally distributed. Repeated-measures analysis of variance (ANOVA) was used to analyse the effects of cold stress on body temperatures, metabolic responses and cognitive performance variables, and the means were compared between men and women using a univariate ANOVA. The data are reported as mean (), standard deviation (*SD*) and 95% confidence interval (95% *CI*). The partial eta squared (h_p^2) was estimated as a measure of cold stress effect size. The level of significance was set at $p < .05$. If a significant effect was found, the statistical power (*SP*, in %) was estimated. All statistical analysis was performed using SPSS v.21.0 (IBM Corp., Armonk, NY, USA).

RESULTS

Physical characteristics. The baseline characteristics of the participants are described in Table 1. Height, weight and BSA were higher in men than in women ($p < .05$), whereas age and BMI did not differ between genders.

Effect of body cooling on body temperature variables. Table 2 summarizes the body temperatures variables for men and women before and after

Table 1. **Physical characteristics of the participants**

Physical characteristics of the participants	Men (n = 13)		Women (n = 13)		
	± *SD*	95% *CI*	± *SD*	95% *CI*	**p* value
Age (years)	20.6 ± 1.1	19.9–21.3	20.8 ± 1.6	19.9–21.8	.678
Height (cm)	182.6 ± 6.5	178.7–186.6	170.7 ± 7.2	166.3–175.1	.000
Mass (kg)	75.4 ±7.4	70.9–79.9	62.6 ± 9.9	56.7–68.6	.001
Body mass index (kg/m$^{2)}$	22.6 ± 1.8	21.5–23.6	21.5 ± 3.0	19.7–23.3	.281
Body surface area (m$^{2)}$	1.95 ± 0.12	1.88–2.02	1.7 ± 0.2	1.65–1.83	.001

Note. – mean; *SD* – standard deviation*;* *CI* – confidence interval; **p* – men compared to women.

Table 2. **Body temperature variables before and after body cooling**

Body temperature variables	Men		Women		
	± *SD*	95% *CI*	± *SD*	95% *CI*	**p* value
Rectal temperature					
Before cooling (°C)	37.0 ± 0.2	36.8–37.1	36.9 ± 0.2	36.8–37.0	.346
After cooling (°C)	35.9 ± 0.5	35.6–36.2	35.9 ± 0.6	35.5–36.2	1.000
η_p^2	.816		.748		
§*p* value	.000		.000		
Skin temperature					
Before cooling (°C)	32.6 ± 0.7	32.2–33.3	32.2 ± 0.5	31.9–32.4	.062
After cooling (°C)	18.7 ± 1.3	17.8–19.3	20.5 ± 3.4	18.6–22.9	.096
ŋp2	.989		.930		
§p value	.000		.000		
Rectal-skin temperature gradient					
Before cooling (°C)	4.3 ± 0.8	3.8–4.8	4.7 ± 0.4	4.5–5.0	.107
After cooling (°C)	17.2 ± 1.4	16.6–18.2	15.8 ± 3.4	12.9–17.3	.101
ŋp2	.990		.914		
§p value	.000		.000		
Body temperature					
Before cooling (°C)	35.4 ± 0.3	35.2–35.7	35.2 ± 0.2	35.1–35.43	.053
After cooling (°C)	29.9 ± 0.6	29.5–30.2	30.5 ± 1.2	29.8–31.4	.118
ŋp2	.984		.943		
§p value	.000		.000		

Note. – mean; *SD* – standard deviation*;* *CI* – confidence interval; h_p^2 – partial eta squared; **p* – men compared to women; §*p* – before cooling compared to after cooling.

Table 3. **Oxygen consumption (VO_2) and metabolic heat production (MHP) before and after body cooling**

Variables	Men		Women		
	± *SD*	**95% *CI***	**± *SD***	**95% *CI***	***p* value**
VO_2 (ml/min)					
Before cooling	164.7 ± 56.2	124.4–195.2	156.9 ± 42.4	126.5–176.4	.691
During cooling	924.5 ± 215.2	785.8–1070.9	542.1 ± 150.2	452.6–648.0	.000
h_p^2	.935		.899		
§*p* value	.000		.000		
VO_2 (ml/min/kg)					
Before cooling	2.2 ± 0.7	1.7–2.6	2.6 ± 0.8	2.0–3.0	.226
During cooling	12.4 ± 3.3	10.3–14.6	8.9 ± 3.3	7.1–11.3	.013
h_p^2	.919		.847		
§*p* value	.000		.000		
VO_2 (ml/min/m²)					
Before cooling	84.4 ± 27.2	64.8–97.7	90.8 ± 25.2	72.6–104.2	.542
During cooling	475.6 ± 113.4	400.1–550.5	316.2 ± 101.7	257.2–388.4	.001
h_p^2	.931		.875		
§*p* value	.000		.000		
MHP (W)					
Before cooling	58.2 ± 20.3	43.6 – 69.1	55.4 ± 14.8	44.8–62.2	.696
During cooling	318.2 ± 74.4	270.0 – 368.7	188.0 ± 51.8	157.0–224.5	.000
h_p^2	.934		.899		
§*p* value	.000		.000		
MHP (W/kg)					
Before cooling	0.77 ± 0.25	0.59–0.90	0.90 ± 0.27	0.71–1.06	.217
During cooling	4.28 ± 1.15	3.52–5.01	3.10 ± 1.15	2.45–3.92	.016
h_p^2	.915		.846		
§*p* value	.000		.000		
MHP (W/m²)					
Before cooling	29.8 ± 9.8	22.8–34.5	32.1 ± 8.8	25.7–36.7	.539
During cooling	163.8 ± 39.7	137.2–189.9	109.7 ± 35.2	89.2–134.7	.001
h_p^2	.928		.874		
§*p* value	.000		.000		

Note. – mean; *SD* – standard deviation*;* *CI* – confidence interval; h_p^2 – partial eta squared; **p* – men compared to women; §*p* – before cooling compared to after cooling.

body. Passive cooling time did not differ between genders (132.2 ± 43.4 min for men and 140.6 ± 41.5 min for women). T_{RE}, T_{SK}, and T_B decreased ($p < .05$, *SP* > 99%), and $T_{RE} – T_{SK}$ increased ($p < .05$, *SP* > 99%) after cold exposure for both genders. Body temperature variables did not differ between men and women.

