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The issue includes articles prepared according to the Proceedings of the 4th International Scientific Conference “Physical Activity and Sport at University 2012”, held in Kaunas, Lithuania, on October 12, 2012.

Research articles in Social and Biomedical Sciences are given in this issue.

KAUNAS UNIVERSITY OF TECHNOLOGY

PHYSICAL CULTURE & SPORTS CENTER
DEPARTMENT OF PHYSICAL CULTURE

4th INTERNATIONAL CONFERENCE

PHYSICAL ACTIVITY AND SPORT AT UNIVERSITY 2012

12th October, 2012
Kaunas, Lithuania

CONFERENCE IS ORGANIZED BY
Kaunas University of Technology
Centre for Physical Education and Sports

4th INTERNATIONAL CONFERENCE

12th October, 2012 | Kaunas, Lithuania

PHYSICAL ACTIVITY AND SPORT AT UNIVERSITY 2012

SECTIONS

I Humanistic, Social and Psychological Aspects of Sport

II Fitness and Health; Sport Management

III Biomedical Aspects of Sport; Rehabilitation, Physical & Sport Medicine; Biomedical Engineering of Sport

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8^{30} — 10^{00}	Registration (12th October, 2012 Hotel "BEST WESTERN Santaka") Gruodzio str. 21, Kaunas
10^{00} — 11^{00}	Plenary session,
11^{30} — 13^{00}	Reports in the sessions,
14^{00} —15^{00}	Poster session,
15^{00} — 16^{00}	Closing ceremony

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Phone +370 37 302636
Fax +370 37 204515
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CONTENTS

ASSESSMENT OF PHYSICAL WORKING CAPACITY OF DIFFERENTLY TRAINED AND AGED FEMALE AEROBIC GYMNASTS

Roma Aleksandravičienė[1, 2], Jovita Liaudeneckaitė[3], Ramunė Liaugminienė[1], Arvydas Siaurodinas[1], Loreta Stasiulevičienė[2]
Aleksandras Stulginskis University[1], Kaunas, Lithuania
Lithuanian Academy of Physical Education[2], Kaunas, Lithuania
Kaunas Vocational Training Centre for Business Specialists[3], Kaunas, Lithuania

ABSTRACT

Research background and hypothesis. Physical working capacity by PWC_{170} test allows estimating physical preparation of athletes' bodies, but these indices may not be directly linked to their sports achievements.

Research aim. The aim of this study was to identify and assess physical working capacity characteristics of differently trained and aged female athletes.

Research methods. The study included 40 subjects: young athletes (juniors) (12–14-years-old girls) and students of Lithuanian Academy of Physical Education – studying in aerobic gymnastics specialization. According to performance (training) level they were divided into the following groups: juniors (n = 10), beginners (n = 10), moderately trained (n = 10) and well-trained (n = 10) representatives of aerobic gymnastics. The testing included anthropometric measurements, heart rate (HR) measurements (HR values were recorded using heart rate measuring device "Sigma PC-15", Germany), and PWC_{170} tests. Athletes carried out two loads of physical activity at different intensities with a duration of 3 and 5 minutes (the rate of stepping (30 times per minute) was regulated according to the tempo of music that was specially prepared in the recording studio).

Research results. We found that the differences in physical working capacity between well trained gymnasts and the beginners were not statistically significant. We established similar values of PWC_{170} in moderately trained and junior groups; statistically significant difference ($p < 0.05$) was established only comparing the latter two groups with well-trained athletes.

Discusion and conclussions. The results showed that physical working capacity of well trained aerobic gymnastics athletes (participating in international competitions, world and European Championships) had not reached very high training level, but they were assessed as adequately trained. Physical working capacity of beginners was satisfactory and the indices of moderately trained (with twice more training and competition experience) and junior athletes were very low.

Keywords: aerobic gymnastics, physical working capacity, $PWC_{170,}$ heart rate.

INTRODUCTION

Aerobic gymnastics is a sport that requires the ability to perform high intensity aerobic movements with music combining them with the complex exercise of strength, jumps, flexibility and balance. Like other types of gymnastics, aerobic gymnastics requires aerobic and anaerobic endurance, very good flexibility, strength and excellent coordination. All these physical skills must be performed during the competition routine performing a complex of aerobic movements at high intensity and combining them with difficulty elements (jumps, dynamic, static strength and flexibility) without any intervals of rest (Aleksandravičienė, 2005). This sport is suitable for physically well-

prepared individuals who develop not only physical abilities, but also improve the functional capacity of their and respiratory systems (Aleksandravičienė et al., 2004). Aerobic gymnastics is one of the newest branches of gymnastics, so the data on the physiological changes predominant in this kind of sports are extremely scarce in the special literature on the subject. Spanish *scientists* (Rodriguez et al., 1998) investigated elite aerobic gymnastics athletes (three of them were world champions), who performed their competition routines (individual, mixed pairs and trio) (*Aerobic Gymnastics Code of Points* 2009–2012, 2009). The heart rate and oxygen consumption were continuously recorded during exercise and recovery phase, as well as blood lactate concentration measured during recovery. It was established that some subjects' (lower level athletes) maximum aerobic capacity indices were higher than those of the top level athletes (world champions) and lactate concentration of some world champions was higher twice (from 9.4 to 20 mmol/l).

The changes in heart rate values during specific competition routine of Lithuanian aerobic gymnasts were not significantly different from those of the world's elite (99% of the maximum HR) athletes and reached 95% of the maximum HR (Aleksandravicienė, 2005). However, HR values of aerobic gymnasts during competitive activities were significantly higher compared to the HR values of artistic gymnastics athletes during competition exercise with the ball, their HR maximum was 88.2%, and blood lactate concentration was only 4 mmol/l (Guidetti et al., 2000). This was mostly influenced by the structure – contest of competition routine, while the HR values at the beginning of routine in aerobic gymnastics and in artistic gymnastics had already reached a fairly high level. The gymnastics competitive routine is performed without rest intervals and fast increase in HR values at the beginning of routine is explained by some researchers by emotional stress and the fact that for athletes it is difficult to stand in a static position (posture) (Alexander, 1991). Some investigations in aerobic gymnastics activities were performed assessing energy consumption during competitive routine. Research found that about 50% of the total energy consumed during the competitive exercise was produced by aerobic ATP resynthesis (Aleksandravičienė, 2005).

We did not find any data assessing physical working capacity of female aerobic gymnastics athletes. At present telemetric systems are used to estimate aerobic capacity (Wideman et al., 1996; Maiolo et al., 2003), but these devices not always can be used by many sports specialists. Therefore, PWC_{170} test was chosen to assess the physical working capacity, as it is also widely used in sports medicine centers, sports clubs testing the athletes in different kind of sports (Bloomfield et al., 1990).

The study carried out provides additional knowledge of physical working capacity of aerobic gymnastics athletes. Thus, the aim of this study was to identify and assess physical working capacity characteristics of differently trained and aged female aerobic gymnastics athletes.

RESEARCH METHODS

The subjects. The study included 40 subjects: young athletes (12–14-year-old girls) and students of the Lithuanian Academy of Physical Education studying in aerobic gymnastics specialization. According to performance (training) level they were divided into the following groups: juniors (training experience in aerobic gymnastics – 3 years), beginners (training experience in aerobic gymnastics 1.5 year and no experience in competitions), moderately trained (athletes with experience in national competitions) and well trained representatives of aerobic gymnastics (members of the national team, who participated in world and European championships).

Experimental procedure. All participants were informed about the aim of the study. All subjects had no extra training on the day of testing. Before the testing all participants performed 5-minute specific warm up including low impact aerobics steps ant stretching exercises. The age and anthropometric characteristics of all the subjects are presented in Table 1.

All subjects underwent two sessions of testing of physical activity of two different intensities with a duration of 3 and 5 minutes. All athletes were asked not to train vigorously on the evening before both tests. The first exercise included: 3 min stepping (the height of platform was 21.5 cm) with the frequency of 30 times per minute. The rate of stepping (30 times per minute) was regulated according to the tempo of music that was specially prepared in the recording studio. The second exercise included stepping at the same frequency for 5 minutes (the height of the platform was 43 cm). Between the first and the second physical activity the rest time interval of 3 minutes was allowed. Before the test, as well as after the first and the second physical activities HR values were

Table 1. **Anthropometric characteristics and age of aerobic gymnasts**

Groups of the subjects	Number of the subjects	Age, years (mean (SD))	Height, cm (mean (SD))	Body mass, kg (mean (SD))
Beginners	10	19.8 (0.75)	168.3 (4.24)	59.2 (5.94)
Moderately trained	10	21.5 (1.21)	164.7 (5.04)	56.5 (4.90)
Well-trained	10	21.6 (1.50)	163.2 (3.52)	53.5 (3.50)
Young athletes	10	13.1(1.79)	155.1 (9.97)	46.1 (9.86)

recorded using heart rate measurement device "Sigma PC-15", Germany).

According to the obtained data we calculated the indices of physical working capacity using the following formula (Raslanas, Skernevičius, 1998):

$$PWC_{170} = N_1 + \frac{(N_2 - N_1)(170 - f_1)}{(f_2 - f_1)},$$

where N_1 – the first physical activity, kgm/min; N_2 – the second physical activity, kgm/min; f_1 – HR at the end of the first physical activity, beats/min; f_2 – HR at the end of the second physical activity, beats/min.

Further we determined PWC_{170} per kilogram of body weight:

$$\frac{PWC_{170}}{kg},$$

where PWC_{170} – physical working capacity; kg – body weight.

Table 2. **Evaluation of physical working capacity**

Rating	PWC_{170}, kgm/min/kg
Very high training level	25 and more
High training level	21–25
Satisfactory training level	16–20
Low training level	12–15
Very low training level	less than 12

Statistics calculations. The data were calculated using computer programs *Microsoft Excel* and *Statistica for Windows 5.0*. Descriptive data are presented as mean and standard deviation. Arithmetic averages of measurements were compared using the nonparametric Wilcoxon test and Student's t test. The level of significance was set at 0.5.

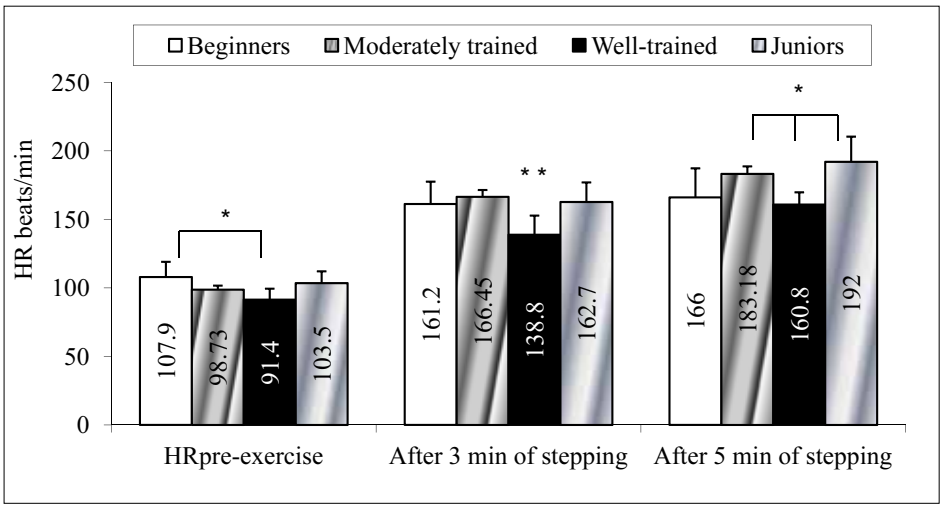
RESEARCH RESULTS

We established that the highest heart rate pre-exercise period ($HR_{pre\text{-}exercise}$) was in the group of beginners 107.9 (11.1), while in the junior group it was 103.5 (8.6) beats/min and $HR_{pre\text{-}exercise}$ of moderately trained athletes was 98.7 (8.9) beats/min, the differences among these groups were not statistically significant ($p > 0.05$). Statistically significant difference ($p < 0.05$) of $HR_{pre\text{-}exercise}$ was found between well-trained gymnasts (91.4 (8.0) beats/min.) and beginner athletes. The HR values after 3 minutes of stepping exercise of well trained group (138.8 (14.0) beats/min) were statistically significantly lower ($p < 0.05$) than those in other three groups. The HR after first physical load was almost identical in junior (162.7 beats/min) and beginner groups (161.2 beats/min) and it slightly differed from moderately trained athletes (166.5 beats/min). The results showed that HR values after the second physical load (5 minutes of stepping exercise) were not statistically different ($p > 0.05$) between beginners and well trained athletes and they were respectively – 160.8 (9.0) beats/min and 166 (21.3) beats/min. HR values of well-trained athletes (after 5 minutes physical load) were statistically significantly lower ($p < 0.05$) than moderately trained athletes (183.18 (13.7)) and juniors (192 (18.4)). The HR of beginners athletes after the first and second physical loads were similar (respectively 161 (21.3) and 166.5 (16.3) (Figure 1).

The results showed that HR recovery values after 5-minutes exercise were lower in the group of well-trained aerobic gymnastics athletes (100.6 (6.9) beats/min) and they statistically significantly differed ($p < 0.05$) from those in the other three gymnast groups. The HR recovery values of beginners, moderately trained and junior athletes were similar and the differences between them were not statistically significant ($p > 0.05$) (respectively were 113.8 (11.8) beats/min, 116.9 (10.7) beats/min and 120.3 (9.4) beats/min) (Figure 2).

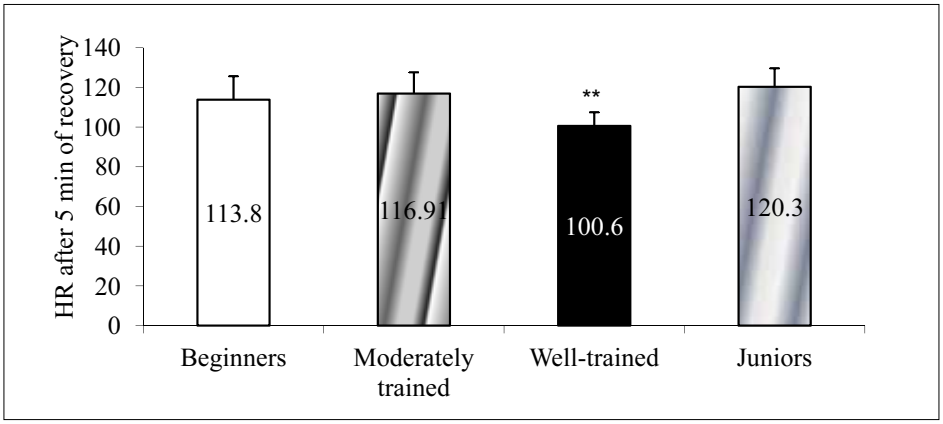
Physical working capacity was established using PWC_{170} test. We found that the difference between well-trained and beginner athletes was not statistically significant ($p > 0.05$) (well-trained athletes' PWC_{170} was 22.0 (3.5) kgm/min), beginners' group – 15.8 (5.5)). We found similar

Figure 1. **HR values of aerobic gymnastics athletes during the first minute of recovery, 3 minutes and 5 minutes after physical load**



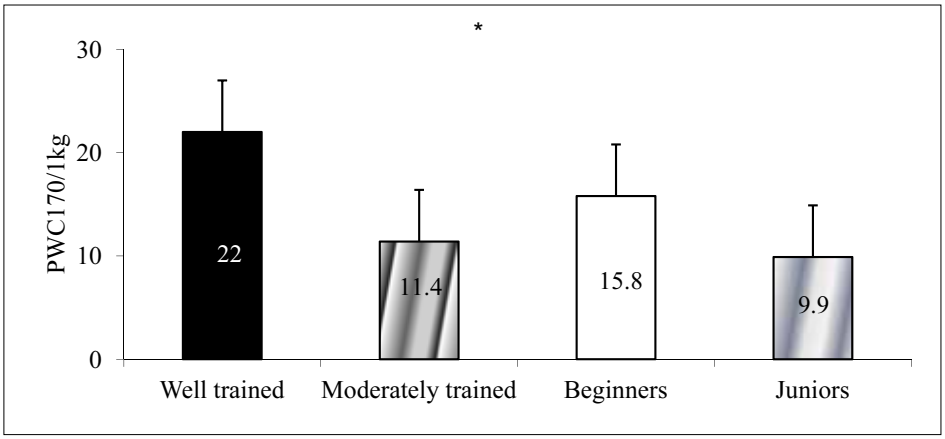
Note. * – statistically significant difference ($p < 0.05$); ** – statistically significant difference ($p < 0.05$) compared to other three groups.

Figure 2. **HR values of aerobic gymnastics athletes during recovery**



Note. ** – statistically significant difference ($p < 0.05$) compared to other three groups.

Figure 3. **The indices of physical working capacity of aerobic gymnastics athletes (per kilogram of body weight)**



Note. * – statistically significant difference ($p < 0.05$).

values of PWC_{170} in moderately trained and junior groups: there were 11.4 (5.5) kgm/min and 9.9 (4.3) kgm/min. The statistically significant difference ($p < 0.05$) was established only comparing these two groups with well-trained athletes (Figure 3).

DISCUSSION

The present study was aimed to identify and assess physical working capacity characteristics of aerobic gymnastics athletes. As we expected, the lower $HR_{pre\text{-}exercise}$ was in well-trained aerobic gymnastics group, but it was not significantly different from beginner group. It was established that HR values after both physical loads (3- and 5-minute stepping exercise of the same intensity) increased by 50% and more in all groups. There was hardly any difference in the relative means of HR after the first physical load, when the highest value in the moderately trained group reached 68.6%. The highest HR values after the second physical load (as we expected) were in junior group.

It may be explained by higher heart rate of children which is variable and depends on the child's age (Saris, 1985). However, the HR relative changes after 5-minute stepping exercise of young athletes coincided with those of the well-trained gymnasts and reached 85.5%. It was probably influenced by the fact that before taking up aerobic gymnastics well-trained athletes might have been practicing artistic gymnastics for a number of years. Besides, it is known that aerobic capacity of representatives of aerobic gymnastics is by 25% higher than the normative values of girls at similar age, but it is considerably (about 35%)) lower than the respective indices of athletes developing endurance (Aleksandravičienė, 2005). The results of our study do not coincide with the findings of other authors claiming that after regular classes in aerobics gymnastics there is a significant decrease in the HR of women going in for sports (Garber et al., 1992).