Effect of body cooling on pulmonary gas exchange variables. Table 3 summarizes the VO_2 and MHP variables for men and women before and after body cooling. Baseline VO_2 and MHP did not differ between men and women. Cold-water immersion increased the total and normalized $VO_{2\ and}$ MHP in both genders ($p < .05$, *SP* > 99%). The VO_2 and MHP ($p < .05$, total, *SP* > 99%; normalized against weight, *SP* > 70%; normalized against BSA, *SP* > 95%) during cold exposure were higher in men than in women. Cold water immersion induced increase of MHP corresponded high intensity shivering in men (5.96, *SD* 2.28, 95% *CI* 4.61 – 7.69) and moderate intensity shivering in women (3.59, *SD* 0.79, 95% *CI* 3.32 – 4.16). A significantly greater increase in shivering intensity was observed in men then in women during cold exposure ($p < .05$, *SP* > 90%).

Effect of body cooling on cognitive performance. Values representing performance in attention tasks for men and women are presented in Table 4. Body cooling significantly increased the duration of Schulte table task performance for both genders ($p < 0.05$, *SP* > 55% for men and *SP* > 90% for women). In men, body cooling significantly increased the duration of Schulte-Gorbov table performance ($p < .05$, *SP* > 50%), whereas cold did not affect task duration in women.

Table 4. **Attention task performance before and after cooling**

Variables	Men		Women		
	± *SD*	95% *CI*	± *SD*	95% *CI*	**p* value
Schulte table (s)					
Before cooling	188.8 ± 27.8	170.0–206.9	176.0 ± 38.4	148.9–191.3	.342
After cooling	203.4 ± 29.5	182.9–221.6	195.8 ± 38.9	167.8– 15.5	.579
h_p^2	.318		.549		
§*p* value	.036		.002		
Schulte-Gorbov table (s)					
Before cooling	168.8 ± 36.5	146.4–194.3	167.8 ± 43.2	136.8–190.1	.950
After cooling	186.8 ± 47.3	157.1–219.4	175.9 ± 46.9	142.5–202.8	.562
h_p^2	.284		.215		
§*p* value	.049		.095		

Note. – mean; *SD* – standard deviation*; CI* – confidence interval; h_p^2 – partial eta squared; **p* – men compared to women; §*p* – before cooling compared to after cooling.

DISCUSSION

The main aim of this study was to compare if whole body cooling induced any gender-specific response in attention stability task performance due to the differences of *catecholamine*-induced *metabolic heat production between men and women*. As expected, men exhibited greater whole body cooling induced MHP and shivering thermogenesis than women. Besides, the results of this study have shown that greater mental manipulation requiring Schulte-Gorbov table was affected in men but not in women, whereas less cognitively demanding Schulte table performance was adversely affected in both genders.

Whole body cooling induced thermoregulatory response in men and women. The origin of thermoregulation in non-cold-adapted humans involves metabolic (an increase in heat production), hypothermic (a reduction in core temperature) and insulative (a reduction in T_{SK} relative to core temperature) (Brazaitis et al., 2014a, b). In accordance with a previous study (McArdle, Toner, Magel, Spina, & Pandolf, 1992; Solianik et al., 2014b), on exposure to cold water, both men and women exhibited an insulative response (an increase in T_{RE} – T_{SK} gradient), a metabolic response (an increase in MHP and shivering (VO_2)), and a hypothermic response (a decrease in T_{RE}). As expected and in accordance with our previous study (Solianik et al., 2014b) we have observed that MHP and shivering were significantly greater in men than in women. It is well established that catecholamines cause a rise in MHP, including shivering (Banet et al., 1978; Maggs et al., 1994); specifically increased circulating epinephrine in men compared to women (Maggs et al., 1994; Solianik et al., 2014b; Wagner et al., 1987).

Whole body cooling induced attention stability response in men and women. We chose to assess attention stability using *two tasks* of *different* task *complexity*, such as Schulte table (less cognitively demanding task) and Schulte-Gorbov table (more cognitively demanding task). As previously mentioned cold-induced catecholamines increase particularly deteriorates tests involving complex attentional functions (Hyafil et al., 2009). Thus in a recent study observed greater metabolic response in men then in women indicates greater epinephrine response in men (Maggs et al., 1994; Solianik et al., 2014 b; Wagner et al., 1987), which deteriorates Schulte-Gorbov task performance in men, but not in women. The arousal hypothesis suggests that a slight decline in core temperature leads to improved performance, whereas with continued, prolonged and more severe cooling performance is degraded (Enander, 1987). It can be suggested that especially complex cognitive tasks are susceptible to the arousal caused by the cold exposure (Giesbrecht et al., 1993; Mäkinen et al., 2006; Mäkinen, 2007; Palinkas et al., 2005), and follows 'inverted U-shaped' pattern (Arnsten, 2009; Lupien, McEwen, Gunnar, & Heim, 2007; Shansky & Lipps, 2013). Thus it can be expected that women blunted Schulte-Gorbov performance change was due to parallel move ahead of the inverted U shaped curve; by contrast, in men greater catecholamines response moved further ahead and caused performance deterioration.

In contrast to more cognitively demanding Schulte-Gorbov table, less cognitively demanding Schulte test duration increased in men and women. The distraction hypothesis suggests that the discomfort caused by cold produces a shift of attention from the primary task and leading to performance decrement (Mäkinen, 2007; Teichner, 1958), such as longer response time (Mäkinen, 2007). It is suggested that especially simple cognitive tasks are susceptible to the distraction caused by the cold exposure (Giesbrecht et al., 1993; Mäkinen et al., 2006; Mäkinen, 2007). Off note, it is suggested that cold-induced discomfort may be a distraction factor reducing the performance of task (Mäkinen, 2007). In our previous study (Solianik et al., 2014b) we did not observe any gender differences in thermal sensation and comfort perception, which is in line with our resent findings indicating similar Schulte test duration increase in men and women.

CONCLUSIONS

Whole body cooling induced stress had similar influence on simple attention stability task in men and women, whereas more complex attention stability task was adversely affected only in men. This greater men's decrement of more complex cognitive task performance can be associated with men's greater catecholamine conveyed metabolic heat production, including shivering, compared to women. This is the first study to find the evidence supporting the idea of gender-specific and task-dependent attention stability response after whole body cooling.

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Corresponding author **Rima Solianik**
Lithuanian Sports University
Sporto str. 6, LT-44221 Kaunas
Lithuania
Tel. 8 606 95214
E-mail rima.solianik@lsu.lt

CARDIOVASCULAR CHANGES DEPENDING ON EXERCISING: STRENGTH EXERCISE OR NORDIC WALKING

Živilė Ščevinskaitė, Eugenijus Trinkūnas, Kristina Poderienė
Lithuanian Sports University, Kaunas, Lithuania

ABSTRACT

Background. The aim of the study was to compare the acute training effect on the cardiovascular changes under influence of different kinds of health enhancing exercising.

Methods. Ten healthy males carried out two health promotion sessions by applying strength type exercising or Nordic-walk. Cardiovascular functional state was assessed before the training session and 30 minutes after the health promotion session by continuous 12-lead ECG recording while performing a Roufier Test (*30 squats per 45 s*) and by measuring arterial blood pressure.

Results. A significant increase in the heart rate at rest was registered after the training session both after the gym training and after Nordic-walking session and reduced diastolic blood pressure values were recorded at rest and after the exercise stress test. If prior to the exercise sessions transient ischemic episode in some subjects was registered, after the training sessions the ischemic episodes were less expressed.

Conclusion. Comparing the Nordic walking exercise effects with the effects of strength training exercising during the training session, less increased heart rate and systolic blood pressure were observed; a significantly higher decrease in the diastolic blood pressure, and a significantly lower degree on the short-term effects of functional ischemic myocardium were recorded.

Keywords: Nordic walking, strength exercise, cardiovascular system.

INTRODUCTION

In many countries one of the most common causes of death is cardiovascular diseases. Morbidity due to cardiovascular system diseases is the most common health problem among middle-aged and elderly people. Physical activity and exercising is important not only for the performance of daily activities, but also for health promotion (Karmisholt & Gøtzsche, 2004). Nowadays one of physical activity forms with growing popularity is Nordic walking. It is a way of walking using special walking poles. The basic difference between Nordic walking and normal walking is that in Nordic walking technique special poles adapted to the walker's height are used (Figard-Fabre, Fabre, Leonardi, & Schena, 2010). Nordic walking claims a number of additional health benefits over normal walking such as increased oxygen uptake (11%), heart rate (HR) (8%) and calorie expenditure (18%) (Tschentscher, Niederseer, & Niebauer, 2013). There are some studies, which compared Nordic walking with jogging or fast walking. Nordic walking has the advantage in all cases (Tschentscher et al., 2013). Nordic walking is a safe way of increasing aerobic working capacity because people can choose the walking speed and stop exercising if they feel a discomfort (Stief et al., 2008). According to the same scientific research, Nordic Walking can be used for children, middle-aged or elderly people (Parkatti, Perttunen, & Wacker, 2012) as well as pregnant women (Korsten-Reck, 2010). Thus, Nordic walking is a widely adaptable form of physical activity. Although there is no doubt in the benefit of Nordic walking, comparative studies that evaluated Nordic walking and other health promoting effects of exercise on the cardiovascular system have not been executed. The aim of this study was to compare the acute training effect on the cardiovascular changes during different kinds of health enhancing exercising.

METHODS

In order to proceed with the research, permission has been requested and was it granted by the Committee of Bioethics of Lithuanian University of Health Sciences. The research was performed in the Kinesiology Laboratory in Lithuanian Sports University. Ten volunteers participated in the study (males, age – 46.3 ± 1.2), who regularly exercised for health in a sports club. All participants were relatively healthy, non-complainant of cardiovascular dysfunction, with a permission from the doctor to participate in health strengthening exercises. They were randomly divided into two groups and participated in health strength exercise with a three-day break between them. The first group exercised in the gym and after a three-day break they did Nordic walking exercises. The second group, on the contrary, had Nordic walking first, and then they exercised in the gym doing strength training exercises after a three-day break.

The two testing procedures, i.e. before the training session and 30 minutes after the health promotion session were performed. Functional state assessment of the cardiovascular system was assessed by continuous 12-lead ECG recording while performing a Roufier Test (*30 squats per 45 s*), and measuring the arterial blood pressure (ABP) every single minute.

Statistical analysis was performed using *Microsoft Office Excel* and *SPSS* software packages. In order to identify the differences between two independent groups we used the Mann-Whitney *U* test, between three related groups – Friedman test. The results are represented as arithmetic mean ± the standard error of the mean (SEM). Statistical significance was accepted when $p < .05$.

RESULTS

The results of the research are presented in Figures 1–4. They represent the cardiovascular functional state changes while comparing their dynamics during Roufier Test.

Figure 1 presents the HR changes during testing procedures. The HR before using Roufier Exercise Test in the relative repose was 73.1 ± 2.16 beats/min. After repeating the exercise in the gym the test registered statistically significantly ($p < .05$) higher HR values. Average HR was 100.9 ± 2.46 beats/min. At rest after Nordic walking HR was also significantly higher than before walking (103.2 ± 2.36 beats/min, $p < .05$). After the training, there was no difference between the Nordic walking and strength exercise in HR ($p > .05$). There were no statistically significant differences between the groups. Other HR assessed values recorded using

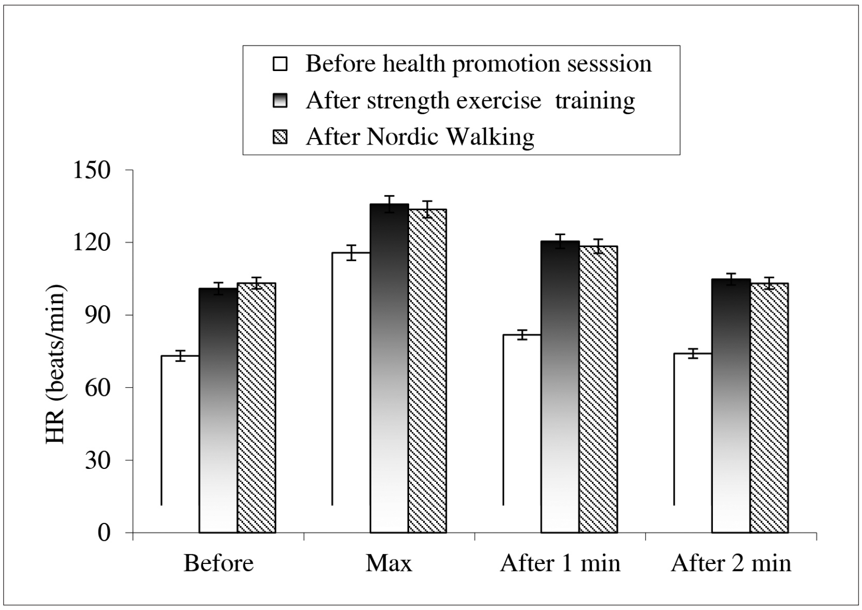


Figure 1. **HR changes while performing Roufier Exercise Test**

Roufier exercise test were statistically significantly ($p < .05$) higher than it was observed before the training session.