At present, telemetric systems are used to estimate aerobic capacity (Wideman et al., 1996; Maiolo et al., 2003), but these devices not always can be used by many sports specialists. Therefore, PWC_{170} test was chosen to assess the physical working capacity as it is also widely used in different kinds of sports (Bloomfield et al., 1990). In our research HR was recorded during the recovery after two stepping loads. The results show that the best recovery was in well-trained gymnasts' group. This confirms the results of other authors who argue that endurance training improves maximal oxygen consumption, increases the working muscle capillary network, reduces the heart rate during exercise at the same intensity (Kubukeli et al., 2002). It was found that after strenuous exercise HR decreases to a level that is higher than it was before the exercise. It depends on the duration of exercise intensity: the heavier the load, the longer the recovery. In our study, in beginner and moderately trained groups HR recovery values were quite close to the $HR_{pre\text{-}exercise}$. HR during recovery in junior group was the highest, but the relative values were similar to those in moderately trained group (60 and 56%).

It is known that physical working capacity (PWC_{170}) depends on athlete's sports activity. The findings of other authors (Svannshvili et al., 2009) established that the PWC_{170} of athletes in cyclic kinds of sports was 21.8 (0.6). In our research we found similar values of physical working capacity in the group of well-trained subjects where PWC_{170} was 22.0 (6.1). But these results were lower compared to those of endurance-trained athletes (PWC_{170} 23.1 (4.1) kgm/min) and higher than those of speed-power trained athlete's (PWC_{170} 20.3 (2.8) kgm/ min).

Our results indicated that physical working capacity of moderately trained and junior gymnasts were similar. We did not establish any statistically significant differences of physical working capacity of moderately trained (PWC_{170} 11.4 (5.9), beginner and junior aerobic gymnastics athletes (PWC_{170} 9.9 (5.4)) while in the beginner group, the PWC_{170} indices were about 30% higher (15.8 (6.3)) than those in the other two groups.

Results of our study confirm the hypothesis that physical working capacity by PWC_{170} test allows estimating physical preparation of athletes' bodies, but these indices may not be directly linked to their sports achievements.

CONCLUSIONS AND PERSPECTIVES

The results showed that physical working capacity of well-trained aerobic gymnastics athletes (participating in international competitions, world and European championships) had not reached very high training level, but they were assessed as adequately trained. Physical working capacity of beginner gymnasts was satisfactory and the indices of moderately trained (with twice more training and competition experience) and junior athletes were very low.

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SKIRTINGO MEISTRIŠKUMO IR AMŽIAUS AEROBININKIŲ FIZINIO DARBINGUMO VERTINIMAS

Roma Aleksandravičienė[1, 2], Jovita Liaudeneckaitė[3], Ramunė Liaugminienė[1], Arvydas Siaurodinas[1], Loreta Stasiulevičienė[2]

Aleksandro Stulginskio universitetas[1], Kaunas, Lietuva

Lietuvos kūno kultūros akademija[2], Kaunas, Lietuva

Kauno paslaugų verslo darbuotojų profesinio rengimo centras[3], Kaunas, Lietuva

SANTRAUKA

Tyrimo pagrindimas ir hipotezė. Fizinio darbingumo nustatymas taikant PWC_{170} testą leidžia įvertinti sportininko organizmo fizinį pasirengimą, tačiau šie rodikliai ne visada turi tiesioginį ryšį su sportiniais rezultatais.

Tikslas – nustatyti ir įvertinti skirtingo meistriškumo ir amžiaus aerobininkių fizinį darbingumą.

Metodai. Buvo tiriama 40 respondenčių: jaunosios sportininkės (jaunės – 12–14 m. mergaitės) ir Lietuvos kūno kultūros akademijos studentės – aerobinės gimnastikos specializantės. Tiriamosios pagal meistriškumą buvo suskirstytos į šias grupes: jaunosios sportininkės (jaunės) (n = 10), pradedančiosios (n = 10), pažengusios, (n = 10) ir didelio meistriškumo (n = 10). Testavimo metu atlikti antropometriniai matavimai, pulsometrijos ir PWC_{170} testai. Taip pat buvo atliekami du skirtingo intensyvumo fiziniai krūviai, kurių trukmė – 3 ir 5 minutės (laipiojimo tempas (30 kartų per minutę) buvo reguliuojamas pagal muzikos greitį).

Rezultatai. Fizinio darbingumo rodikliai tarp didelio meistriškumo ir pradedančiųjų aerobininkių statistiškai reikšmingai nesiskyrė. PWC_{170} reikšmės panašios pažengusiųjų ir jaunių grupėse, statistiškai reikšmingas skirtumas ($p < 0.05$) buvo nustatytas tik lyginant pastarąsias dvi grupes su didelio meistriškumo sportininkėmis.

Aptarimas ir išvados. Rezultatai rodo, kad didelio meistriškumo aerobininkių (dalyvaujančių tarptautinėse varžybose, pasaulio ir Europos čempionatuose) fizinio darbingumo rodikliai nebuvo labai geri, o atitiko tik gerą treniruotumo vertinimą. Tuo tarpu pradedančiųjų aerobininkių fizinio darbingumo rodikliai buvo geresni negu pažengusiųjų sportininkių, turinčių dvigubai didesnį treniruočių stažą ir varžybinę patirtį. Pažengusiųjų ir jaunųjų sportininkių, turinčių tokį patį treniruočių stažą, fizinis darbingumas statistiškai reikšmingai nesiskyrė ir atitiko mažą treniruotumą.

Raktažodžiai: aerobinė gimnastika, fizinis darbingumas, $PWC_{170,}$ širdies susitraukimų dažnis.

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Corresponding author **Roma Aleksandravičienė**
Lithuanian Academy of Physical Education
Sporto str. 6, LT-44221 Kaunas
Lithuania
Tel +370 686 36488
E-mail romanellagrande@gmail.com

THE RESIDUAL EFFECT OF PRIOR DROP JUMPS ON CARDIO RESPIRATORY PARAMETERS DURING MODERATE CYCLING IN YOUNG WOMEN

Neringa Baranauskienė, Arvydas Stasiulis
Lithuanian Academy of Physical Education, Kaunas, Lithuania

ABSTRACT

Research background and hypothesis. Unaccustomed prior drop jumps (PDJ) can cause muscle damage with concomitant delayed onset muscle soreness (DOMS) and decreased concentric contraction performance efficiency, but the residual effect of PJD on cardio respiratory system parameters during moderate cycling exercise (MC) remains equivocal. We suppose that DOMS, induced of PDJ, has altered cardio respiratory system parameters during MC exercises.

Research aim of the study was to assess the residual effect of *100 prior drop jumps* on cardio respiratory system parameters kinetics during moderate cycling exercise.

Research methods. On four different days 10 women performed one increasing and three (control, 45 min and 24 h after 100 drop jumps) MC (Ergoline-800, Germany) exercises. The cadence of cycling was 70 rpm. The oxygen uptake ($\dot{V}o_2$), carbon dioxide output ($\dot{V}co_2$); minute ventilation (V_E) and heart rate (*HR*) were continuously recorded during MC. Subjects rated their perceived exertions at the end of MC, and the DOMS was rated 24 h after PDJ.

Research results. After 24 h the subjects felt moderate DOMS (5.0 (2.79)) according to 10 point scale. The $\dot{V}o_2$; $\dot{V}co_2$ and *HR* kinetics were unaltered by moderate DOMS after 45 minutes and 24 hours, but V_E tended to increase 45 minutes after PDJ. The negative correlation between DOMS and $\dot{V}o_2$ (r = –0.52) was observed.

Discussion and conclusion. Prior drop jumps seem not to have significant residual effect on cardio respiratory parameters kinetics after 45 minutes or 24 hours, but they tend to increase V_E after 45 minutes of recovery during moderate cycling exercise in young women.

Keywords: delayed onset muscle soreness, oxygen uptake, constant load.

INTRODUCTION

Unaccustomed eccentric exercise, which involves active lengthening of muscle, induce delayed muscle soreness (DOMS) with concomitant damage and disarrangement of muscle fibers (Hortobagy et al., 1998; Stupka et al., 2000; Laanksonen et al., 2006; Malm, Yu, 2012), elevates creatine kinase activity (Gleeson et al., 1995; Stupka et al., 2000; Skurvydas et al., 2010; Chen et al., 2011) and reduces muscle force production and performance (Laanksonen et al., 2006; Semmler et al., 2007; Chen et al., 2010; Gorianovas et al., 2010; Skurvydas et al., 2010).

Residual effect of prior drop jumps (PDJ) as a form of eccentric – concentric exercise on cardio respiratory system parameters during constant cycling remains equivocal. No residual effect of PDJ has been observed on $\dot{V}O_2$, minute ventilation (V_E) and heart rate (*HR*) during the steady state phase of moderate cycling (70 W), but increased $\dot{V}O_2$ and V_E during the steady state phase of heavy cycling one hour after PDJ have been reported in men (Ratkevičius et al., 2006). Moreover, the moderate DOMS induced of bench stepping exercise did not appear to impact $\dot{V}O_2$ during

heavy cycling 48 and 72 h after eccentric exercise in women (Schneider et al., 2007) or eccentric squatting exercises in men (Gleeson et al., 1995; Moysi et al., 2005; Twist, Eston, 2009). Contrary, significant increases in $\dot{V}O_2$ during steady state of moderate intensity running performed one hour after prior drop jumps with straight legs have been found in women (Zaičenkovienė, Stasiulis, 2010) as well as increased V_E during moderate and severe cycling performed 48 hours after comprising squats in men (Davies et al., 2009). Nevertheless, we could not find data about the residual effect of prior eccentric-concentric exercises on cardio respiratory parameters within 24 hours of recovery during moderate intensity cycling exercise (MC) in women.

The aim of the study was to assess the residual effect of 100 prior drop jumps PDJ on oxygen uptake ($\dot{V}o_2$), carbon dioxide output ($\dot{V}co_2$); minute ventilation (V_E) and heart rate (*HR)* during moderate cycling exercise MC in young women.

RESEARCH METHODS

Participants. Ten healthy young women (anthropometry and physical characteristics are presented in Table 1) volunteered to participate in this study after giving written informed consent. The subjects were physically active but did not take part in any formal physical exercise or sport program. The experimental protocol was approved by the Lithuanian Ethical Committee of Kaunas University of Medicine and conducted in accordance with the Declaration of Helsinki.

Ergometer cycling and data collection. The electronically braked cycle ergometer "Ergometrics–800S" (*Ergo Line, Medical Measurement Systems*; Binz, Germany) was used. The pedal cadence was 70 repetitions per minute. Subjects breathed through low resistance mouthpiece and pulmonary gas exchange parameters ($\dot{V}o_2$; $\dot{V}co_2$; V_E) were measured breath-by-breath using wireless portable spirometry system "Oxycon mobile" (*Viasys Healthcare*; California, USA). Subjects' *HR* was recorded simultaneously by *HR* monitor (S810 Polar, Finland). The seat and handlebar positions on the cycle ergometer were adjusted for each subject prior to initial exercise test and maintained in that position for the subsequent exercise tests.

Incremental cycling exercise. The first and the second ventilation thresholds (VT_1 and VT_2, respectively) and peak oxygen uptake ($\dot{V}O_{2peak}$) were evaluated using an incremental cycling exercise (ICE) test (two watts (W) every five seconds). The test was started by three min of baseline pedalling at 20 W and continued until the intensity of cycling could not be maintained at the required level for longer than 10 s. The average value of $\dot{V}O_2$ over the last 30 s of cycling was referred to as $\dot{V}O_{2peak}$ and the VT_1 and VT_2 were determined from the result of the ICE.

Moderate cycling exercise. The intensity of MC test was 80% of VT_1. The MC was preceded by three min of baseline pedalling at 20 W, then six min MC and three min baseline (20 W) were performed.

Cardiorespiratory system parameters kinetics analysis. Cardio respiratory system parameters ($\dot{V}o_2$; $\dot{V}co_2$; V_E; *HR)* kinetics during MC were determined using a mono – exponential model with independent time delays. The following equation was used to model mono – exponential response kinetics:

$$y\,(t) = y\,(b) + A\,(1 - e^{-t/\tau}),$$

where y (t) represents the variable of $\dot{V}o_2$; $\dot{V}co_2$; V_E and *HR* at any time (t); y(b) is the baseline (average value of last 30 s during cycling at 20W) of $\dot{V}o_2$; $\dot{V}co_2$; V_E and *HR*; A is the phase II component amplitude of *y* response, and $(1 - e^{-t/\tau})$ is the exponential function describing the rate at which *y* is rising towards the phase II component amplitude. In the exponential function, t is time; τ is the phase II component time constant. $\dot{V}o_2$; $\dot{V}co_2$ and V_E data were fit from the phase II response (phase I – "cardiodynamic" increase were removed) to the end of MC, (Rossiter et al., 1999). *HR* data were modeled mono – exponentially from the onset to the end of MC.

Table 1. **Subject's descriptive characteristics. Values are means (SD)**

Subjects (n = 10)	Age, yrs	Weight, kg	Height, m	Free fat mass, kg	Maximal power, W	VO_{2peak}, ml/kg/min
Mean (SD)	21.7 (1.9)	61.1 (4.6)	1.71 (0.06)	45.1 (2.3)	199 (21)	35.03 (3.84)

Note. VO_{2peak} – relative peak oxygen uptake.

Prior drop jumps. Subjects performed 100 drop jumps from a 0.47 m stage with 20 s of recovery between every drop jump. After drop the subject got to amortization phase while the knee joints were flexed at the angle of 90° when a vertical jump (hands on hips) was performed.

Blood lactate concentration. Blood sample (25 µl) for the measurement of blood lactate concentration ([La]) (Accutrend Portable Lactate Analyzer, Roche, Germany) was taken from fingertips.

Muscle soreness and perceived exertion rating. DOMS was reported subjectively performing one squat using a visual scale of 0–10 points in which 0 represented no pain and 10 represented intolerably intense pain.

The subject was asked to rate their perceived exertion (RPE) using the Borg scale, ranging from 6 to 20 (7 – very, very light; 19 – very, very heavy).

Experimental protocol. Subjects reported to the laboratory on four separated days within a two-three week period. Exercise testing was performed at approximately the same time of day for each subject. The first session was used to familiarize subjects with the testing equipment and procedures. In the same session, each subject performed an ICE test (after five min warm up and five min rest). Subsequently, subjects performed control (CON) MC in the second session (no sooner than after 48 hours of rest after ICE). On the third occasion subject performed PDJ and after 45 minutes (45'PDJ) they performed the same MC. On the fourth occasion subject performed MC 24 hours after PDJ (24h PDJ). The DOMS was rated 24 h after PDJ. The [La] was taken and each subject was asked to rate her perceived exertion at the end of MC tests.

Statistical analysis. $\dot{V}o_2$ and V_E were analyzed using two-way repeated measures ANOVA design evaluating time and testing conditions (CON; 45'PDJ; 24h PDJ) as the main effects. $\dot{V}o_2$; $\dot{V}co_2$; V_E and *HR* parameters kinetics was analyzed using paired one – way ANOVA (CON; 45'PDJ; 24h PDJ). Significant results were further analyzed using Bonferroni corrections. Statistical significance was accepted when $p < 0.05$. All data are reported as the means (SE).

RESEARCH RESULTS

The power output of MC was 82 (16) W, which corresponds to 40.7 (5.1) percent of maximal power of ICE. There were no significant differences in perceived exertion rating during MC under 45'PDJ (11.7 (1.4) and 24 h PDJ (11.4 (1.1)) compared with CON – (11.7 (1.5)).

The absolute $\dot{V}o_2$ (Figure 1) unaltered during MC under different testing conditions (CON; 45'PDJ; 24h PDJ). The V_E (Figure 2) increased during 45'PDJ compared with CON, but the elevation was not statistically significant ($p = 0.51$).

Table 2 shows mean values of base line (b), fast components A and τ of $\dot{V}o_2$, $\dot{V}co_2$, V_E and *HR* respectively, during MC, but there were no significant differences under different testing conditions (CON; 45'PDJ; 24h PDJ). The [La] did not differ 45'PDJ (3.43 (0.98) mmol/L) and 24h PDJ (3.67 (0.98) mmol/L) compared with CON (3.47 (0.69) mmol/L) at the end of MC. Negative moderate, but not statistically significant ($p = 0.13$) relationships between $\dot{V}O_2$ during 45' PDJ and DOMS (Figure 3) and $\dot{V}O_2$ during 24h PDJ and DOMS (Figure 4) were observed. The mean value of DOMS was 4.8 (2.5) points on a 10 point scale.

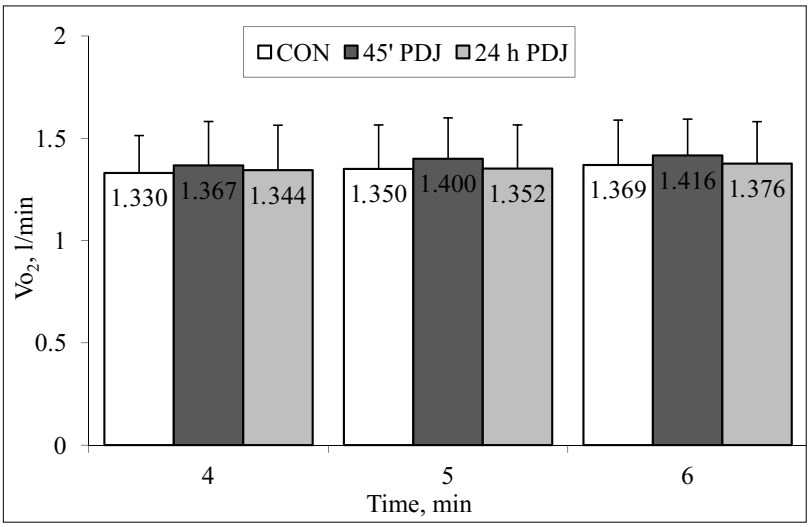


Figure 1. **Group mean response of oxygen uptake ($\dot{V}o_2$) during moderate cycling exercise steady state (4 – 6 minutes) under control condition (CON); 45 minutes (45'PDJ) and 24 hours after prior drop jumps (24h PDJ)**

Table 2. **Cardiorespiratory parameter responses to moderate intensity cycling exercise under control 45 min and 24 hours after prior drop jumps**

Parameters	Control conditions	45 min after prior drop jumps	24 h after prior drop jumps
$\dot{V}o_2$ baseline, l min^{-1}	0.700 (0.071)	0.692 (0.041)	0.714 (0.061)
A $\dot{V}o_2$, l min^{-1}	0.630 (0.170)	0.700 (0.170)	0.640 (0.184)
τ_1 $\dot{V}o_2$, s	32.65 (8.33)	32.85 (9.73)	29.22 (8.75)
$\dot{V}co_2$ baseline, l min^{-1}	0.550 (0.064)	0.554 (0.056)	0.563 (0.069)
A $\dot{V}co_2$, l min^{-1}	0.74 (0.17)	0.80 (0.18)	0.76 (0.19)
τ $\dot{V}co_2$, s	58.25 (10.41)	53.8 (23.00)	56.9 (21.18)
V_E baseline, l min^{-1}	18.82 (2.64)	19.03 (2.77)	19.01 (2.73)
A V_E, l min^{-1}	19.74 (4.68)	21.96 (4.46)	19.82 (5.38)
τ V_E, s	77.34 (18.18)	68.62 (19.45)	76.04 (34.59)
HR baseline, 1 min^{-1}	103.4 (13.0)	104.0 (10.1)	98.7 (8.3)
A *HR*, l min^{-1}	40.4 (4.7)	43.7 (5.0)	39.7 (5.3)
τ *HR*, s	61.52 (12.12)	57.59 (15.11)	55.65 (12.51)

Note. Values are means (SD). $\dot{V}_{O_2}$ – oxygen uptake; $\dot{V}_{CO_2}$ – carbon dioxide output; V_E – pulmonary ventilation; *HR* – heart rate; A – fast component amplitude; τ – fast component time constant.