Figure 2 presents the data of ST-segment depression at relative rest and maximal values registered during Roufier Exercise Test. Statistically significant results ($p < .05$) were found comparing the maximum ST-segment depression values which were registered in the squat. Comparison of the values before and after exercise showed significant ($p < .05$) differences between them. Before walking ST-segment depression maximal value was 0.35 ± 0.6 mV, then it decreased to 0.12 ± 0.5 mV. There was also a significant difference comparing the exercise in the gym and Nordic walking. After the Nordic walking ST-segment depression was 0.12 ± 0.5 mV, and after the exercise in the gym the averaged values were higher, i.e. 0.29 ± 0.5 mV ($p < .05$). Figure 3 shows the results of systolic ABP changes in response to Roufier Test, which confirms its increase due to the physical strain as well as full recovery in two minutes of rest. The results of the study revealed some changes in systolic ABP change features. After the exercise (Nordic walking and exercise in the gym) systolic ABP was reduced, i.e. post-exercise hypotension was observed, but this difference was not statistically significant ($p > .05$).

As it is presented in Figure 4, the diastolic ABP value before exercise at rest was 85 ± 2.2 mmHg, after Nordic walking it was 79.3 ± 2.3 mmHg, which demonstrated a significant increase ($p < .05$).

Figure 2. **ST-segment depression values registered before Roufier Exercise Test and during the exercising (*30 squats per 45 s*)**

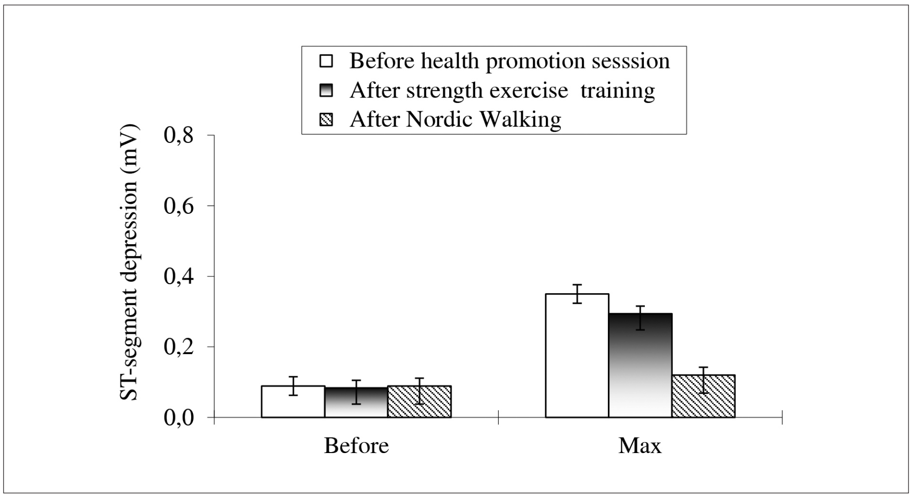
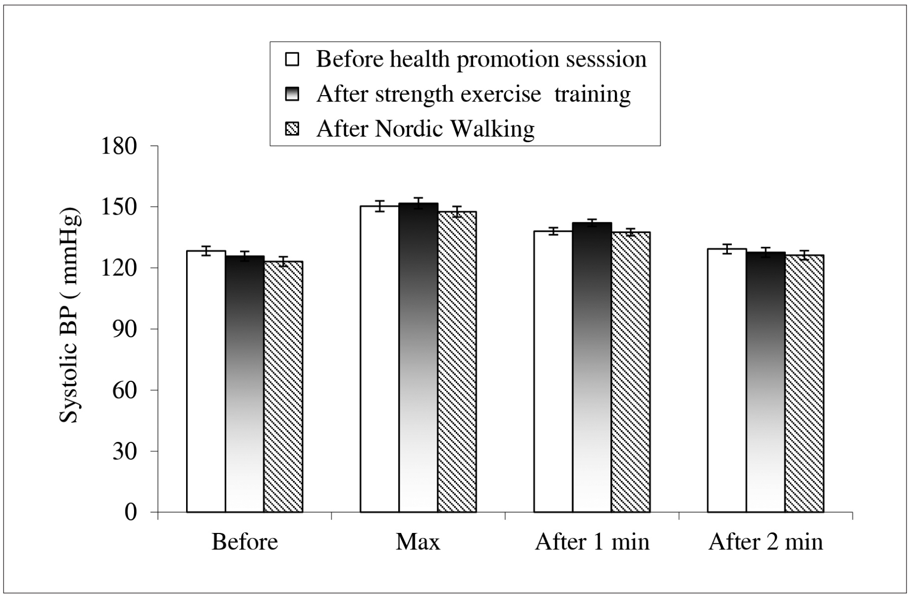


Figure 3. **Diastolic ABP changes while performing Roufier Exercise Test**



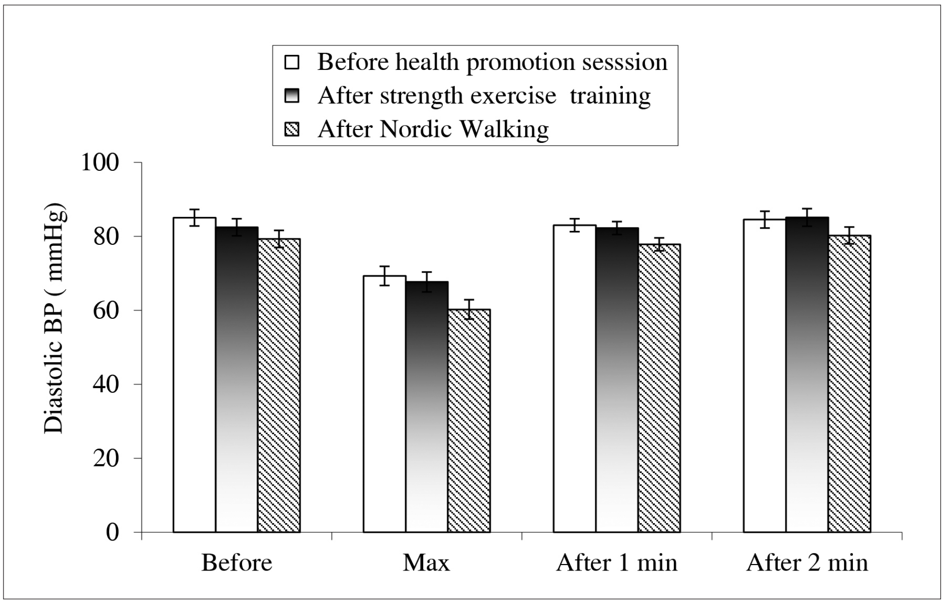


Figure 4. **Diastolic ABP changes while performing Roufier Exercise Test**

There was no significant change at rest during the exercise test before and after exercise in the gym (p > .05). The maximum value of diastolic blood pressure (60.2 ± 2.6 mmHg) after Nordic walking statistically significantly decreased comparing it with the blood pressure after the exercise in the gym (67.7 ± 2.6 mmHg) and the control group before walking (69.3 ± 2.6 mmHg) (p < .05).