Figure 2. **Group mean response of pulmonary ventilation (V_E) during moderate cycling exercise steady state (4–6 minutes) under control condition (CON); 45 minutes (45'PDJ) and 24 hours after prior drop jumps (24h PDJ)**

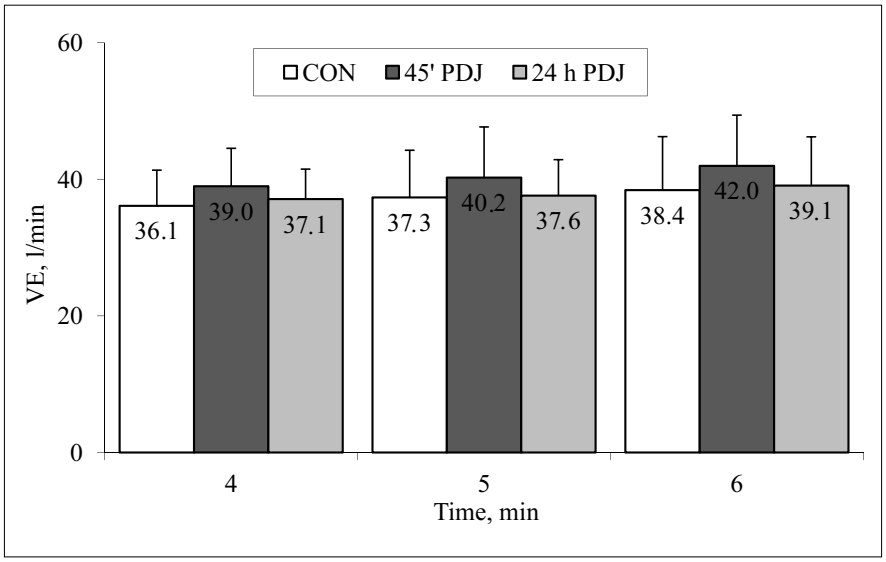
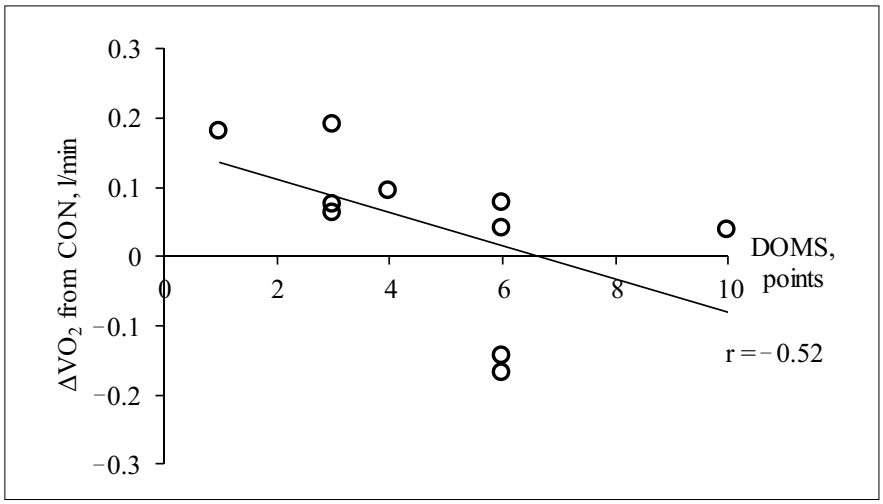


Figure 3. **The correlation between changes (from control moderate cycling conditions (CON)) on oxygen uptake (ΔVO_2) during moderate cycling 45 minutes after prior drop jumps and delayed onset muscle soreness (DOMS) 24 hours after prior drop jumps**



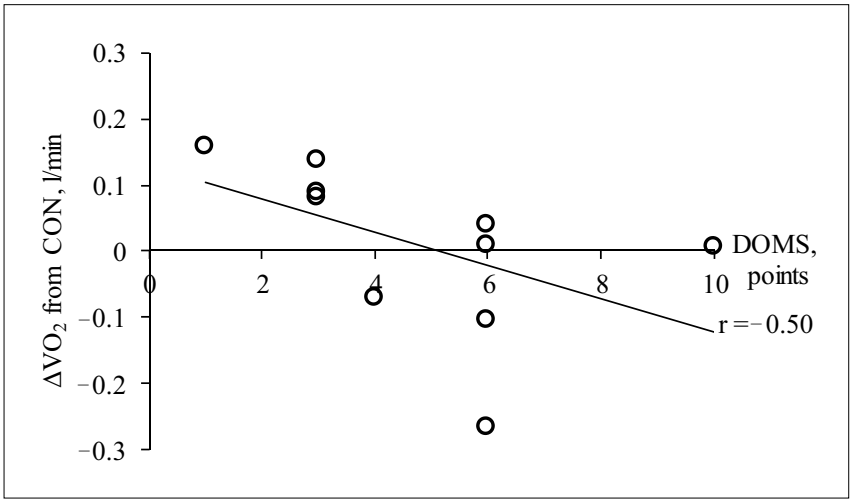


Figure 4. **The correlation between changes (from control moderate cycling conditions (CON)) on oxygen uptake (ΔVO_2) during moderate cycling 24 hours after prior drop jumps and delayed onset muscle soreness (DOMS) 24 hours after prior drop jumps**

DISCUSSION

This is the first study examining cardiorespiratory parameters response to PDJ 45 minutes and 24 hours after PDJ during MC in young women. The main finding of this study is that PDJ does not change the steady state of $\dot{V}o_2$ and cardiorespiratory parameters phase II kinetics, but has a tendency to elevate V_E during moderate cycling 45 minutes after PDJ.

As expected, moderate DOMS was induced in thighs muscles after 24 hours in the present study. Drop jumps from a 0.4–0.5 m high platform (Nielsen et al., 2005; Ratkevičius et al., 2006; Skurvydas et al., 2007; Gorianovas et al., 2010) either bench stepping exercise (Gleeson et al., 1995; Schneider et al., 2007) or squats with a load corresponding 70–150 percents of body mass (Moysi et al., 2005; Davies et al., 2009) are commonly used to induce DOMS, which is first felt 6–10 hours post exercise and peaks between 24 and 78 hours post exercise. Unfortunately, changes in force generating capacity of thigh muscles and CK activity in blood were not measured in our study, but our experiment was performed like in the previous study and represented maximal voluntary contraction (MVC) decrease by ~20% as measured one hour post-exercise (Skurvydas et al., 2000) and still shows deficit within 72 hours and CK activity increase within 24–48 hours of recovery (Nielen et al., 2005; Skurvydas et al., 2007; Gorianovas et al., 2010). Thus, it is reasonable to assume that muscle damage was induced in the present study.

Previously study results showed no residual effect of on $\dot{V}O_2$ during heavy (Gleeson et al., 1995; Moysi et al., 2005; Schneider et al., 2007) and moderate (Davies et al., 2009) cycling performed 24–72 hours after eccentric exercise in men or women. However, in contrast, increased $\dot{V}O_2$ has been reported during steady state phase at three different cycling intensities (~40; 50 and 65% of $\dot{V}O_{2peak}$) in men (Ratkevičius et al., 2006) and during moderate running in women one hour after eccentric exercise (Zaičenkovienė, Stasiulis, 2010). Sustaining these findings, it is possible to suppose that prior eccentric exercises elevate $\dot{V}O_2$ of steady state phase during constant cycling and running one hour after DOMS inducing exercise, but in the present study unaltered absolute $\dot{V}O_2$ of steady state phase during MC performed 45 minutes after PDJ is in contrast with this assumption. However, unaltered $\dot{V}O_2$ during MC performed 24 h after PDJ concurs with previous studies, demonstrating no residual effect on $\dot{V}O_2$ during constant cycling within 24–72 hours post eccentric exercises (Gleeson et al., 1995; Moysi et al., 2005; Schneider et al., 2007; Davies et al., 2009). Moreover, in the present study, negative insignificant correlation which has been observed between DOMS and $\dot{V}o_2$ (see Figures 3 and 4) did not confirm DOMS negative impact on $\dot{V}o_2$. Hence we may infer that eccentric exercise has slight residual effect within the first hour of recovery, with no alteration on $\dot{V}O_2$ 24–72 during constant cycling. However, elevated V_E and [La] and HR have been previously observed (Gleeson et al., 1995; Schneider et al., 2007; Davies et al., 2009) with increases in ratings of perceived exertion during constant exercise (Gleeson et al., 1995; Zaičenkovienė, Stasiulis, 2010) 1–48 hours after eccentric exercise. In the present study, V_E tended to increase after 45 minutes, but [La] and RPE were unaltered after PDJ 45 minutes and 24

hours of recovery. Increases in V_E observed whilst exercising with DOMS have been associated with the additional recruitment of type II fibers and a concomitant rise in the rate of glycogenolysis (Chein et al., 2007) and in turn increased RPE (Davies et al., 2009). Contrary, increases in RPE with no alteration in V_E have been found (Zaičenkovienė, Stasiulis, 2010) during moderate running, conversely, elevated V_E with no changes in a sense of effort have been observed during moderate exercise one hour after PDJ in the present study. The concert between V_E, [La] and RPE are still contradictory. Despite the unclear reason of elevation in V_E, it is one of the most sensitive cardiorespirarory parameters which could be altered by eccentric exercise.

CONCLUSIONS AND PERSPECTIVES

In conclusion, prior drop jumps have induced delayed onset muscle soreness after 24 hours of recovery. The delayed onset muscle soreness does not change during the steady state of oxygen uptake, carbon dioxide output and heart rate phase II kinetics both after 45 minutes and 24 hours after prior drop jumps, but it tends to elevate ventilation 45 minutes after prior drop jumps during moderate cycling exercise. The delayed onset muscle soreness does not alter blood lactate concentration and perceived exertion ratings during moderate cycling exercise in young women.

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ŠUOLIŲ PRIEŠKRŪVIO POVEIKIS MERGINŲ KVĖPAVIMO BEI ŠIRDIES IR KRAUJAGYSLIŲ SISTEMŲ RODIKLIŲ KAITAI ATLIEKANT VIDUTINIO INTENSYVUMO KRŪVĮ VELOERGOMETRU

Neringa Baranauskienė, Arvydas Stasiulis
Lietuvos kūno kultūros akademija, Kaunas, Lietuva

SANTRAUKA

Tyrimo pagrindimas ir hipotezė. Neįprasti nušokimai vertikaliu šuoliu (NVŠ) sukelia raumenų pažaidą, lydimą vėluojančio raumenų skausmo ir sumažėjusio koncentrinių susitraukimų atlikimo veiksmingumu, tačiau nėra aišku, koks NVŠ liekamasis poveikis širdies ir kraujagyslių bei kvėpavimo sistemų rodikliams, jų kaitai atliekant vidutinį krūvį veloergometru (VK). Manoma, kad atliekant VK po ekscentrinių pratimų pakis širdies ir kraujagyslių bei kvėpavimo sistemų funkcijų rodikliai.

Tikslas – nustatyti 100 NVŠ poveikį širdies ir kraujagyslių bei kvėpavimo sistemų funkcjų rodiklių kaitai atliekant VK.

Metodai. Skirtingų testavimų metu 10 merginų atliko vieną nuosekliai didinamą krūvį, per kitus tris kartus (kontrolinį, praėjus 45 minutėms ir 24 valandoms po NVŠ) – VK veloergometru („Ergotine-800“, Vokietija). Mynimo dažnumas – 70 k./min. VK metu buvo registruojamas deguonies suvartojimas ($\dot{V}o_2$), anglies dioksido išskyrimas ($\dot{V}co_2$), minutinė plaučių ventiliacija (V_E) ir širdies susitraukimų dažnis (*ŠŠD*). VK pabaigoje buvo vertinamos subjektyviai suvokiamos pastangos. Praėjus 24 valandoms po NVŠ, tiriamosios vertino skausmą.

Rezultatai. Tiriamosios jautė vidutinį šlaunies raumenų skausmą praėjus 24 valandoms po NVŠ (5,0 (2,79) balų). Praėjus 45 minutėms ir 24 valandoms po VK, $\dot{V}o_2$, $\dot{V}co_2$ ir ŠSD nepakito, tačiau $V_E$po 45 minučių didėjo, bet nereikšmingai. Buvo nustatytas neigiamas koreliacinis ryšys tarp VRS ir $\dot{V}o_2$ (r = –0.52).

Aptarimas ir išvados. Apibendrinant galima teigti, kad 100 nušokimų vertikaliu šuoliu, praėjus 45 minutėms 24 valandoms po jų, neturi reikšmingo poveikio moterų kvėpavimo ir širdies bei kraujagyslių sistemų rodiklių kaitai, tačiau turi tendenciją padidinti V_E praėjus 45 minutėms po NŠV, kai atliekamas vidutinio intensyvumo krūvis veloergometru.

Raktažodžiai: vėluojantis raumenų skausmas, deguonies suvartojimas, pastovus krūvis.

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Corresponding author **Neringa Baranauskienė**
Lithuanian Academy of Physical Education
Sporto str. 6, LT-44221 Kaunas
Lithuania
Tel +370 615 80008
E-mail neringa_bara@yahoo.com

ASSESSMENT OF THE RELIABILITY OF COGNITIVE (ATTENTION AND MEMORY) TESTS

Vaida Berneckė[1, 2], Nerijus Eimantas[2], Henrikas Paulauskas[2], Beata Skaisgirytė[2], Justas Kudrevičius[2], Marius Brazaitis[2]
Šiauliai State College[1], Šiauliai, Lithuania
Lithuanian Academy of Physical Education[2], Kaunas, Lithuania

ABSTRACT

Research background and hypothesis. Special neuropsychological tests, which are used to assess cognitive functions in clinical practice, are often complicated, time-consuming, demanding special knowledge and expensive; therefore, cognitive functions frequently remain insufficiently assessed. For this reason, our selected and validated tests intended for the assessment of short-term memory and attention could be successfully applied in sports and clinical rehabilitation.

Research aim. The aim of this study was to assess the reliability of the tests of cognitive functions (memory and attention).

Research methods. The reliability of the tests was assessed using the intraclass correlation coefficient (ICC) and variation coefficient (*VC*). Young and healthy students (n = 41), aged from 18 to 30 (24.6 ± 2.3), participated in the research. The participants accomplished the tests 4 times, i. e. 2 times (with a one-hour break) on the first day (teaching) and 2 times (with a one-hour break) on the second day (reliability testing).

Research results. The results of testing the volume of spatial memory and even number recognition ranged from high to very high reliability of the tests. The results of ICC single of testing memory for figure recognition demonstrated low reliability, whereas ICC average proved average reliability. The results of complex reaction assessment, search for image samples and attention transfer ranged from high to a very high reliability of the tests.

Discussion and conclusions. The reliability of the tests of memory and attention assessment is high (with the exception of figure recognition tests, the reliability of which is average/low); therefore, the tests are suitable to be used in sport and clinical rehabilitation practice, aiming at determining the changes in cognitive functions under the influence of external factors, e. g. cold, heat, etc.

Keywords: brain functions, validity, stability, testing.

INTRODUCTION

The most frequently used tool of exploring the reliability of tests is their re-testing. The stability of re-testing is assessed by repetitive testing of the same respondents after a certain amount of time (Liu et al., 2010). The reliability of re-testing is based on the correlation of two (or more) experiments. Provided the tests are compiled in the right way, their results should be similar after re-testing. The validity of the test defines whether the research method really measures what it is supposed to measure, and whether the test results are correct (Gur et al., 2010). The main principles of compiling the methodology of memory and attention assessment have undergone only minor changes since the times of H. Ebbinghaus (1885/1962) and G. A. Miller (1955); these methodologies are based on the well-known principles of the research of memorization and attention processes. The tasks, which are applied for the assessment of attention and memory processes, are frequently included into the composition of more complex research, e. g.

Wechsler Adult Intelligence Scale (WAIS) (Kramer et al., 2011). Therefore, these tests do not demand additional proof for their reliability.

Depending on the specificity of the task (attention or memory), a cognitive test indirectly points to separate functions of chief nerve centers and are intensively applied in the fields of medicine, sports and psychology (Collie et al., 2003). Attention helps to distinguish a separate item from the group clearly and assuredly. An adult person can focus his/her attention on 4 to 6 independent objects (Martens et al., 2010). The frontal lobe of the brain determines concentration of attention, integrates the awareness and understanding of all the components of information, as well as organizes the processing of information data. The pre-frontal lobe controls alertness as well as the states of attention and activeness (Chein, Fiez, 2010). The duration of reaction (indirectly) shows the speed of "calculation" performed by the brain. It has been determined that when a choice has to be made, the processes in the central nerve system slow down (Skurvydas, 2011). The frontal part of cerebral cortex is responsible for the action plan (Correani, Humphreys, 2011), whereas thalamus is responsible for understanding, and the frontal nuclei of the thalamus regulate memorization of new information. The complex functions of cognition and analysis are formed in the parietal lobe of cerebral cortex (Min, 2010).