DISCUSSION

The question which type of physical activity improves health most effectively remains relevant as a scientific and practical issue (Dunn, Lark, & Fallows, 2013; Vainoras, 2004). In order to find an answer to this question, an evaluation and comparison of the early and long term adaptation has to be made. The majority of body's functional systems pick up the pace when carrying out a physical exercise, it also affects an increase of activity of most regulatory systems, therefore a lot of research can be carried out and scientific articles can convey different approaches.

Within the last few years a number of studies have been carried out on the effects of Nordic walking on different human body systems (Mikalacki, Cokorilo, & Katić, 2011; Patanè, Marte, Dattilo, Grassi, & Patanè, 2009; Simic, Hinman, Wrigley, Bennell, & Hunt, 2010), although cardiovascular system has been much researched. This research was aimed at showing that Nordic walking is a safe and handy way of dealing with diseases caused by cardiovascular disease. Being easy to learn and of a reasonable price, Nordic walking could be a great way to improve health and is available for almost anyone. Considering the fact that we were evaluating the benefits of walking for the cardiovascular system of healthy individuals, we suggest that this type of exercise could be an alternative to gym training.

The results of the research have revealed that the functional state and change of the human body due to physical impact can be determined by electrocardiograms and vascular blood pressure values by taking a dozed physical impact. After taking dozed physical activity sample after training, the HR increases and an increase in systolic as well as a decrease in diastolic blood pressure can be observed. Short-term effects of functional ischemic episodes in myocardium could also be observed in persons with lower physical fitness. The research results confirm those of other researchers (Zachariene, 2012) presenting the results about changes due to the performed activity and energy loss. When considering the results, it is important to remember that they have been taken 30 minutes post training, thus they reflected the post workout state of the body that provokes the phenomenon of long term adaptation.

CONCLUSION

The benefit of Nordic walking comparing with the effects caused by strength exercising could be evidenced by the fact that when there was a less increase in heart rate, there was a significantly greater decrease in diastolic blood pressure, and smaller short-term functional ischemic episodes were registered during the dosed exercise test.

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Corresponding author **Živilė Ščevinskaitė**
Lithuanian Sports University
Aušros str. 42, LT-44221 Kaunas
Lithuania
Tel. +370 30 26 50
E-mail scevinskaite@gmail.com

ANALYSIS OF STRIDE PARAMETERS AND RUNNING VELOCITY AT INDOOR 400 M RUNNING

Viktoras Šilinskas, Albinas Grūnovas, Juratė Stanislovaitienė
Lithuanian Sports University, Kaunas, Lithuania

ABSTRACT

Background. 400 m race is one of most difficult and complex events in athletics. In order to achieve good results in the distance an athlete must have not only good velocity characteristics, but also be able to tactically correctly allocate them, i.e. depending on their total and special endurance level be able to distribute efforts in the entire range, select the optimum running velocity for the start and keep it until the finish. Research aim was to analyse the choice of running tactics and change of stride parameters and running velocity of the best Lithuanian 400 m runners during a running indoor contest.

Methods. The study was conducted during Lithuanian Indoor Championship. The best 15 runners of 400 meters were investigated. The runners were filmed by Digital cameras from the side at a distance of 90, 190, 290 and 390 meters. We analysed stride kinematic parameters (duration of support and flight, stride length, stride frequency) and the running velocity.

Results. The maximum decrease of the stride length and running velocity were observed between 190 and 290 m where the stride length decreased from 2.22 ± 0.03 to 2.08 ± 0.03 m and running velocity from 8.18 ± 013 to 7.36 ± 0.07 m/s. In the first distance range, i.e. 90 m, the stride frequency was 3.83 ± 0.05 Hz. Later it gradually decreased to 3.46 ± 0.05 Hz in 390 meters. Duration of support at 90 m was 0.119 ± 0.001 s and till 290 m it become longer, later it was almost unchanging. Time of flight phase changed insignificantly over the entire distance.

Conclusion. It was found that athletes' choice of running tactics depended not only on their preparation type (sprint or endurance), but also on the conditions in which the athlete starts (indoor or outdoor), as well as on the number of the track in which the athlete starts. The maximum change of running velocity and stride length during the indoor running was observed in the second half of the range, while the stride frequency decreased gradually during the entire range. Change of support time had greater impact for stride frequency than change of flight time.

Keywords: stride frequency, stride length, duration of support, duration of flight, tactics.

INTRODUCTION

400 m race is one of most difficult and complex events in athletics. In order to achieve good results in the distance an athlete must have not only good velocity characteristics, but also be able to tactically correctly distribute them, i.e. depending on their total and special endurance levels be able to distribute efforts in the entire range, select the optimum running velocity for the start and keep it until the finish (Бухарина, 2003; Мирзоев, 2002). Generally, it can be assumed that 400 m runners should maintain an average velocity that corresponds to 94% of the best athlete's 200 m result. At the same time, the athlete must be able to maintain stride length which corresponds to 1.3 of athlete height (Jarver, 2005).

Running velocity during the distance decreases gradually and reaches a maximum change at 50 m till the finish (Gajer, Hanon, & Thepaut-Mathieu, 2007; Letzelter & Eggers, 2003). The difference between the first and second half-range drubbing time is 1.6 to 2.0 seconds (Мирзоев 2002). For 400 m runners energy supply is very important, in particular glycolytic capacity (Duffield & Dawson, 2003; Duffield, Dawson, & Goodman, 2005; Лисовский, 2001). There are a number of works dealing with the change of running velocity and stride parameters on the 400 meters run in the stadium (Bruggemann, Koszewski, & Müller, 1999; Gajer et al., 2007; Hanon & Gajer, 2009; Nummela, Stray-Gundersen, & Rusko, 1996), but we could not find any studies where these parameters were examined in indoor running.

Research aim was to analyse the choice of running tactics and changes of stride parameters (stride length, frequency, duration of support and flight) as well as the running velocity of the best Lithuanian runners during indoor contest running.

METHODS

The study was conducted during Lithuanian Winter Championship. The best 15 runners of 400 meters were investigated. Their mean age, height and body mass were (mean ± standard error) 20.3 ± 0.68 years, 1.81 ±.01 m and 72.6 ± 2.3 kg, respectively. Runners were filmed with digital 25 Hz for Canon XM1 video cameras from the side at the distance of 90, 190, 290 and 390 meters (Figure 1). Video cameras were directed perpendicular to the track. After that the filmed material by the SIMI MOTION program was transferred from the cameras to a computer and analysed by 50 Hz. The analysis of running technique was performed using a specialized motion analysis program SIMI MOTION 2D where we analysed and calculated stride kinematic parameters (duration of support and flight, stride length, stride frequency) and the running velocity.

The time after the first and second half of the distance was registered by fully automated finishing system ("Monochrome EtherLynx 2000 Black & White Camera", standard resolution 1000 lines/sec @ 500 pixels.), which automatically turned on by the starter's signal (shot) and automatically recorded the finish time. This finish system is certified by the IAAF.

Two-way analysis of variance (two-way ANOVA) for the dependent samples was applied for the evaluation of changes between the measurements. The difference between the measurements (Student's *t* test) was considered to be significant at $p \leq .05$. Before the test of means, equality of dispersion was checked. The data are expressed as means ± standard error. These calculations were performed by using statistical functions of the SPSS statistics 17.0.

RESULTS

Analysing results of 400 m runners' run we can see that the best Lithuanian athletes overcome the first half of the distance on the average 3.02 ± 0.21 seconds faster than the second one (Figure 2).

Also we calculated the relationship between this difference and the running track on which athlete ran. Athletes who ran the first half of the distance on the fourth track were on the average 3.77 ± 0.31 seconds faster than when they were on

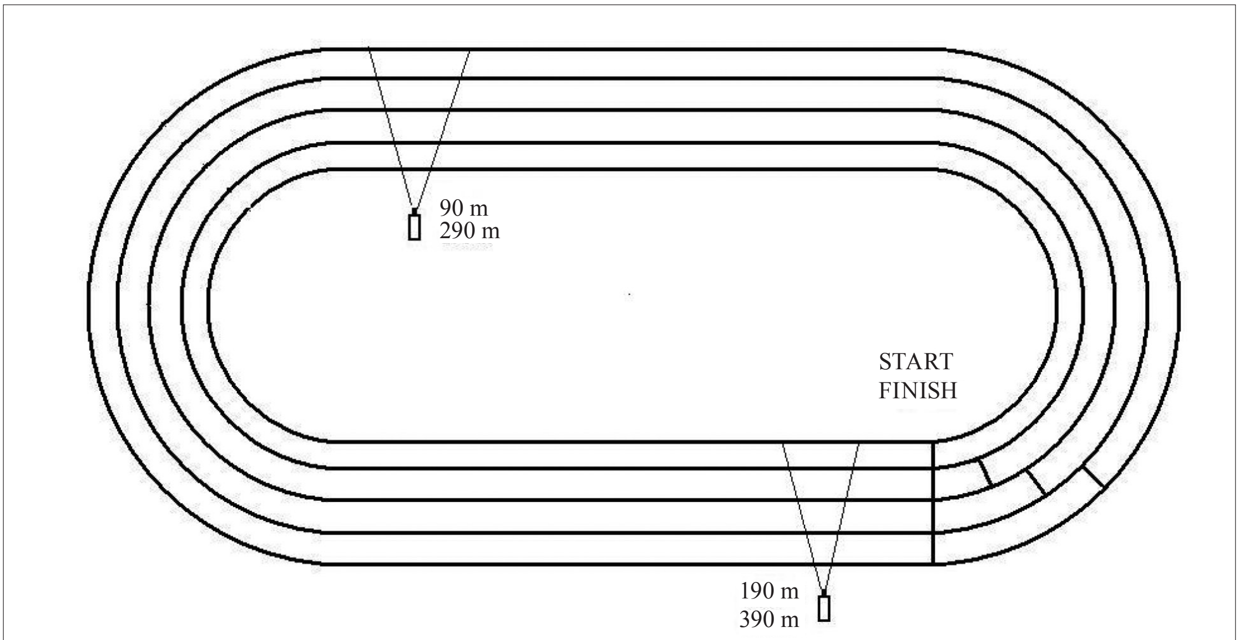


Figure 1. **Layout of cameras**

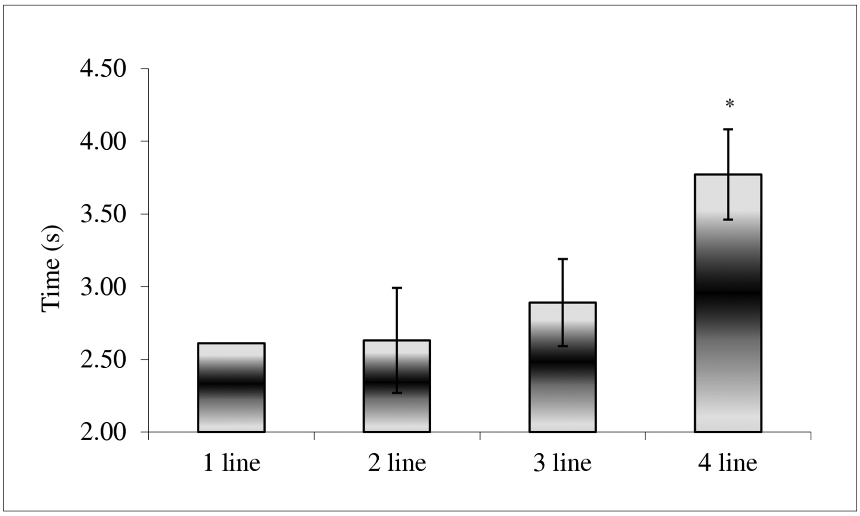


Figure 2. **Difference in time between the first and second halves of the race depending on the running track**

Note. * – significantly different, compareв with values of other lines ($p \leq .05$).