Memory is one the most important and main functions of the brain. From the temporal point of view, memory consists of three stages: sensory (0.1–0.5 s), short-term (up to 20 s), and long-term (information is stored for unlimited time) (Axmacher et al., 2009). One of the most significant components of any cognitive activity is short-term storage of information and its management in memory. Short term memory is located in the cerebral cortex (Thoresen et al., 2011). According to the type of memorization, long-term memory is divided into episodic (for personal experience), semantic (for general knowledge) and procedural (intended for skills). Hyppocampus and hypothalamus are responsible for episodic and semantic memory. Hippocampus is also responsible for working memory, whereas the chief nerve ganglion and cerebellum – for procedural memory (Correani, Humphreys, 2011). *In short-term (operational, working) memory* important data from sensory organs and long-term memory are fixed for a short time and promptly rearranged. Working memory, also referred to as operational, is defined as a system, which temporarily stores and manages the necessary information to accomplish complex cognitive tasks, such as learning, reasoning and understanding (Eng et al., 2005). In other words, working memory is needed so that we could operate in the surrounding world, whereas short-term and long-term memories ensure that we use the obtained information (Morey, Cowan, 2005). Working memory is very short, it lasts from several seconds to a few dozens of seconds (Axmacher et al., 2009). Depending on the sensory organs, which were used to obtain information, four types of memory are distinguished: motor (memory of movements), emotional, visual, and verbal-logical (verbal) (Mizuno, Takeda, 2009).

In this research the reliability of cognitive tests has been assessed using intraclass correlation coefficient (ICC), which is widely applied in the assessment of the correlation of re-tests. This method assesses not only the interdependence between two variables, but also the compatibility of these two variables in terms of their average mean (Friedman et al., 2008; Singh et al., 2011). There are two possible ways of the assessment of ICC: reliability of single assessments (*ICC single*), when the data of individual experts is analyzed; and reliability of assessment averages (*ICC average)*, which covers the analysis of the average mean of experts' data. Besides, variation coefficient (*VC*) has also been applied, which shows the percentage of the average deviation from the mean. The drawback of cognitive tests lies in the alterations of the results, obtained in different populations; the result may also be affected by such factors as age (Stein et al., 2010), education, disease, e. g. cerebrum distemperantia, etc. (Gur et al., 2010); therefore, the reliability of tests should be assessed individually for a particular population in particular circumstances. It is also important to determine whether the interaction, the researcher and the research participants are reliable (Skurvydas et al., 2011).

The aim of the research is to assess the reliability of tests of cognitive functions (memory and attention).

Organization and Procedure of the Research. The research was conducted in the laboratory of The Centre of Fundamental and Clinical Research in Movement at the Lithuanian Academy of Physical Education. The research participants were introduced to the aims, procedure and possible

inconveniences of the research. Young and healthy students of the Lithuanian Academy of Physical Education (n = 14), aged from 18 to 30 (24.6 ± 2.3), participated in the research. They accomplished the tests four times, i. e. two times (with an hour's break) on the first day (teaching) and two times (with one hour's break) on the second day (re-testing to assess the reliability). There was a 24-hour break between the first and the second day's testing. The research participants had to complete six tests (three tests for memory and three for attention), the tests were presented in random order. The accomplishment of all tests lasted approximately for 20 minutes. The participants completed the tests in a quiet environment: they were not disturbed by other people, noise, music or other distracters.

RESEARCH METHODS

Memory assessment. Memory tests are used to assess the stages of short-term memory: memorization, storage and recall (Morey, Cowan, 2005). To assess the above-mentioned peculiarities, three standard memory tests were selected (Collie et al., 2003), which helped to assess the volume of spatial memory, as well as recognition of even numbers and figures.

The volume of spatial memory was assessed using "the test of memorizing the quantity of numbers". The test is based on G. A. Miller's (1955) standardized norm applied for short-term memory, stating that a person is able to memorize 7 ± 2 symbols in three seconds or a very short time (up to 20 seconds). To test spatial memory, research participants had to memorize a sequence of numbers; after memorizing it, they had to enter it on the computer. The following line of numbers appeared only after the participant got ready (Figure 1 (a)). The duration of showing the numbers on the monitor (in our case a sequence of numbers) is very important in such kind of tests. Since the demonstrated numbers are not complex objects, an interval of 3000 ms was chosen. If a research participant forgot one or several numbers, s/he had to enter only those numbers that s/he had memorized; they should not have entered invented numbers. The first line of numbers consisted of 7 numbers. If the participant memorized and entered the right sequence of numbers, the following one should consist of 8 numbers. If s/he made a mistake, the next task contained 6 numbers. In case the participant made another mistake, the following line would consist of 5 numbers and so on. Sixteen numeric lines were presented for the participants. The results of the test reflect the average length of the memorized sequence of numbers, i. e. the quantity of numbers constituting the sequence and the average of recognized numbers.

During the assessment of *memory for equal number recognition*, the participants were given a sequence of even numbers on their screens. They had to memorize 10 even numbers, and after their disappearance, enter them into the empty spaces on the computer in random order (Figure 1 (b)). The research included two sequences of ten numbers. The results of the test depended on the number of correct answers of both attempts (maximum 20).

The test of the assessment of *memory for figure recognition* was based on the research results conducted by J. H. Song and Y. Yang (2006). They proved that visual working memory is able to memorize 3 colors, 2 shapes of objects and 2 objects in terms of their color and shape. Only a few features can be memorized at a time. Despite that we can memorize 4 basic features (e. g. color), we can memorize only 2 complex features (e. g. a random form). In terms of the duration of information storage, short-term memory lasts only up to 20 seconds (Endestad, 2011); therefore, the figures on the monitor were displayed for 15 seconds so that we could avoid the transfer of information into long-term memory. While identifying the quantity of visual memory, a participant was shown 9 different geometrical shapes at a time, which they had to memorize in 15 seconds (Figure 1 (c)). After the picture had vanished, there appeared a table with 28 different figures, including the ones to memorize. The result of our test for the memorization and recall of geometrical shapes depended on the number of correctly recognized figures (the maximum possible assessment was 9).

Attention assessment. Testing of attention allows investigating the main characteristics of attention: stability, concentration, distribution and transfer (Correani, Humphreys, 2011). The research of the mentioned peculiarities included the following tests: assessment of complex reaction, search for visual objects and tests of attention transfer.

Test for the assessment of complex reaction is intended to determine the speed of the choice of correct response in a given situation, when a person needs to choose one of the two possible responses to

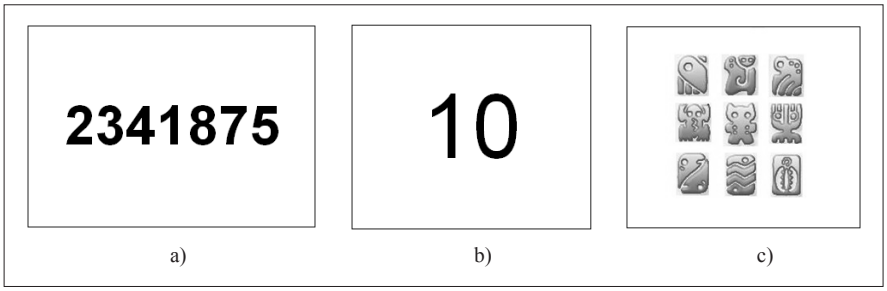

Figure 1. **Tests for the assessment of memory characteristics**

Note. a) test for the volume of special memory, b) test for even number recognition, c) test for figure recognition.

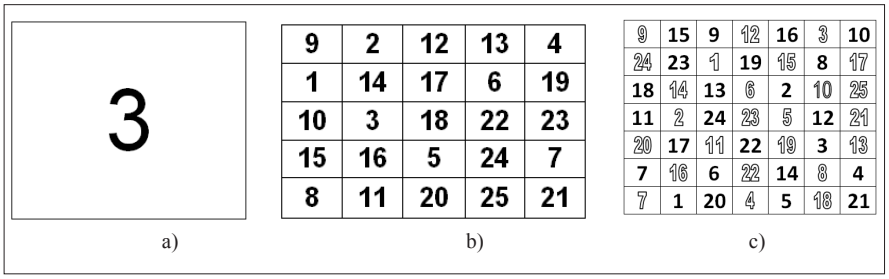

Figure 2. **Tests for attention assessment**

Note. a) test for a complex reaction; b) test for the search of visual objects; c) test for attention transfer.

a stimulus as fast as possible (Kubicki et al., 2012). While accomplishing the test for complex reaction assessment, the research participant had to press the right arrow (→) as quickly as possible when an even number appeared on the computer screen, and press the left arrow (←) when an odd number appeared (Figure 2 (a)). While accomplishing the test, attention was focused on one visual field area. The time span between the emergence of numbers (the span between the last pressing of the button and appearance of the next number) shifted from 0.5 to 3 seconds. The variation in time was necessary that the participant would not know when to expect the next number. The duration of the test was 3 minutes, the result depended on the latent period of the responses (the time between the appearance of a number on the screen and pressing on the arrow), the number of responses and the number of correct answers.

The test for the search of visual objects was intended to assess the distribution of attention, i.e. the ability to accomplish several actions at a time (Kastner et al., 1999). A participant was provided with a matrix of 25 boxes, which listed the numbers from 1 to 25 in random order (Figure 2 (b)). Using the mouse, the participants had to find and order the right sequence of numbers as quickly as possible. The result depended on the average time of accomplishing five tasks.

The test for attention transfer was intended for the investigation of attention concentration and sustention as well as the speed of information processing (Martens et al., 2010). The essence of this test was a purposeful transfer of attention from one object to another. The research participant was presented with a matrix of 25 hollow and 24 solid numbers (Figure 2 (c)). The participants had to arrange the hollow numbers in the increasing order from 1 to 25, and solid numbers in the decreasing order from 24 to 1. Using the computer mouse, the numbers were ordered in the following sequence: 1 – a hollow number, 24 – a solid number, 2 – a hollow number, 23 – a solid number, etc. The sum of the hollow and solid numbers should always equal to 25 (1 + 24 = 25, 2 + 23 = 25, etc.). The duration of the test was 5 minutes. The result reflected the speed of the accomplishment of the task, which ranged from 0 to 300 seconds.

The reliability of research results was assessed by calculating the average of the population, standard deviation, and intraclass correlation coefficient (*ICC*), which shows the correlation of re-testing (Singh et al., 2011) and coefficient of variation (*CV*), which shows the variation of the characteristics of different compared totalities. The lower the coefficient of variation, the lower the variation of the characteristics, and vice versa. This is a percentage proportion of the average square deviation and the mean. It is claimed that if the significance of the coefficient of variation is lower than 10%, it shows a high stability of the results between the two characteristics (Sutton et al., 2002). The assessment of ICC: if it ranges from 1.00 to 0.90, the correlation is very high; from 0.89 to 0.70 – the correlation is high; from 0.69 to 0.50 – the correlation is average; from 0.49 to 0.26 – the

correlation is low; and < 0.26 shows low correlation. The statistical significance is $p < 0.05$ (Aarrestad et al., 2004). The reliability was assessed using the program *SPSS 12.0.1 for Windows*.

RESEARCH RESULTS

Results of assessment reliability of memory Tests. The data averages and intraclass correlation coefficient of the two memory tests (the test and re-test) are presented in Table 1.

The results of the average length of number sequence in *testing the volume of spatial memory* showed high reiteration of the results of both tests (the test and re-test). The results of the reliability of single assessments (*ICC single*) and reliability of assessment averages (*ICC average)* revealed a high and very high reliability of the test (significant at $p < 0.001$). Variation coefficient (1.32%) disclosed a very high stability and minimal variation between the test and re-test results. The results of the intraclass correlation coefficient and variation coefficient (2.22%) of the average number of guessed symbols of testing *the amount of numbers memorization* also revealed a very high reliability of test results (significant at $p < 0.001$).

The results of single assessment reliability (*ICC single*) and assessment averages reliability (*ICC average*) of testing *even number recognition* proved a very high reliability of the test (significant at $p < 0.0001$) (Table 1). The coefficient of the afore-mentioned test (1.56%) showed a very high stability and minimal variation between the test and re-test results.

The results of single assessment reliability (*ICC single*) of testing *memory for figure recognition* demonstrated low reliability, whereas the results of assessment averages reliability (*ICC* average) proved average reliability of the test (significant at $p < 0.01$) (Table 1). However, the variation coefficient of the test (4.73%) showed high stability between test results.

Results of assessment reliability of attention tests. The data averages and intraclass correlation coefficient of the two attention tests (the test and re-test) are presented in Table 2.

The results of the test of *complex reaction assessment* revealed a high reliability of single ICC assessments and a very high reliability of ICC

Table 1. **Results of the assessment of the reliability of memory tests**

Criterion	Volume of spatial memory				Memory for even number recognition		Memory for figure recognition	
	Average length of numeric sequence		Average number of guessed symbols		Number of correct answers		Number of correctly recognized figures	
	Test	Re-test	Test	Re-test	Test	Re-test	Test	Re-test
The average mean and SD	6.6 ± 0.69	6.69 ± 0.71	6.22 ± 0.86	6.36 ± 0.80	9.39 ± 2.50	9.54 ± 2.18	7.22 ± 1.19	6.88 ± 1.42
ICC (single)	0.82**		0.86**		0.68***		0.36*	
ICC (average)	0.90**		0.93**		0.81***		0.53*	

Note. SD – standard deviation; ICC (single) – reliability of single assessments of intraclass correlation coefficient; (average) – reliability of assessment averages of intraclass correlation coefficient; * – $p < 0.01$; ** – $p < 0.001$; *** – $p < 0.0001$.

Table 2. **Results of the assessment of the reliability of attention tests**

Criterion	Test of complex reaction		Test of search for image samples		Test for attention transfer	
	Time of reaction, ms		Average time of the accomplishment of five tasks, s		Speed of accomplishing the task, ms	
	Test	Re-test	Test	Re-test	Test	Re-test
Average mean and SD	662.54 ± 95.43	642.34 ± 78.52	39.98 ± 8.66	38.90 ± 8.35	206.98 ± 44.32	199.24 ± 45.90
ICC (single)	0.75*		0.89*		0.94*	
ICC (average)	0.86*		0.94*		0.97*	

Note. SD – standard deviation; ICC (single) – reliability of single assessments of intraclass correlation coefficient; (average) – reliability of assessment averages of intraclass correlation coefficient; * – $p < 0.0001$.

average assessments (significant at $p < 0.0001$) (Table 2). Variation coefficient (3.05%) disclosed a high stability between test results.

The results of the reliability of *ICC* single assessments and *ICC* assessment averages of testing *the search for image samples* revealed a high reliability of the test (significant at $p < 0.0001$) (Table 2). Variation coefficient (2.68%) disclosed a very high stability between test results.

The results of assessing the reliability of *ICC* single assessments and *ICC* average assessments of testing *attention transfer* revealed a very high reliability of the test (significant at $p < 0.0001$) (Table 2). Variation coefficient (3.74%) disclosed a high stability between test results.

DISCUSSION

There are no standardized tests to assess cognitive functions in Lithuania. This research aims at the assessment of the reliability of attention and memory tests. The chosen collection of tests is meant for the assessment of such cognitive functions as attention and memory. The assessment of attention helps to explore the main characteristics of attention: stability, concentration, distribution and transfer (Martens et al., 2010). Memory tests are used to assess the stages of short-term memory: memorization, storage and recall. Re-testing has been organized to determine the reliability of tests (test – re-test), which include two cases of observing the same participant in two different periods. The tests are referred to as reliable, since similar results have been obtained in both cases. Reliability assessment can be attributed to objective methods of assessment, as methods of statistical calculation have been strictly observed (Friedman et al., 2008). Two coefficients, namely intraclass correlation coefficient (ICC) and coefficient of variation (CV), have been selected to assess the reliability of tests.

The volume of spatial memory has been assessed in accordance with the theory of H. Y. Eng, D. Chen and Y. Yang (2005), who state that the intervals of 5000 ms or even shorter can be applied for the testing of sensory memory. The duration of the appearance of objects (in our case numeric sequences) on the monitor is very important in this type of tests. According to the afore-mentioned authors, 3000 ms is the average time span to assess the volume of visual working memory accomplishing such or similar tasks. Using the functional magnetic resonance imaging (fMRI), J. H. Song and Y. Yang (2006) determined that parietal, frontal and parietal-temporal lobes are responsible for the visual working memory.

The assessment of the memory of even numbers recognition is based on structuring, i.e. coding of information in larger units, which enhance the quantity of the processed information. The grouping of numbers is effective in enhancing the volume of short-term memory, and we employ this either consciously or unconsciously (Palmgren, 2010). The structuring is possible provided the information, which is stored in long-term memory, is activated (e. g. the number 10 is the month of birth, etc.). It has been determined that the coding of information is especially dependent on the capacity of working (operational) memory (Skurvydas, 2011). The part of brain, which is responsible for working memory, is hyppocampus, whereas parietal lobe, which is in the back part of the brain, is responsible for information recall (Thoresen et al., 2011).

The results of testing the volume of our spatial memory and memory for even number recognition, in accordance with intraclass correlation coefficient (ICC *single,* ICC *average*), show a high or very high correlation of the results of both tests (the test and re-test).

The occipital lobe of the brain is responsible for the recognition of spatial figures (Palmgren, 2010). M. C. Jackson and J. E. Raymond (2008) have determined that the pictures, which present recognizable objects, are better memorized rather than those, which depict abstract motifs. The results of the reliability of single assessment (*ICC* single) of our testing the memory for figure recognition have demonstrated low reliability, whereas the results of the reliability of assessment averages (*ICC average*) have shown average reliability. It is credible that the complexity of the test has determined the average and low reiteration of test results. A. Skurvydas (2011) maintain that concentration of attention on two or more objects almost always results in worse accomplishment of tasks.

Selection of important information is performed with the help of visual attention. The dorso-lateral pre-frontal lobe of cerebral cortex is important in the accomplishment of the test of assessing a complex reaction. It is the controlling center, which supervises information loads obtained by senses, and controls the areas, which need attention. Another important part is temporal lobe, which is responsible for attention (Kastner et al., 1999). Pre-frontal lobes are responsible for the results of testing the search for image samples,

which control alertness, and regulate the states of attention and activeness. The frontal lobe is highly important in testing attention transfer, which determines concentration of attention, integrates the awareness and understanding of all the components of information, as well as organizes the processing of information data (Chein, Fiez, 2010). After having summarized the indicators of the reliability of attention tests, and referring to intraclass correlation coefficient (ICC *single,* ICC average), it occurred that all the accomplished tests show a high or a very high stability of the results of both tests (the test and re-test).

The indicators of variation coefficients obtained from all tests, both attention and memory, are lower than 5%, which shows a high stability between the test and re-test results with a minimum variation.

CONCLUSIONS AND PERSPECTIVES

The reliability of the tests of memory and attention assessment is high (with the exception of figure recognition tests, whose reliability is average/low); therefore, the tests are suitable to be used in sport and clinical rehabilitation practice, aiming at determining the changes in cognitive functions under the influence of external factors, e. g. cold, heat, etc.

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KOGNITYVINIŲ FUNKCIJŲ (DĖMESIO IR ATMINTIES) TESTŲ PATIKIMUMO VERTINIMAS

Vaida Berneckė[1, 2], Nerijus Eimantas[2], Henrikas Paulauskas[2], Beata Skaisgirytė[2], Justas Kudrevičius[2], Marius Brazaitis[2]

Šiaulių valstybinė kolegija[1], Šiauliai, Lietuva

Lietuvos kūno kultūros akademija[2], Kaunas, Lietuva

SANTRAUKA

Tyrimo pagrindimas ir hipotezė. Klinikinėje praktikoje kognityvinių funkcijų vertinimui naudojami specialūs neuropsichologiniai testai dažnai yra sudėtingi, užimantys daug laiko, reikalaujantys specialių žinių, brangūs, todėl kognityvinės funkcijos dažnai lieka nepakankamai įvertintos. Dėl to mūsų pasirinkti ir patikrinti trumpalaikės atminties ir dėmesio vertinimo testai galėtų būti sėkmingai taikomi sporto, klinikinėje reabilitacijos praktikoje.

Tikslas – įvertinti kognityvinių funkcijų (atminties ir dėmesio) testų patikimumą.

Metodai. Testų patikimumas buvo vertintas naudojant intraklasinį koreliacijos koeficientą, kuris turi dvi versijas: pavienių vertinimų patikimumo (*ICC single*); vertinimų vidurkio patikimumo (*ICC average*) ir variacijos koeficientą (*VC*). Buvo tiriami jauni sveiki studentai (n = 41), kurių amžius nuo 18 iki 30 metų (24.6 ± 2.3 m.). Testus tiriamieji atliko iš viso keturis kartus, t. y. du kartus (darydami vienos valandos pertrauką) pirmą dieną (mokymas) ir du kartus (darydami vienos valandos pertrauką) antrą dieną (testavimas patikimumui nustatyti).

Rezultatai. *Erdvinės atminties apimties ir porinių skaitmenų atpažinimo atminties* testų rezultatai parodė didelį ir labai didelį testų patikimumą. *Figūrų atpažinimo atminties* testo *(ICC single)* rezultatai parodė mažą, o (*ICC average)* rezultatai – vidutinį testo patikimumą. *Sudėtingos reakcijos vertinimo, vaizdinių pavyzdžių paieškos ir dėmesio nukreipimo* testų rezultatai parodė didelį ir labai didelį patikimumą.

Aptarimas ir išvados. Dėmesio ir atminties vertinimo testų patikimumas yra aukštas (išskyrus figūrų atpažinimo atminties testo, kurio patikimumas vidutinis/žemas), todėl testai tinkami naudoti sporto, klinikinėje reabilitacijos praktikoje norint nustatyti kognityvinių funkcijų pokyčius organizmą paveikus išoriniams veiksniams, tokiems kaip šaltis, šiluma ir kt.

Raktažodžiai: smegenų funkcijos, pagrįstumas, stabilumas, testavimas.

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Corresponding author **Vaida Berneckė**
Šiauliai State College
Radviliškio str. 66–12, LT-76366 Šiauliai
Lithuania
Tel +370 68871470
E-mail vaidabernecke@gmail.com

THE EFFECT OF INCREASED FEMALE SEX HORMONE CONCENTRATION ON MOVEMENT PROPRIOCEPTION

Laura Daniusevičiūtė[1], Vitas Linonis[1], Lina Barsienė[2]
Kaunas University of Technology[1], Kaunas, Lithuania
Lithuanian University of Health Sciences, Medical Academy[2], Kaunas, Lithuania

ABSTRACT

Research background and hypothesis. Over the last years, basic research on the effect of different hormones on tendons and ligaments has been initiated. Regarding oestrogen receptor localization in brain and their interaction with neurotransmitters (Maki et al., 2002; Friden et al., 2003; Farage et al., 2008), we speculate that the increase in the level of female sex hormone concentration will improve the sense of movement.

Research aim was to study the effect of increased female sex hormone concentration on movement proprioception.

Research methods. Subjects were healthy and physically active women (n = 15) with normal menstrual cycle, aged 19–23 years, body weight – 58.2 ± 6.1 kg, height – 168.4 ± 5.6 cm as well as female basketball players (n = 15) with normal menstrual cycle, aged 19–23 years, body weight – 78.31 ± 2.81 kg, height – 182.40 ± 4.71 cm. We performed three experiments with each participant: in follicular phase, ovulation and luteal phase. The samples of 5 ml venom blood were taken to establish the amount of estradio17β-estradiol and progesterone concentration. The sense of knee joint position was evaluated using isokinetic dynamometer (*System 3; Biodex Medical Systems, Shirley*, New York, USA). During a training session, a subject's right leg was flexed at the knee joint and fixed at the angle of 90°. Prior to each test, the researcher demonstrated the target angle of 60° by stretching subject's leg. In order to train the flexion of the knee joint, a subject's right leg was extended at the knee joint and fixed at the angle of 0°. The researcher demonstrated the target angle of 50° by flexing subject's leg. The subjects had to perform three tests at the velocity of 2°/s, 5°/s and 10°/s with their eyes open and closed.

Research results. Females in the control group performed knee joint proprioception task better with an extended knee at velocity of 2°/s with open eyes during the follicular phase, but at the velocity of 10°/s the values were better during ovulation. Basketball players performed the same task better at velocity of 5°/s during ovulation, but at velocity of 10°/s the values were better during the luteal phase. Females in control group performed knee joint proprioception task with an extended knee at the velocity of 5°/s with closed eyes better during the luteal phase. No statistical difference between control group and basketball player indices of knee joint position proprioception task with a flexed knee at velocity of 2°/s, 5°/s and 10°/s with closed eyes during the menstrual cycle was found.

Discussion and conclusion. Knee joint proprioception indices were better during ovulation phase in control group and basketball players.

Keywords: knee joint proprioception, follicular phase, ovulation, luteal phase.

INTRODUCTION

Proprioception is related to the senses of position and movement of limbs. These senses are mediated through neural input from peripheral mechanoreceptors in the skin, muscles, tendons, ligaments and joint capsules (Friden et al., 2003). Over the last years, basic research on the effect of different hormones on tendons and ligaments has been initiated. Estrogen and progesterone receptors have been indentified on fibroblasts in the humans (Nakata et al., 2010). Estrogen has been shown to decrease the proliferation of fibroblasts and the synthesis of Type 1 procologen (Nakata

et al., 2010). Previous studies have suggested that the variation of estradiol and progesterone during the menstrual cycle influences neurological and motor functions (Osterlund et al., 2001). Increased levels of progesterone metabolites during the luteal phase are known to affect various transmitters and hormone systems, for example in the cerebellum, resulting in effects on motor functions (Shen Yin-Chen, Franz, 2005). It was ascertained that oestrogen receptors (ERβ) detected in cerebellum interact with neurotransmitter γ-aminobutyric acid (GABA) (Friden et al., 2003) and higher estradiol concentration improve procedural memory (Gur et al., 2000). However, the performance of right movements, movement coordination, and balance during ovulation are worse when comparing the indices during follicular and luteal phases (Friden et al., 2003). Several investigations have studied the relationship between menstrual cycle phase and the risk of anterior cruciate ligament (ACL) injuries. There are multiple indications that ACL laxity (Friden et al., 2003), neuromuscular factors (Friden et al., 2006), as well as athletic performance (Shen Yin-Chen, Franz, 2005), may fluctuate during the menstrual cycle. However, these findings have been equivocal and there is little consensus in research literature. Some studies suggested that pre-menstrual and menstrual symptoms affect the athletic performance and neuromuscular control, and may increase the risk of musculoskeletal injuries (Shultz et al., 2005). However, few studies have investigated the influences of these dysfunctions on noncontact ACL injuries (Eiling et al., 2007). The implications of these physiological changes during the menstrual cycle on ACL injury risk in female athletes have not been clarified yet. Regarding oestrogen receptor localization in brain and their interaction with neurotransmitters (Maki et al., 2002; Friden et al., 2003; Farage et al., 2008), we speculate that the increase in the level of female sex hormone concentration will improve the sense of movement. The aim of the study was to study the effect of increased female sex hormone concentration on movement proprioception.

RESEARCH METHODS

Subjects were healthy and physically active women (n = 15) with normal menstrual cycle, aged 19–23 years, body weight – 58.2 ± 6.1 kg, height – 168.4 ± 5.6cm as well as female basketball players (n = 15) with normal menstrual cycle, aged 19–23 years, body weight – 78.31 ± 2.81 kg, height – 182.40 ± 4.71 cm. The healthy and physical active women (n = 15) were chosen as control group. All the participants had not been using oral contraceptives for six months and had regular (28 days) menstrual cycle. Ethical approval was obtained from Kaunas Regional Ethics Committee of Biomedical Research (report number BE-2-24). Written informed consent was obtained from the volunteers prior to their participation in this study. All the volunteers could be considered as physically active as they took part in recreational activities two or three times per week.

Estimation of basal body temperature. Basal body temperature (BBT) estimation is a method for identifying the approximate day of ovulation, and thus the relative length of follicular and luteal phases (Bauman, 1981). Each subject measured BBT every morning for three months before the experiment. BBT increased approximately by 0.3° C after ovulation, which sustained throughout the luteal phase. Using BBT method we chose subjects in the study on their early-follicular phase, when oestrogen and progesterone concentrations were low, and on ovulation, when estrogen concentrations were high (Bauman, 1981).

Estimation of estrogen concentrations. At the beginning of every study, 5 ml of venous blood sample was taken to establish estradiol (17β-estradiol) and progesterone concentration in blood. The enzyme immunoassay analysis ECLIA was used to establish estradiol (17β-estradiol) and progesterone concentration in blood in vitro with *Roche Elecsys 1010/2010 cobas e 411* (*Roche Diagnostics GmbH*, Germany) and *Modular Analytics E170* immunological analyzers (*Roche Diagnostics GmbH*, Germany). In our study we measured estradio17β-estradiol and progeterone concentration in blood on the second (follicular phase), fourteenth (ovulation) and twenty third day (luteal phase) of menstrual cycle.

Estimation of knee joint position sense. Knee joint position sense was evaluated using isokinetic dynamometer (*System 3; Biodex Medical Systems, Shirley, New York, USA*). During a training session, a subject's right leg was flexed at the knee joint and fixed at the angle of 90°. Prior to each test, the researcher demonstrated the target angle of 60° by extending subject's leg. A subject's right leg was extended at the knee joint and fixed at the angle

of 0°. The researcher demonstrated the target angle of 50° by flexing subject's leg (Figures 1 A, B). The same sequence of actions was used throughout the research while performing the test of the knee joint position sense. The subjects had to perform three tests at the velocity of 2°/s, 5°/s and 10°/s with their eyes open and closed (Hertel et al., 2006).

Testing schedule. Training tests were administered for the subjects to get used to the laboratory environment and learn how to perform joint position sense tests. Each study was conducted at least a week after the training tests. During the experiment, the room temperature was usual (20–22°C). The subjects were selected randomly, females were chosen according to the duration of their menstrual cycle and ovulation day. The day for the test was set in the early follicular phase (estradiol and progesterone in blood is low); on ovulation, estradiol in blood is peak during the menstrual cycle; during luteal phase, estradiol – medium, progesterone – peak during the menstrual cycle. At the beginning of the experiment, 5 ml of venous blood sample was taken to measure the concentration of female sex hormones: estradiol and progesterone. The knee joint position sense tests were conducted.

Descriptive data is presented as means (SEM). The one-way analysis of variance (ANOVA) for repeated measures was used to determine the effect of menstrual cycle on the knee joint position sense values separately at different velocities. If significant effects were found, post hoc testing was performed, applying paired t-tests with a Bonferroni correction for multiple comparisons. Statistical significance of all tests was set at $p < 0.05$.

RESEARCH RESULTS

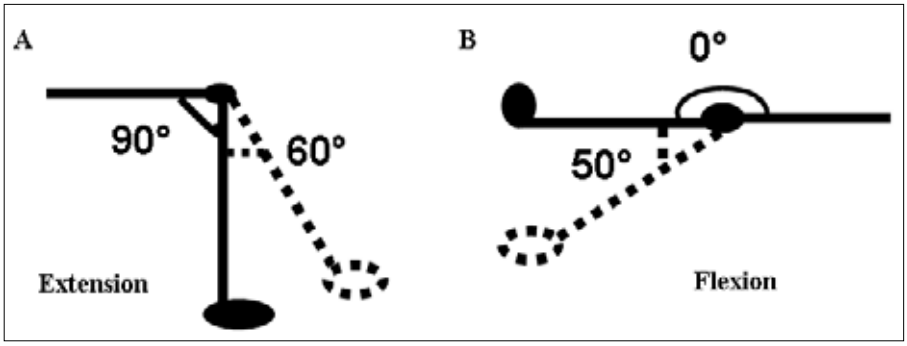
Control group values of estradiol and progesterone concentration in blood were higher during ovulation and luteal phases than in the follicular phase ($p < 0.05$; Figures 2 A, B).

Female basketball players' values of estradiol and progesterone concentration in blood were higher during ovulation and luteal phases than in the follicular phase ($p < 0.05$; Figures 3 A, B).

Females in control group performed knee joint position sense task better with an extended knee at the velocity of 2°/s with open eyes during the follicular phase ($p < 0.05$; Figure 4 A), but at the velocity of 10°/s the values were better during ovulation ($p < 0.05$; Figure 4 A). Basketball players performed the same task better at the velocity of 5°/s during ovulation ($p < 0.05$; Figure 4 A), but at the velocity of 10°/s the values were better during the luteal phase ($p < 0.05$; Figure 4 A). The females in control group performed knee joint position sense task with an extended knee at the velocity of 5°/s with closed eyes better during the luteal phase ($p < 0.05$; Figure 4 B).

Females in control group and basketball players performed the knee joint position sense task better with a flexed knee at velocity of 10°/s with open eyes during ovulation ($p < 0.05$; Figure 5A). No statistical difference between control group and basketball player indices of knee joint position sense task with a flexed knee at velocity of 2°/s, 5°/s and 10°/s with closed eyes during the menstrual cycle ($p > 0.05$; Figure 5 B) was found.

Figure 1. **Estimation of knee joint position sense**



Note. A – knee joint extension till 60° angle; B – knee joint flexion till 50° angle.

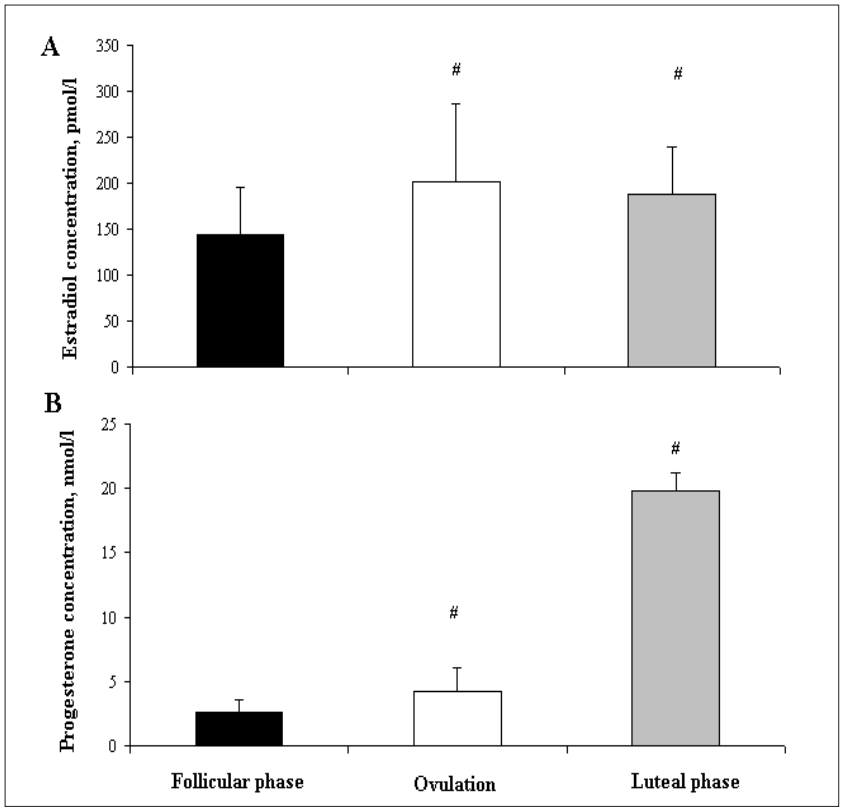


Figure 2. **Control group women's estradiol (A) and progesterone (B) concentration in blood during follicular, ovulation and luteal phases**

Note: # – compared to the follicular phase indices ($p < 0.05$).