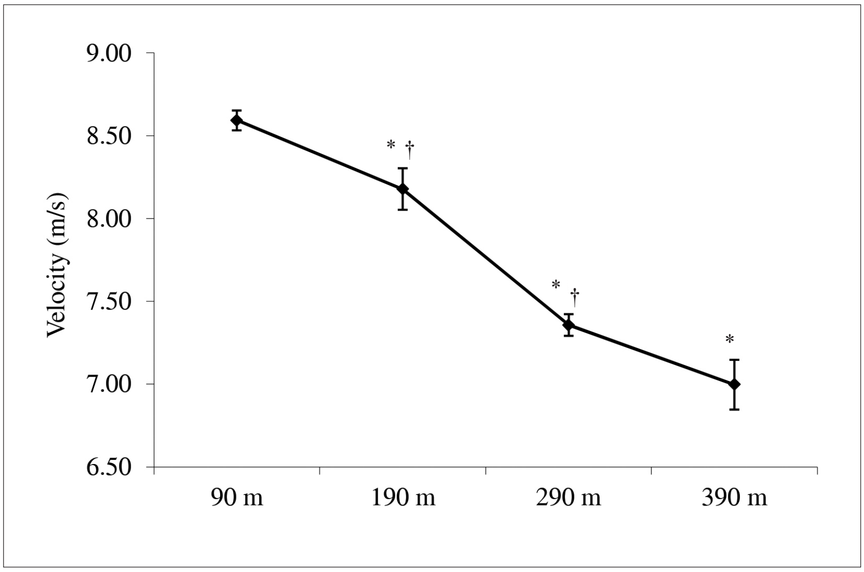


Figure 3. **Change of running velocity in different points of distance**

Note. * – significantly different from 90 m point values ($p \leq .05$), † – significantly different from previous measurement values ($p \leq .05$).

the second one. Meanwhile, athletes who ran the first half of the distance on the third and second tracks overcame it only 2.89 ± 0.30 and 2.63 ± 0.36 seconds faster than the second one. Time difference between the first and second distance halves of athletes started in the fourth track was statistically significant ($p < .05$) higher than others who started on other tracks. The correlation between the result of the first running half and the number of the track was –.59. And average correlation between the time difference of the first and the second running halves and the number of the track was .55.

Analysing the change of running velocity (Figure 3), we can see that running velocity after 90 m was 8.59 ± 0.06 m/s, and at 190 m range it decreased to 8.18 ± 0.13 m/s ($p < .05$). The biggest slowdown (0.82 ± 0.12 m/s) was between 190 and 290 m ranges. There running velocity decreased from 8.18 ± 013 m/s to 7.36 ± 0.07 m/s ($p < .05$). In the last running range velocity of athletes decreased to 7.00 ± 0.15 m/s, but compared to the velocity of 290 m, this decrease was not statistically significant ($p > .05$).

Stride length (Figure 4) in 90 m was 2.25 ± 0.03 m and in 190 m 2.22 ± 0.03 m. Decrease was not statistically significant ($p > .05$). The maximum decrease of stride length was observed between 190 and 290 m where the stride length was 2.08 ± 0.03 m ($p < .05$). In the last running range the stride length decreased to 2.02 ± 0.04 m ($p > .05$).

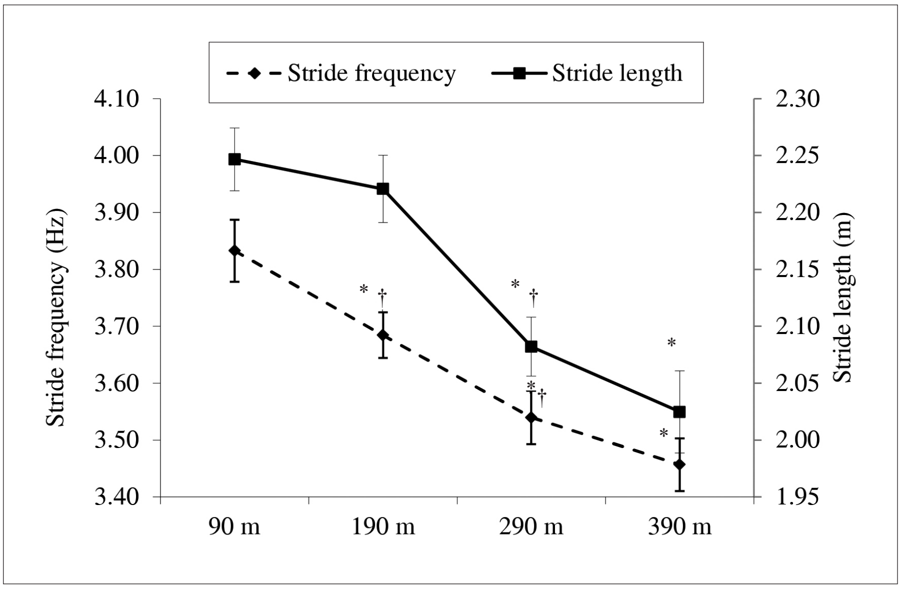
In the first distance range, i.e. 90 m, the stride frequency (Figure 4) was 3.83 ± 0.05 Hz. Later it gradually decreased. At 190 m it decreased to 3.68 ± 0.04 Hz, and at 290 m – to 3.54 ± 0.05 Hz. These decreases were statistically significant ($p < .05$). In the last running range the stride frequency decreased to 3.46 ± 0.05 Hz, but it was not statistically significant ($p > .05$).

Duration of support at 90 m was 0.119 ± 0.001 s and till 290 m it become longer ($p < .05$) and later remained almost unchanging. Duration of flight at 90 m was 0.153 ± 0.004 s, later reduced to 0.148 ± 0.003, and unchanged till 290 m, at 390 m it increased to 0.153 ± 0.004 s. There were no statistically significant differences between the flight phase values (Figure 5).

As can be seen from Table 1, the biggest percentage of change in the running velocity was between 190 and 290 m of the distance. The total percentage decrease of running velocity was 18.42 ± 2.17%. The maximum stride length reduction was also observed in the range between 190 and 290 m (6.11 ± 1.28%). Total decrease of stride length was 9.71 ± 1.88%. Stride frequency decreased during the whole distance. The largest decrease was in the range between 190 and 290 m (3.89 ± 0.96%). Total decrease of stride frequency from 90 to 390 m was 9.64 ± 1.49%. Support time most increased from 90 to 190 m (12.24 ± 2.19%), and total (from 90 to 390 m) change of support time was 17.73 ± 2.82%. Duration of flight from 90 m to 190 m fell by 2.61 ± 1.24%, then it began to grow and the biggest change was from 290 m to 390 m, where it increased to 3.85 ± 2.21%.