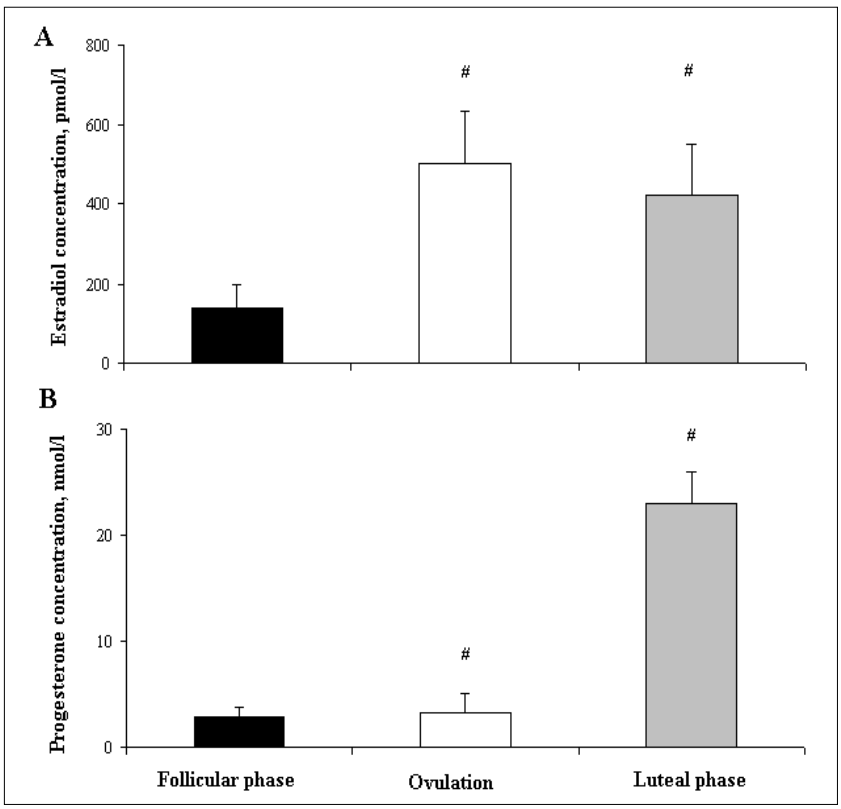


Figure 3. **Female basketball players' estradiol (A) and progesterone (B) concentration in blood during follicular, ovulation and luteal phases**

Note: # – compared to the follicular phase indices ($p < 0.05$).

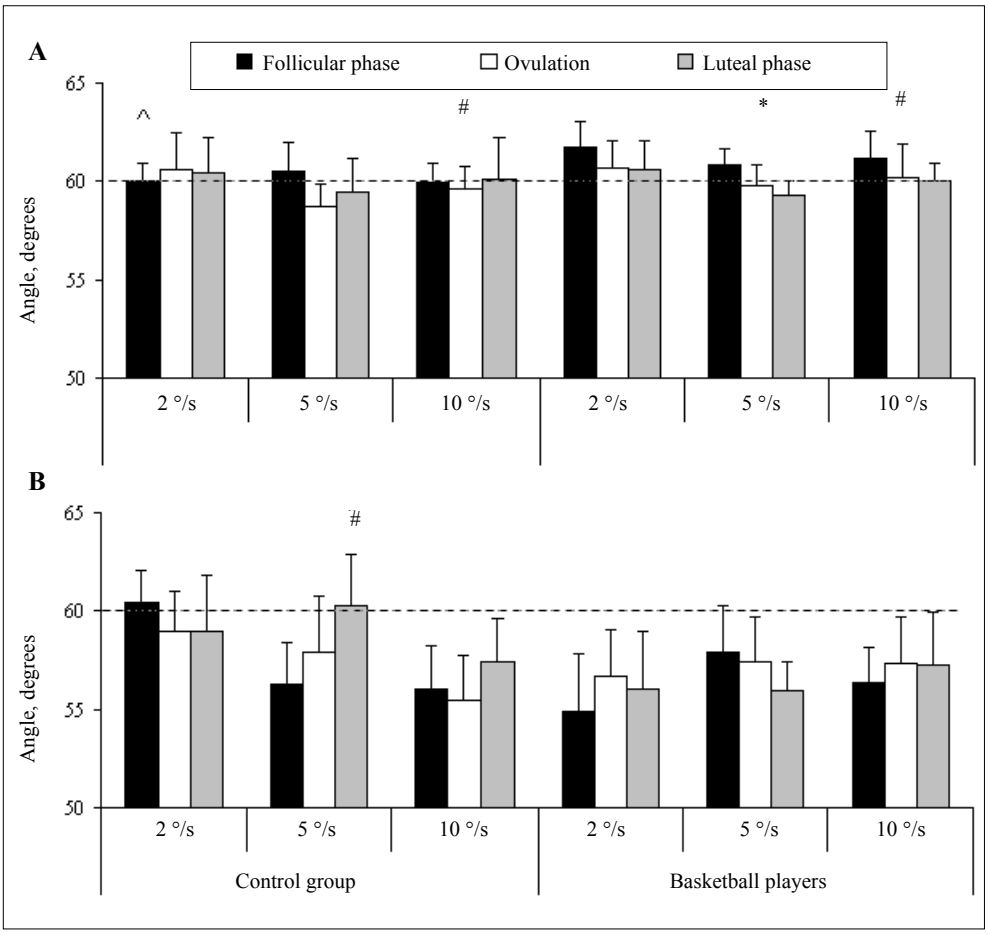


Figure 4. **Knee joint position sense for control group and basketball players with extended knee with open (A) and closed (B) eyes during the menstrual cycle.**

Note: * – compared to the ovulation phase ($p < 0.05$); # – compared to the luteal phase ($p < 0.05$); ^ – compared to the follicular phase ($p < 0.05$).

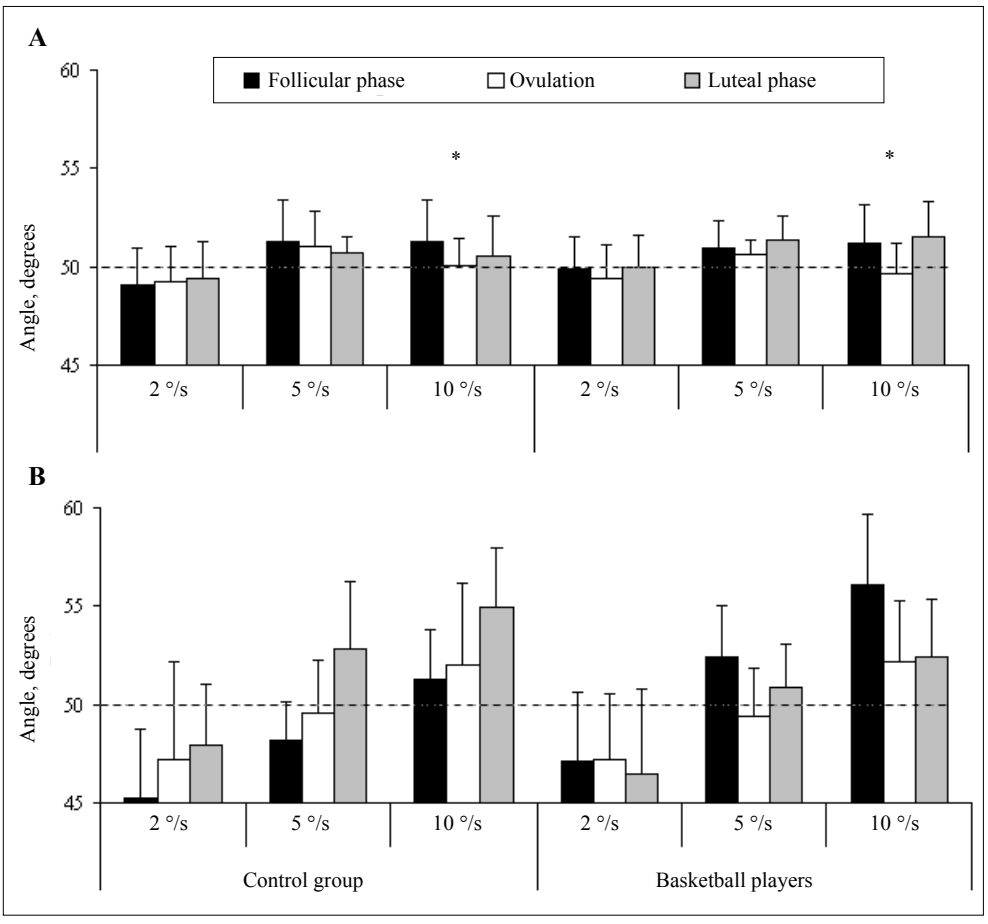


Figure 5. **Knee joint position sense for control group and basketball players with extended knee with open (A) and closed (B) eyes during the menstrual cycle**

Note. * – compared to the ovulation phase ($p < 0.05$); # – compared to the luteal phase ($p < 0.05$); ^ – compared to the follicular phase ($p < 0.05$).

DISCUSSION

The aim of the study was to investigate the effect of increased female sex hormone concentration on movement proprioception. The present results showed that subjects were in proper menstrual cycle phase. The estradiol concentration was higher in ovulation than in follicular and luteal phases, and progesterone concentration was higher in luteal phase than in follicular phase and ovulation, when ovulation day was counted as day 14, follicular phase – day 2 for female participants. By the classical terminology of menstrual cycle phase with corresponding days of 28-day, ovulation occurring on day 14, follicular phase – on the 1st–13th days (Janse de Jonge, 2003). The indication of corresponding hormone concentrations on ovulation day – estradiol is high, on the day of follicular phase estradiol is low (Janse de Jonge, 2003). Knee joint proprioception indices were better during follicular and ovulation phases. When investigating female kinaesthesia indices during the menstrual cycle, no statistically significant difference between the indices of control and basketball players' groups was determined. Yet both control group women and basketball players indicated knee joint position angles when flexing and extending their leg more precisely during the luteal phase. Kinaesthesia comprises a complex of functions related to nervous and muscular systems; therefore scientists wonder whether sex hormones affect the functions through peripheral or central mechanisms. Increased level of estradiol and progesterone concentration in blood during the luteal phase affects neurotransmitters in cerebellum, which is responsible for motor functions (McEwen, 2002). The impact of changes in sex hormone concentration in blood on female bone system components, soft and connective tissues was also revealed (Wojtys et al., 2002). When estimating kinaesthetic indices, no statistically significant differences were found between movement rates. The indices varied, yet better results were recorded when performing a task at the velocities of 2°/s and 10°/s. It is possible to make assumption that when position sense velocity is low (2°/s) and the task is performed accurately, adaptation of CNS increases from I α muscle spindles and receptors in joints to peripheral signals; and when position sense velocity is high (10°/s) and the task is performed accurately, CNS adaptation to peripheral signals increases from type II or dynamic muscle spindles during the movement (Brindle et al., 2009). Movement sense at the velocity of 5°/s encompasses information of I α and II type muscle spindles; thus the plane for mistakes increases.

CONCLUSIONS AND PERSPECTIVES

Knee joint proprioception indices were better in control and basketball players groups during ovulation phase.

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PADIDĖJUSIOS MOTERIŠKŲJŲ LYTINIŲ HORMONŲ KONCENTRACIJOS POVEIKIS JUDESIO PROPRIORECEPCIJAI

Laura Daniusevičiūtė[1], Vitas Linonis[1], Lina Barsienė[2]
Kauno technologijos universitetas[1], Kaunas, Lietuva
Lietuvos sveikatos mokslų univesitetas, Medicinos akademija[2], Kaunas, Lietuva

SANTRAUKA

Tyrimo pagrindimas ir hipotezė. Paskutinių metų žmonių tyrimų rezultatai rodo hormonų poveikį sausgyslių ir raiščių dariniams. Dėl estrogenų receptorių lokalizacijos galvos smegenyse ir jų sąveikos su neurotransmiteriais (Maki et al., 2002; Friden et al., 2003; Farage et al., 2008) spėjama, kad moteriškųjų lytinių hormono koncentracijos padidėjimas pagerins judesio jutimo rodiklius.

Tikslas – ištirti padidėjusios moteriškųjų lytinių hormonų koncentracijos poveikį judesio propriorecepcijai.

Metodai. Tiriamosios – sveikos nesportuojančios, turinčios natūralų mėnesinių ciklą, fiziškai aktyvios merginos (n = 15), kurių amžius – 19–23 m., kūno masė – 58,2 ± 6,1 kg, ūgis – 168,4 ± 5,6 cm. Taip pat moterys krepšininkės (n = 15), turinčios natūralų mėnesinių ciklą, kurių amžius – 19–23 m., kūno masė – 78,31 ± 2,81 kg, ūgis – 18,40 ± 4,71 cm. Kiekvieno eksperimento pradžioje buvo paimamas 5 ml veninio kraujo mėginys menstruacinio ciklo fazėms (folikulinei, ovuliacinei ir liuteininei) nustatyti. Tyrimo metu estradiolio ir progesterono koncentracija kraujyje nustatyta antrą dieną nuo menstruacinio ciklo pradžios (folikulinėje fazėje), 14-ą dieną nuo menstruacinio ciklo pradžios (ovuliacijos metu) ir 23-ią dieną nuo menstruacinio ciklo pradžios (liuteininėje fazėje). Kelio sąnario padėties jutimas buvo vertinamas naudojant izokinetinį dinamometrą (*System 3; Biodex Medical Systems, Shirley, New York, USA*). Mokantis tiesti kelio sąnarį, tiriamųjų dešinė koja buvo sulenkiama per kelį ir fiksuojama 90° kampu. Tyrėjas prieš kiekvieną bandymą parodydavo, kaip tiesti koją 60° kampu. Mokantis kelio sąnarį lenkti, tiriamųjų dešinė koja buvo ištiesiama per kelį ir fiksuojama 0° kampu. Tyrėjas prieš kiekvieną bandymą parodydavo, kaip lenkti koją 50° kampu. Tiriamosios atliko tris bandymus: lenkė kojas 2°/s, 5°/s ir 10°/s greičiu atmerktomis ir užmerktomis akimis.

Rezultatai. Kontrolinės grupėje moterys užduotį geriau atliko atmerktomis akimis kelio sąnarį tiesdamos 2°/s greičiu folikulinės fazės metu, tačiau tą pačią užduotį atlikdamos 10°/s greičiu geresnių rezultatų pasiekė ovuliacijos fazėje. Krepšininkės tą pačią užduotį geriau atliko 5°/s greičiu ovuliacijos fazėje, o kai greitis siekė 10°/s, užduotį geriau atliko liuteininėje fazėje. Nebuvo nustatytas statistiškai patikimas skirtumas lyginant kontrolinės grupės ir krepšininkių kelio sąnario lenkimo užduoties rodiklius užmerktomis akimis, kai kelio sąnario lenkimo greitis 2°/s, 5°/s ir 10°/s menstruacinio ciklo metu.

Aptarimas ir išvados. Kontrolinės grupės krepšininkių kelio sąnario propriorecepcijos rodikliai buvo geresni ovuliacijos fazėje.

Raktažodžiai: kelio sąnario propriorecepcija, folikulinė fazė, ovuliacija, liuteininė fazė.

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Corresponding author **Laura Daniusevičiūtė**
Lithuanian Academy of Physical Education
Sporto str. 6, LT-44221 Kaunas
Lithuania
Tel +370 600 65490
E-mail lauruka@yahoo.com

ARTHROSCOPIC SURGERY AND REHABILITATION GUIDELINES OF SHOULDER INJURIES IN THE YOUNG OVERHEAD ATHLETES

Rimtautas Gudas[1, 2], Laimonas Šiupšinskas[2], Vilma Mauricienė[2], Mindaugas Balčiūnas[3]

Hospital of Lithuanian University of Health Sciences Kauno Klinikos[1], Kaunas, Lithuania
Lithuanian University of Health Sciences, Institute of Sport[2], Kaunas, Lithuania
Lithuanian Academy of Physical Education[3], Kaunas, Lithuania

ABSTRACT

Research background and hypothesis. Overhead athletes are at higher risk to suffer from acute and chronic shoulder injuries.

Research aim was to evaluate shoulder complex functional characteristics of the overhead and non-overhead young athletes before and two years after the concomitant arthroscopic type II superior labrum anterior posterior (SLAP) and partial – thickness rotator cuff (PTRC) repair and to present specific rehabilitation guidelines needed for successful return to sports.

Research methods. The sample of the research included 38 male athletes: overhead (n = 19) and non-overhead (n = 19) athletes. All participants underwent concomitant arthroscopic type II SLAP and PTRC repair and were available for review at a minimum of two years after surgery. Shoulder range of motion was measured with goniometer. Constant score was used for the evaluation of the shoulder functional quality.

Research results. Function of the shoulder complex had higher increase in non-overhead group ($p < 0.05$). Constant score two years after surgery did not return to optimal level. Shoulder flexion and internal rotation ROM in both groups and external rotation ROM of non-overhead athletes were the same as before surgery.

Discussion and conclusions. Functional characteristics of shoulder complex measured with Constant score of overhead and non-overhead athletes statistically significantly increased two years after the arthroscopic surgery. Significant change of external rotation was established in overhead athletes: two years after surgery it was significantly smaller and did not return even to preoperative level. Sports specific and diagnose-based rehabilitation is needed to decrease deficit in function of the shoulder complex after concomitant arthroscopic type II SLAP and PTRC repair.

Keywords: shoulder complex, SLAP, partial-thickness rotator cuff tears, sports physical therapy.

INTRODUCTION

Shoulder injuries are serious health problems in athletes affecting performance, training schedule and competition results. Athletes who use overhead movements are at higher risk to suffer from acute and chronic shoulder injuries. Acute injuries of the shoulder involve traumatic episodes especially in contact sports. Symptoms of chronic shoulder injuries are: present pain, decreased range of motion, weak muscles of the shoulder complex, joint laxity (instability), scapula position and posture change. Players in basketball, tennis, volleyball, baseball, handball and etc. use overhead throwing motions. It is highly skilled movement, which requires flexibility, coordination, neuromuscular control, muscular strength and synchronicity. The throwing motion generates extraordinary demands on the shoulder joint. G. S. Fleisig et al. (1995, 1996) report that angular velocity of the overhead throw during baseball pitching reaches over 7250 degrees per second,

which is the fastest recorded human movement. This motion results in high forces being generated at the shoulder joint, where the dynamic and static stabilizing structures of the shoulder are vulnerable. The authors suggested that anterior forces up to one time affect body weight during external rotation (ER) and up to 1.5 times – during the follow-through phase (distracting the joint) (Fleisig et al.,1995, 1996). These forces are similar to the ones in other overhead-throwing athletes. The overhead-throwing athletes demonstrate several different physical characteristics-specifically, shoulder ROM, scapular position, laxity, muscular strength and proprioception. These characteristics must be understood to accurately assess what is a normal physical adaptation rather than pathology (Reinold, Gill, 2009).