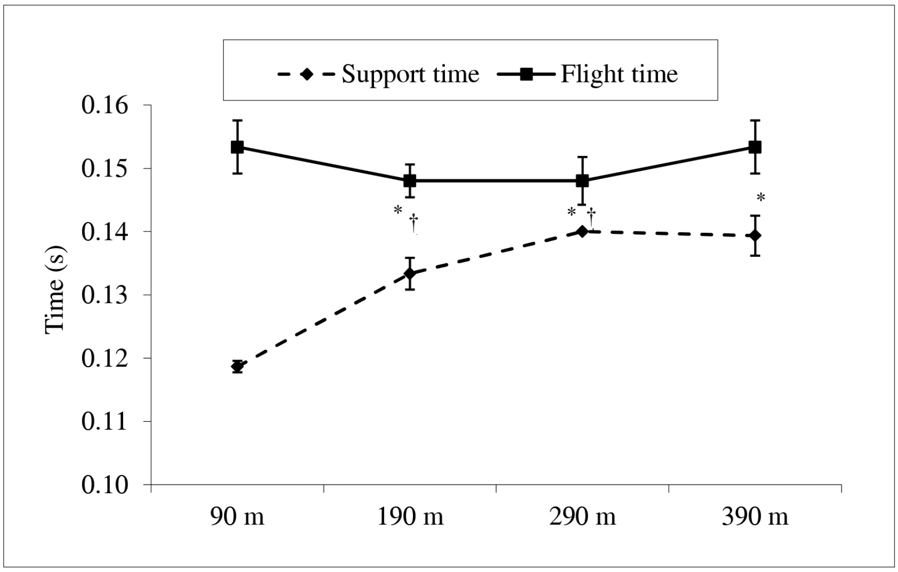
As we can see from Table 2, the change of stride length and stride frequency had the greatest influence on running velocity.

Figure 4. **Change of stride length and stride frequency in different points of distance**



Note. * – significantly different from 90 m point values ($p \leq .05$), † – significantly different from previous measurement values ($p \leq .05$).

Figure 5. **Change of duration of support and flight in different points of distance**



Note. * – significantly different from 90 m point values ($p \leq .05$), † – significantly different from previous measurement values ($p \leq .05$).

Parameters	90–190 m	190–290 m	290–390 m	90–390 m
Velocity	–4.76 (1.62)	–9.81 (1.32)	–4.72 (2.45)	–18.42 (2.17)
Stride length	–1.04 (1.38)	–6.11 (1.28)	–2.55 (2.10)	–9.71 (1.88)
Stride frequency	–3.71 (1.24)	–3.89 (0.96)	–2.19 (1.52)	–9.64 (1.49)
Support time	12.24 (2.19)	5.56 (2.10)	–0.48 (2.26)	17.73 (2.82)
Flight time	–2.61 (1.24)	0.36 (3.00)	3.85 (2.21)	0.52 (2.80)

Table 1. **Percentage change of running velocity and stride parameters between the different points of distance**

Range of distance	Stride length	Support time	Flight time	Stride frequency
from 90 m to 190 m	.689	.102	–.537	.589
from 190 m to 290 m	.759	.095	–.067	.423
from 290 m to 390 m	.784	.028	–.125	.559
from 90 m to 390 m	.779	–.230	–.508	.606

Table 2. **Correlations between the percentage change of running velocity and percentage change of stride parameters between at different points of registration**

DISCUSSION

400 m runners, who are generally medium to tall in height and physically strong in build, fall into two distinct categories. One group includes the athletes who have a speed base and the other – athletes who have an endurance base. It has also been suggested that the two groups should have distinct tactical approaches to running 400 m. It was thought that the speed-based athlete ran a fast first half of the race and then "held on" for as long as possible, hoping that fatigue would not slow him/her too much before the completion of the race. The endurance-based athlete would run differently, with a more even paced race, the time of the first half of the race being roughly similar to the time of the second half (Schiffer, 2008).

Obviously the sprinter type has the advantage through the early stages; however, if he or she is not trained properly, this advantage can melt away in a hurry toward the end of the race. The endurance type will definitely have an advantage from the 300 m mark to the finish (Hart, 2000).

The success of the sprinter-type 400 m runner is usually explained by the fact that it is easier to develop speed endurance in sprinter types than speed capacities in endurance-type athletes. Generally, it can be assumed that 400 m runners should maintain an average velocity that corresponds to 94% of the best athlete's 200 m result (Jarver, 2005).

Comparing velocity change dynamics of our surveyed athletes who ran indoor with similar performance athletes who ran in the stadium (Gajer et al., 2007) we found out that running indoor maximum decrease of velocity is between 190 and 290 m (9.81 ± 1.32%) while running in the stadium the largest decrease is in the last 100 meters. Total velocity decrease of our surveyed athletes was 18.42 ± 2.17, other authors in similar works found from 14 to 19% (Bruggemann et al., 1999) and more than 20% (Gajer et al., 2007). Similar situation exists with the change of stride length.

Most of our surveyed athletes chose sprinter run tactic because the difference between the first and second halves of range on average was 3.02 ± 0.21 s. The reason for this selection may be the peculiarity of indoor 400 m running. Athletes run on their own track indoors only the first half of the range, and later everyone runs on the first track. Therefore it is very important to start in a good position because later is very difficult to overtake an opponent in rather sharp turns and quite short lines.

Running velocity of all our surveyed athletes decreased during the whole race distance. Particularly large decrease was observed in the second half of the range. This could be influenced by the choice of running tactics, the track on which athlete runs the first half of the range, and the resulting tiredness. Generally it is assumed that the energy supply in the 400 m running is anaerobic, but findings of various researchers on the percentage contribution of anaerobic and aerobic energy mechanisms are different. This can be influenced by gender, type of athletes (sprinters or endurance representatives), different research methodologies, and level of athlete's skills. The aerobic contribution increases as a consequence of the extended duration of the race, being 24% for a performance of 44 s, 33% for 48 s and 43% for 52 s. Researchers found that the increased pH level in the first 150–200 meters inhibits aerobic energy generation mechanisms in the II type muscular fibres during further running (Arcelli, Mambretti, Cimadoro, & Alberti, 2008). After running athletes' lactate concentration is increased from 20 to 25 times comparing to resting state (Schwellnus, Nicol, Laubscher, & Noakes, 2004).

The radius of turn is less; the decrease of maximum athletes' velocity is higher. Difference between the results of athletes running in the 1 and 8 tracks was 0.35 s (Quinn, 2009). We believe that running indoor where turning radius is less, loss of velocity is also significant. This is also demonstrated by our research results which indicate that the difference between the first and the second halves of range running in the fourth track was bigger because in the first half of the range athletes could meet faster because of the geometry of the track.

CONCLUSIONS

It was found that athletes' choice of running tactics in 400 m event depended not only on athletes' preparation type (sprint or endurance), but also on the conditions in which the athlete starts (indoor or outdoor), and on the number of track on which the athlete starts.

The maximum change of running velocity and stride length during the indoor running was observed in the second half of the range, while the stride frequency decreased gradually during the entire range. Change of support time had greater impact for stride frequency than change of flight time. Change of stride length had the greatest influence on running velocity.

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Corresponding author **Viktoras Šilinskas**
Lithuanian Sports University
Sporto str. 6, LT-44221 Kaunas
Lithuania
Tel. +370 600 13899
E-mail viktoras.silinskas@lsu.lt

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