Range of motion. K. E. Wilk et al. reported such passive range of motion characteristics of the shoulder in 372 professional baseball players: 129° ± 10° of ER and 61° ± 9° of IR (internal rotation) in the throwing shoulder at 90° abduction. ER was by 7° greater on average, and IR was by 7° less on average in the dominant arm when compared to the non-dominant arm. Thus, total rotation ROM at 90° of abduction is bilaterally equal in asymptomatic overhead throwers (Wilk et al., 2002). Most throwers exhibit an obvious motion disparity, whereby shoulder external rotation (ER) is excessive and internal rotation (IR) is limited when measured at 90° of abduction. This loss of IR of the throwing shoulder has been referred to as glenohumeral internal rotation deficit (GIRD) (Wilk et al., 2009). M. M. Reinold et al. found that goniometric measurements of passive ER and IR at 90° of abduction were reliable in overhead-throwing athletes (intratester reliability intraclass correlation coefficients were 0.81 and 0.87). However, bilateral comparisons of ER and IR are not useful (Reinold et al., 2008). If the total rotation motion decreases on the throwing side, careful measurements of ROM should be made to determine if IR has been lost. A loss of IR with a hard endfeel may represent other pathologies, such as a thrower's exostosis (ie, calcification of the posteroinferior glenohumeral capsular attachment due to chronic traction stress) (Ferrari et al., 1992; Wilk et al. 2009).

Scapular position provides a base for entire shoulder complex function especially for motion in glenohumeral joint. The term "shoulder movement" describes the combined motions at both the glenohumeral and scapulothoracic joints (Neumann, 2010). To be able to function properly, the scapula needs to be in the proper position to assist in the movement of the humerus. W. B. Kibler defined alterations in motion of the scapula during coupled scapulohumeral movements as "scapular dyskinesis". Numerous authors have noted the role of scapular dyskinesis and the positive correlation to shoulder pathology (Kibler, 1991).

Joint laxity. The excessive motion observed in overhead-throwing athletes is commonly attributed to an increase in glenohumeral laxity (Reinold et al., 2009). This increased motion can show excessive ER associated to anterior capsular laxity. Excessive laxity may be the result of repetitive throwing or congenital laxity.

Muscle strength. Isokinetic testing of professional baseball pitchers' throwing shoulders during training showed external rotation peak torque by 6% lower on average ($p < 0.05$) than that of the nonthrowing shoulders at 90° of abduction. Internal rotation peak torque of the throwing shoulder was by 3% higher on average ($p < 0.05$) than that of the nonthrowing shoulder. The mean optimal ratio between ER and ER peak torque at 90° of abduction during isokinetic testing was between 66% and 75%. Adduction torque of the throwing shoulder was by 14% greater than that of the nonthrowing shoulder (Wilk et al., 2005).

Proprioception plays important role dynamically stabilizing glenohumeral joint in presence of capsular laxity and dealing with excessive range of motion in the overhead athlete. One study tested shoulder proprioception in 20 healthy overhead-throwing athletes by joint repositioning. The dominant shoulder exhibited diminished proprioception and improved proprioception toward end range of motion (Safran et al., 2001) Proprioception significantly decreased after throwing to fatigue, although deficits returned to normal within 10 minutes after throwing (Tripp et al., 2007).

Proper history taking, physical examination, imaging, type of sport are important for final decision which type of treatment to use: conservative or surgical. The decision of return to sport is always challenging. Each case is individual and lack of objective criteria brings confusion into the final decision of returning to sports. Successful return to unrestricted function requires integrating the appropriate diagnosis, surgical management and rehabilitation in a coordinated effort. It is critical to carefully follow a postoperative rehabilitation program that has been based on an accurate diagnosis that specifies the extent of superior labral

pathology to ensure a successful outcome (Wilk et al., 2005).

SLAP lesions in overhead athletes often occur in combination with PTRC tears (Conway, 2001). It can be difficult to detect them because of the presence of concomitant pathology. Even 45% of patients with SLAP lesions had concomitant partial-thickness tears of the m. supraspinatus. R. A. Mileski and S. J. Snyder reported that 29% of their patients with SLAP lesions exhibited partial-thickness tears, 11% had complete cuff tears and 22% had Bankart lesions (Mileski, Snyder, 1998). During throwing motion when arm is in external rotation, tendon of long head of *m. biceps brachii* and tendon of *m. supraspinatus* impinges in acceleration – deceleration phase (Panossian et al., 2005). Repetitive motions in overhead activities are resulting in the appearance of the symptoms. J. R. Andrews et al. (1985) first hypothesized that SLAP pathology in overhead throwing athletes was the result of high eccentric activity of the m. biceps *brachii* during the arm deceleration and followed through phases of the overhead throw. Later on more data was presented by S. J. Snyder (1990, 1995).

S. S. Burkhart and C. D. Morgan (1998) presented a "peel-back" mechanism that produced SLAP lesion in the overhead athlete. They suggested that when the shoulder was placed in a position of abduction and maximal ER, the rotation produced a twist at the base of the biceps, transmitting torsional force to the anchor. C. Miller and F. H. Savoie (1994) found that about 74 % of the patients with rotator cuff tear had lesion of tendon of the long head of *m. biceps brachii*. S. J. Snyder et al. (1993) reported that 40% of 140 arthroscopically investigated patients with SLAP lesion had partial tear of rotator cuff tendon.

Predictable surgical outcomes can be expected after type II SLAP repair, but the effect of concomitant SLAP type II and PTRC tears on surgical outcome in overhead athletes and non-overhead athletes is still insufficient.

We hypothesize that concomitant SLAP type II and PTRC tears surgery will have good outcome for the overhead athletes but short term rehabilitation in acute phase after the surgery is insufficient for successful healing and fast return to sports.

The aim of the study was to evaluate shoulder complex functional characteristics of the overhead and non-overhead young athletes before and two years after the concomitant arthroscopic type II superior labrum anterior posterior (SLAP) and partial – thickness rotator cuff (PTRC) repair and to present specific rehabilitation guidelines needed for successful return to sports.

Research tasks:

1. To measure and compare shoulder joint ROM in of the overhead and non-overhead young athletes two years after concomitant arthroscopic surgery.
2. To evaluate functional characteristics of shoulder complex using Constant score of the overhead and non-overhead young athletes two years after concomitant arthroscopic surgery.
3. To prepare scientific literature based rehabilitation guidelines for the overhead athletes.

RESEARCH METHODS

The research was carried out following the principles of the Declaration of Helsinki about the ethics of experimentation with humans. The sample of the research included 38 male athletes, mean age = 22.91 ± 2.5 years, age range 18–28 years. According to their participation in different sport activities, they were divided into two groups.

The first group was composed of 19 *overhead athletes*. The mean age during surgery 23.6 ± 2.6 years (range 19–28 years). They underwent arthroscopic type II SLAP repair and were available for review at a minimum of two year after surgery. The second group was composed of 19 *non-overhead athletes* (mean age = 22.2 ± 2.4 years; range 18–26), who had the same shoulder pathology and arthroscopic repair procedure and were available for review at a minimum of two year after surgery. There was no significant difference among groups according to athletes' age ($p = 0.08$). Different sport activities of participants are presented in Table 1.

All surgeries were performed in Sports trauma and arthroscopic surgery sector of LUHS (Lithuanian University of Health Sciences) Hospital Kauno Klinikos, Orthopedics and Traumatology Clinic in 2008–2011. The same experienced surgeon performed all the arthroscopic surgeries.

Only those patients who were diagnosed with combined SLAP and PTRC injuries during shoulder arthroscopy and underwent full endoscopic reconstruction of both injuries, were included in this research. Those patients, who preoperatively had shoulder arthrosis (diagnosed radiographically), cervical osteochondrosis, osteoporosis or underwent opened shoulder reconstruction operations were not

included in this study. All participants had shoulder lesions in their dominant hand.

Table 1. **Distribution of participants according to different sports activities**

Sport activities	Number of athletes	
	Overhead athletes group	Non-overhead athletes group
Basketball	1	0
Volleyball	3	0
Tennis	1	0
Handball	3	0
Swimming	4	0
Water polo	1	0
Javelin throwing	1	0
Gymnastics	2	0
Wrestling	2	0
Rowing	1	0
Football	0	4
Running	0	3
Cycling	0	1
Athletics	0	4
Shooting	0	3
Motocross	0	4
Total	19	19

All participants were assessed preoperatively and postoperatively. Postoperative measures were taken after 22.4 ± 2.7 months. All measures were performed by the same experienced scientist.

All the patients underwent standard rehabilitation process in acute healing phase including physical therapy and physical modalities. Gentle and protective physical exercises were used in acute phase after the surgery. No sport-specific rehabilitation and long term physical therapy was applied in later stages.

Shoulder functional ROM assessment was performed with plastic goniometer. Shoulder flexion ROM and shoulder IR and ER ROM at 90° of abduction were evaluated using standard procedures.

Constant score was used for evaluation of the shoulder functional quality. The Constant score is a widely used shoulder-specific scoring system. It uses subjective and objective measures to determine whether a certain functional movement is possible. As an outcome tool, the Constant score includes the analysis of pain, shoulder motion, strength and function. From a perfect score of 100, it reserves 35 points for patient-reported subjective assessment, including the presence of pain and the ability to perform basic activities of daily living, and 65 points for objective measurement. For the latter, 40 points are allocated to range of motion and 25 points are allocated to strength (Constant, 2008).

The data analysis was performed using *SPSS 17.0 package for Windows*. Hypothesis concerning the difference between groups was verified using nonparametric tests. Differences were regarded as statistically significant when error probability with respect to criteria was $p < 0.05$.

RESEARCH RESULTS

Constant score. Before surgery there was no significant difference according Constant score values between the groups. After 2 years Constant score in both groups of athletes increased statistically significantly (Table 2). Significant difference was established comparing both groups after two years. The mean improvement of Constant score value in overhead athletes group was 21 points, in non-overhead group – 31 points. Although the deficit of Constant score decreased in both groups, the mean value of Constant score after two years did not returned to optimal value (Figure 1).

Table 2. **Constant score values before surgery and after two years follow-up**

Subjects	Before surgery	After 2 years
Overhead athletes	76.2 ± 1.2 ◄►	87.4 ±3.4 ▲
Non-overhead athlete	75.6 ± 3.4 ◄►	94.1±1.8 ▼

Note. ◄► – $p < 0.05$.

Shoulder functional ROM. Analyzing shoulder flexion, ER and IR before surgery, no significant differences were found in all shoulder movements comparing overhead and non-overhead athletes in both groups, the mean value of Constant score after two years did not return to optimal

When calculated total rotation ROM (external rotation ROM plus internal rotation ROM) was analyzed, significant difference among groups was established (141 ± 2.3 degrees in overhead athletes *vs.* 133 ± 2.9 degrees in non-overhead athletes). After two years, shoulder frontal plane flexion and internal rotation ROM in both groups and external rotation ROM of non-overhead athletes were the same as before surgery. Significant change of external rotation was established in overhead athletes. The external rotation ROM at follow up was significantly smaller and hadn't return even to preoperative value (Figure 2). Total rotation ROM after 2 years follow up significantly differed among groups (121 ± 2.9 degrees in overhead athletes *vs* 129 ± 2.8 degrees in non-overhead athletes).

Rehabilitation after shoulder injuries for overhead athletes. The main principles should be

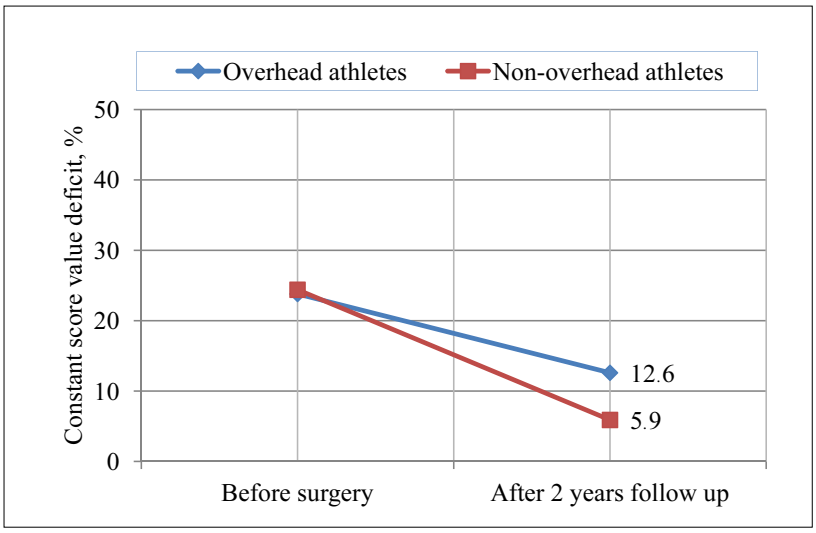

Figure 1. **Constant score value deficit before surgery and 2 years after surgery**

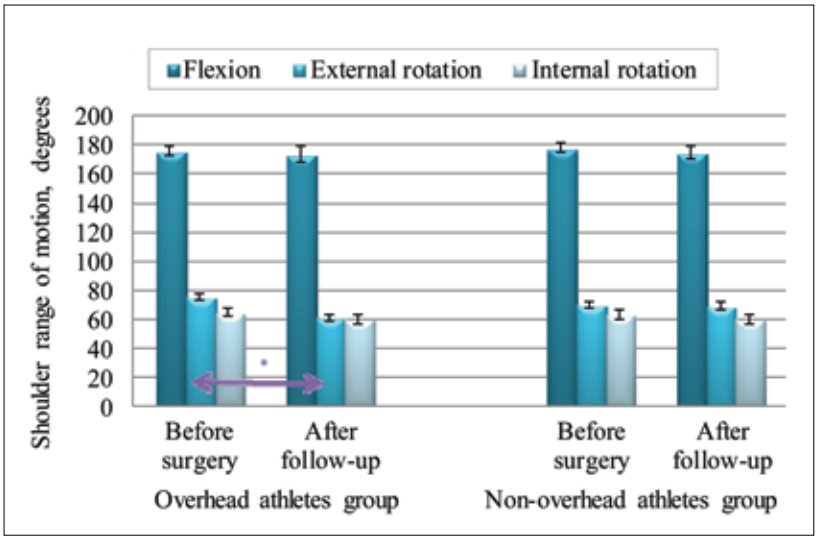

Figure 2. **Shoulder range of motion in overhead and non-overhead athletes groups**

Note. * – $p < 0.05$.

incorporated into prevention and rehabilitation protocol: to maintain or restore – ROM, strength of the glenohumeral and scapulothoracic muscles, dynamic stabilization and neuromuscular control, core stability and lower body condition, off-season preparation and in-season maintenance. Rehabilitation guidelines for overhead athletes differ in stages. In acute phase the main goals are to diminish pain and inflammation, to protect the anatomic repair, to prevent negative effects of immobilization, to improve posterior flexibility, to re-establish posterior strength and dynamic stability (muscular balance) and to control functional stresses. The athlete should abstain from throwing motion until pain-free full ROM and full strength (specific time should be determined by doctor) will be restored. Physical modalities can be applied – iontophoresis, phonophoresis, electrical stimulation and cryotherapy if needed. Flexibility exercises are used to improve IR at 90° abduction to normal total motion values and to enhance horizontal adduction flexibility. Gradual stretching into ER and flexion should be done (not to force into painful external rotation). Physical therapy covers exercises for rotator cuff strengthening (especially external rotation) with light-moderate weight (external/internal rotation with elastic resistance); scapular strengthening exercises (retractors, depressors and protractors); manual strengthening exercises; dynamic rhythmic stabilization exercises; proprioception training; electrical stimulation of posterior rotator cuff if needed during exercises; closed kinetic chain exercises; maintenance of core, lower body, elbow, wrist and forearm strength. A. Jaggi and S. Lambert (2010) suggest to use kinesiotaping for postural control. Early feedback of posture and shoulder girdle position is important for all overhead athletes to avoid inappropriate patterning and strengthening. Kinesiotapes can be invaluable in providing correct sensory feedback facilitating correct muscle activation. Early submaximal isometric exercises for the rotator

cuff should be performed as pain allows and to the exclusion of inappropriate muscle activity for patients. The belly press test, used to test the integrity of subscapularis can be modified for this purpose using pressure biofeedback device (Jaggi, Lambert, 2010). Criteria to progress are: minimal pain or inflammation; normalized shoulder IR and horizontal adduction ROM; baseline muscular strength without fatigue. The goals of intermediate phase are restore full ROM to gradually, preserve the integrity of surgical repair, progress with strengthening exercises, restore muscular balance (ER/IR), enhance dynamic stability, maintain flexibility and mobility, improve core stabilization and lower body strength. Flexibility exercises are done with the control especially for IR and horizontal adduction gradually restoring full ER. Physical therapy involves progress strengthening exercises. For the rotator cuff and scapula shoulder isotonic exercises can be used (later with weights). It is possible to start dynamic rhythmic stabilization exercises (side lying exercises for ER, elastic resistance for ER till end range, wall stabilization onto ball, push ups onto ball with stabilization). If exercises are tolerated well, 2-hand plyometric throws can be started (chest pass, side to side, overhead soccer throws). Criteria to progress are: full, pain-free ROM, full 5/5 strength with no fatigue. Goals in advanced strengthening phase are: aggressive strengthening exercises, progress in neuromuscular control, improvement of strength, power and endurance, start of light throwing activities, maintain shoulder mobility. Physical therapy exercises: stretching before exercise program (continue to normalize total motion, continue strengthening program above, re-initiate upper-body exercises), dynamic stabilization motions (ER with elastic resistance with end-range at 90° abduction, wall stabilization exercises in 90° of abduction and 90° of ER, wall dribble in 90° of abduction and 90° of ER, plyometrics (two-hand drills, one-hand drills, stretch after the exercises)). Criteria to progress are: full nonpain ROM, 75–80% strength of contralateral side, no pain and tenderness, adequate static and dynamic stability, appropriate rehabilitation progression to this point. Goals of return-to-activity phase: progress to throwing motion, continued strengthening and flexibility exercises, return to competitive throwing. Physical therapy exercises: stretching and flexibility exercises, shoulder stability program, plyometrics, dynamic stabilization, interval throwing training, gradual progress to competitive throwing as tolerated (Wilk et al., 2005; Reinold et al., 2010).

DISCUSSION

Shoulder pain, impingement symptoms, variable labral signs, and often a history of shoulder trauma are the most common symptoms for patients with SLAP and PTRC lesion. In throwing athletes, it is common to encounter delaminated (split into layers), intratendinous, partial-thickness rotator cuff tears in conjunction with SLAP lesions (Dodson, Altchek, 2009). When lesions of the labrum and rotator cuff occur concomitantly, arthroscopic repair of both lesions will restore ROM and stability and provide good clinical results in the short term (Voos et al., 2007).

ROM. Numerous researchers have reported abnormalities of ROM in overhead athletes that may influence shoulder complex injuries. So proper assessment of shoulder ROM is very important in profound evaluation of athletes. For this purpose understanding baseline values of ROM is needed. Although the fact that the arc of motion of overhead athlete's shoulder is shifted posteriorly, which increases ER and decreased IR of the abducted shoulder, is well known, very often assessment is rather confusing as many diverse normative values are presented by different investigators. For example, the amplitude of ER at 90 degrees of abduction varies from 103.2 to 136.1 degrees and the amplitude of IR at 90 degrees abduction varies from 42.2 to 79.3 degrees in dominant shoulder of healthy overhead athletes (Wilk et al., 2012). Outcome data after arthroscopic repairs are also rather confusing and the type of surgical intervention has very significant influence on the outcome values. Outcome results in shoulder ROM after SLAP repair in both athlete and non-athlete groups in most cases are much better than outcome results after concomitant SLAP and PTRC surgery. Our results showed that IR ROM in both athlete groups was similar to healthy overhead athletes' data, but ER data differed significantly from normal values even before surgery. It can be explained by concomitant injury repair surgery type. However, there is a lack of outcome data after concomitant SLAP and PTRC surgery, especially comparing overhead and non-overhead athletes. J. E. Voos et al. (2007) reported very similar data of ER restoration after such surgery in the non-athlete (average age 49 years) group. But still there are conflicting reports in literature regarding the outcome of SLAP repairs in overhead athletes and a paucity of data demonstrating the ability to return to the prior level of competition (Neri et al., 2011). Recently there were some critical opinions about

SLAP repair outcomes in research studies which concentrated on using questionnaires that primarily evaluated patients' activities of daily living and which did not focus on sport-specific performance (Neuman et al., 2011). Although in this research we did not analyse how our participants who succefully returned to their sport , though according to their shoulder complex ROM data after two yearstheir returning to sport was not very effective/easy.

Constant score. We could not find research data about Constant score changes in overhead athletes after concomitant SLAP and PTRC repair. However, B. Forsythe et al. (2010) reported that in non-athletes, Constant score after such surgery was 95.8 points. For healthy 21–30 years aged male subjects, normal values of Constant score were 97–99 points (Constant, 2008). So our research data of non-overhead athletes are very similar to these values, but there is a significant deficit of Constant score in overhead athletes. It can be due to the still existing deficit of ER after surgery.

Rehabilitation after SLAP and PTRC arthroscopic repair of overhead athletes. Overhead athletes with an acquired tight posterior inferior capsule and tight scapulothoracic articulation are the most likely to develop the "dead arm syndrome". This posteroinferior capsular contracture is acquired in the throwing athlete and presents as IR deficit with the arm in the 90° abducted position. The healthy throwing shoulder will have increased ER in abduction at the expense of IR. If the gain of external rotation equals the loss of IR, allowing a 180° ROM, problems will be avoided. The shoulder with a posterior inferior capsular contracture that restricts the total ROM to less than 180° is truly a "shoulder at risk". Most overhead athletes who develop an acute posterior superior SLAP may complain of associated activity-related bicipital groove pain (Burkhart, Morgan, 2001). After SLAP repair, biceps muscle strengthening is not allowed until four weeks after surgery. A throwing program may begin after three months, if the following criteria have been met: shoulder motion has been recovered; trunk, scapula, and rotator cuff muscle endurance balance and strength have been restored; and there is no pain with activity or during examination (Conway, 2001)

Return to sports. Return to play following the surgical repair of a type II SLAP lesion typically occurs at approximately 9 to 12 months following surgery. Rehabilitation places emphasis on gradually restoring ROM, strength, and dynamic stability of the glenohumeral joint while controlling forces on the healing structures (Wilk et al., 2005). Only 8% of professional baseball pitchers (1 of 12) with repaired full-thickness tears have returned to the same level of competition at a mean 66-month follow-up (Mazoué, Andrews, 2006). Repair of partial-thickness rotator cuff tears in professional and college throwers allowed 89% to return to the same level of play, with follow-up of only 12 months (Conway 2001). Kim Seung-Ha et al. (2002) evaluated 34 patients at a mean of 33 months after surgical repair of type II SLAP lesions. While the overall results were good (94% satisfactory UCLA shoulder score, 91% return to preinjury shoulder function), significant differences were observed between patients who participated in different types of athletics. Specifically, throwing athletes had lower shoulder scores and a lower percentage of return to their preinjury level of shoulder function than patients who were not involved in overhead sports (Kim Seung-Ha et al., 2002). Overhead athletes without a specific traumatic injury had lower scores and a lower return to preinjury function rate than athletes with a history of a specific traumatic event. These publications suggest that surgical repair of type II SLAP tears in overhead athletes with an overuse-related cause may be less successful than in other patients (Dodson, Altchek, 2009).

CONCLUSIONS AND PERSPECTIVES

Functional characteristics of shoulder complex measured with Constant score in overhead and non-overhead athletes statistically significantly increased two years after the arthroscopic surgery. The function of the shoulder complex more increased in non-overhead group ($p < 0.05$). However, that Constant score did not return to optimal level after two years (healthy, physically active person should have Constant score close to 100). Two years after the arthroscopic surgery, shoulder flexion and internal rotation ROM in both groups and external rotation ROM of non-overhead athletes were the same as before surgery. Significant decrease of external rotation was established in overhead athletes. The external rotation ROM after two years after the surgery was significantly smaller and did not return even to preoperative level. Sports-specific and diagnose-based rehabilitation is needed to decrease deficit in function of the shoulder complex after concomitant arthroscopic type II SLAP and PTRC repair. Decision to return to sport should be based on clinical examination findings and functional evaluation of the athlete.

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JAUNO AMŽIAUS VIRŠ GALVOS RANKŲ JUDESIUS NAUDOJANČIŲ SPORTININKŲ PETIES SĄNARIO PAŽEIDIMŲ ARTROSKOPINIS CHIRURGINIS GYDYMAS IR REABILITACIJOS GAIRĖS

Rimtautas Gudas[1,2], Laimonas Šiupšinskas[2], Vilma Mauricienė[2], Mindaugas Balčiūnas[3]

Lietuvos sveikatos mokslų universiteto ligoninė Kauno Klinikos[1], Kaunas, Lietuva
Lietuvos sveikatos mokslų universitetas, Sporto institutas[2], Kaunas, Lietuva
Lietuvos kūno kultūros akademija[3], Kaunas, Lietuva

SANTRAUKA

Tyrimo pagrindimas ir hipotezė. Virš galvos rankų judesius naudojantys sportininkai turi didesnę riziką patirti ūmias peties sąnario traumas ar lėtinius pažeidimus.

Tikslas – įvertinti virš galvos rankos judesius naudojančių ir nenaudojančių sportininkų peties komplekso funkcines ypatybes prieš bei praėjus dvejiems metams po kompleksinių viršutinės–priekinės–užpakalinės sąnario lūpos (SLAP) ir dalinių viršdyglinio raumens sausgyslės (DVSR) pažeidimų pilnai endoskopinių rekonstrukcijų, pateikti reabilitacijos gaires.

Metodai. Buvo tiriami 38 jauno amžiaus sportininkai vyrai: 19 virš galvos rankų judesius naudojančių ir 19 virš galvos rankos judesių nenaudojančių. Visiems tiriamiesiems buvo atliktos kombinuotos peties sąnario viršutinės–priekinės–užpakalinės sąnario lūpos (SLAP) ir dalinių viršdyglinio raumens sausgyslės (DVSR) pažeidimų rekonstrukcinės pilnai endoskopinės operacijos. Klinikiniai rezultatai vertinti prieš operaciją ir praėjus dvejiems metams po artroskopinės operacijos naudojant Constant skalę ir operuoto peties sąnario žasto judesių amplitudės matavimus.

Rezultatai. Abiejų grupių sportininkų Constant skalės rodiklių vidurkiai nepasiekė sveikų, fiziškai aktyviems asmenims būdingo peties sąnario funkcinio lygio. Praėjus dvejiems metams po artroskopinės peties sąnario operacijos, abiejų grupių sportininkų žasto lenkimo ir vidinės rotacijos judesių amplitudės grįžo į priešoperacinį lygį, o tik virš galvos judesius nenaudojančių sportininkų išorinės žasto rotacijos amplitudė grįžo į priešoperacinį lygį.

Aptarimas ir išvados. Abiejų grupių sportininkams funkciniai peties sąnario rodikliai, įvertinti Constant skale, statistiškai reikšmingai padidėjo praėjus dvejiems metams po operacijos. Virš galvos rankų judesius naudojančių sportininkų išorinės žasto rotacijos amplitudė praėjus dvejiems metams po operacijos negrįžo į priešoperacinį lygį. Virš galvos rankų judesius naudojantiems sportininkams po kombinuotos peties sąnario SLAP ir DVSR pažeidimų rekonstrukcinės pilnai endoskopinės operacijos vėlesniu reabilitacijos laikotarpiu būtina specifinė sporto šakos kineziterapija.

Raktažodžiai: peties kompleksas, viršutinės–priekinės–užpakalinės sąnario lūpos pažeidimas, dalinis viršdyglinio raumens sausgyslės pažeidimas, sporto kineziterapija.

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Corresponding author **Laimonas Šiupšinskas**
Lithuanian University of Health Sciences
M. Jankaus str. 2, LT-50275 Kaunas
Lithuania
Tel +370 37 730580
E-mail laimonas.siupsinskas@lsmuni.lt

CONCEPT AND STRUCTURAL COMPONENTS OF SOCIAL SKILLS

Margarita Jurevičienė[1], Irena Kaffemanienė[1], Jonas Ruškus[2]
Šiauliai university[1], Šiauliai, Lithuania
Vytautas Magnus University[2], Kaunas, Lithuania

ABSTRACT

Research background. Though a variety of social skill explanations exist, in essence they give us plenty examples of controversial interpretation of social skill conception and classification. So, there is a problem of different semantic meanings in the concept of social skills and different classifications of them.

Research aims were to reveal the multidimensionality of the construct of social skills and to create a theoretical model of their structure.

Research method was theoretical analysis.

Discussion and conclusions. After studying various explanations of social skills, we observed that not only a great variety of their interpretations was revealed, but also there is a problem of different semantic meaning: some authors named the same behavioral categories as social competences, others – as social skills, yet others – as social abilities, etc. In addition, the authors present a variety of different classifications of social skill groups and the different structures of social skills. In this theoretical research we tried to analyze and systemize the explanations of social skills with reference to the data of scientific research from various countries.

As a result of analysis and systemization of scientific data we offer a model of social skill structure and give interpretation of social skill concept as a multidimensional construct created from integrative, overlapping and supplementing each other structural components of: 1) interaction skills; 2) communication skills; 3) participation skills; 4) emotional skills; and 5) social cognition skills. Each component of social skills is made up of certain behavioral abilities.

Keywords: interaction skills; communication skills; participation skills; emotional skills; social cognition skills.

INTRODUCTION

Relevance of the problem. In scientific literature there is a variety of social skill conceptions. Social skills are explained as an assumption of a wholesome social life (Osit, 2008), which are essential in pursuance of personal sovereignty, ability to adapt to social situations, to express themselves and understand others (Colombero, 2004); to communicate avoiding conflicts, to maintain good interpersonal skills (Brodeski, Hembrought, 2007); social skills are an important condition for a harmonious existence in a social group, a possibility for an individual to act effectively in a social environment, and an assumption of a successful socialization. Research results prove that a person, who has acquired social skills and learnt to solve problems, can undergo changes more easily, and adapt to the circumstances; due to insufficient social skills an individual becomes dependent on the surrounding people (Gedvilienė, Baužienė, 2008). Undoubtedly, social skills determine the quality of person's social functionality and the quality of social situations' management, as well as make a great influence on the quality of personal and social life. Education and possession of these skills enable individuals to effectively communicate, meet the needs, relate

with others and be able to interact with people in various situations.

So, the effect of social environment on social skill development is analyzed in plenty of research, and an undoubtful importance of social skills for successful socialization is emphasized. However, studying various explanations of social skills, we can observe that scientists revealed a variety of interpretations. For example, some authors name the same behavioral categories as social competences, others – as social skills, yet others – as social abilities, etc. Though variety of social skill concepts shows a great interest of scientists in this problem, in general those studies do not explain the concept of social skills. In addition, the investigators do not have the same view of their structural components. Different authors explain the structure of social skills, selecting different values and varying criteria. That brings confusion in interpreting the concept of social skills in general. So, the problem exists because of using social skill concept in different semantic meanings as well as their different classification and different views of their structural components. It is necessary to find a single concept of social skills and explain their structure. Based on theoretical analysis of t scientific sources, the authors of this article aim at answering the following problem: *How can we define the concept of social skills? What structural components constitute the concept of social skills? What is the relationship between the concept of social skills and social abilities? How do we classify social skills?*

Research aim was to reveal the multidimensionality of social skill construct and to create a theoretical model of social skills structure.

THE CONCEPT OF SOCIAL SKILLS

A number of authors attribute similar meanings or even use as synonymic concepts of *social abilities*, *social skills*, *social competence*. However, when analyzing the *concept* of *skills*, authors usually show different stages in the formation of any act – from the lowest level, which is named as *ability*, to the highest or automated level of the actions, which is called as *skill* (Jovaiša, 1993; Lepaitė, 2003 et al.). So, skill is considered the highest level of performance of the action. The masterful application of skills in different situations or the perfect way of performing actions based on the knowledge, abilities and skills means a competence (Jacikevičius, 1994). According to D. Lepaitė (2003), a connecting link between skills and competence is the ability to apply the skills. Each personal competence is closely linked to the appropriate social skills and social abilities. Social competence extends to a variety of social functioning domains: not only as skills of personal relationships, communication, cooperation, but also as skills of self-management or skills of solving problems. S. Vaughn, A. Hogan (1990) also identified social competence relates to personal characteristics; according to the authors, social competence manifests as social cognition skills, effective communication and positive relations with others.

Theoretical analysis of scientific sources shows that the term of „social ability" is used 1) as one of the elements of any social activities (Lepaitė, 2003); 2) as the lower level of skills in the stage of their development (Jovaiša, 1993; Lepaitė, 2003). Social skills and their elements – social abilities – become apparent in all human social activities, when they carry out certain tasks and operate under certain circumstances (Trotter, Ellison, 2001).

In addition, authors often described social skills as the level or degree of personality, whereby a person demonstrates personal social knowledge and ability to manage social interaction (Hogan, Shelton, 1998); social skills are linked to a person's ability to initiate interactions, as well as an adequate response to other's behavior (Gresham, 2002). S. Cavell (1990) argue that social skills (such as overt behavior skills, social cognitive skills; emotional regulation skills, etc.) enable behavior which meets social expectations (standards of behavior).

Many authors recognize that social skills appear as an appropriate behavior (the ability to choose behavior according to the situation and meet the expectations of behavior, to express positive and negative feelings without the loss of social support, etc.). Social skills are demonstrated in a large variety of interpersonal contact and include the appropriate abilities of verbal and non-verbal reactions and individual perceptions under what circumstances and what behaviors will get environmental approval.

It is clear that a significant part of a person's social competence is determined by the quality of social skills. Consequently, the quality of social skills is important in all areas of human activity and thus social skills can be considered as one of the main measures of social competence.

The analysis of scientific literature shows a particularly high diversity of conceptions of social skills. But there are several most prevalent explanations of social skills among the diversity of conceptions. For example, some of the conceptions interpret social skills as individual personality traits (trait model); other authors describe the social skills as part of behavioral components (molecular model); yet other authors define social skills as intrapersonal (self-understanding, self-esteem, self-regulation) and interpersonal abilities.

Trait model treats social skills as essential personal characteristics, which manifest themselves in a personal behavior style (McNary, 2003). Authors, representing *trait model*, argue that social skills are *stable and long-lasting* personality features, such as empathy – feeling in somebody's emotional state (Nezlek et al., 2001), sociability (Lieberman, Rosenthal, 2001); or an individual difference, which expresses itself in communication (Riggio, 1986). R. Malinauskas (2004) studied such social skills that essentially mean personal traits: "four essential social skills can be named as *emotional expressiveness, emotional sensitivity, social expressiveness* and *social sensitivity*" (p. 2). According to the author, *emotional expressiveness* includes both the need for communication and an attitude towards communication; the *emotional sensitivity* means an ability to recognize emotions of others; the *social expressiveness* includes both verbal expressiveness (abilities to initiate conversations and speak with someone) and the ability to receive and to understand verbal signals; and the main component of *social sensitivity* is the ability to follow social rules and norms.

Molecular model appeared as a response to the trait model. Authors of this model define social skills not as a durable set of personal traits, but as *a person's ability to choose adequate behavior according to different contexts of social situations* (McFall, 1982). Molecular model analyzes behavior in a specific situation and treats social skills as specific behavior that changes depending on the environment and situational factors (Argyle, Kendon, 1967). Molecular model accentuates notable behavior manifestations in each social situation (Danielson, Phelps, 2003); a complex of behavior abilities (Libet, Lewinsohn, 1973); communication, representing one's own rights and aspirations without violating those of others (Phillips, 1978).

Majority of social skill conceptions have some attributes of both theoretical models (trait model or molecular model). According to J. Burgoon and N. Dunbar (2000) and others, social skills are best understood through an interaction between an individual and environment; social skills manifest themselves in certain activities, situations, and social interactions. Subsequently explanations of social skills include both the trait and molecular models and show that social skills are best understood when the personal traits and the situations, in which personality traits emerge, are being compared at the same time (Hochwarter et al., 2006).

In addition, social skills are defined from an *intrapersonal* (self-awareness, self-evaluation, self-control) and *interpersonal* perspectives (Raudeliūnaitė, 2007). According to A. Stravynski and D. Amdao (2001), social skills are described from an *intrapersonal* perspective as behavior that is typical of a personality in all situations and that refers to the person's self-perception. Self-perception and cognition of personal emotions, in D. Goleman's (2001) opinion, are the components of emotional intellect; it means an ability to understand, identify and manage one's own emotions and facilitate understanding situations in social life. Obviously, intrapersonal (or social cognition) skills are related to intellectual actions (self-analysis, reflection); and there is a close relation between intellectual strengths, academic achievements, and social skills (Welsh et al., 2001).

From the perspective of interpersonal model, social skills are explained as a behavior that corresponds to the way of some interaction; and thus social skills are specific behavior which can be learnt to apply in certain situations (Raudeliūnaitė, 2007).

Relation between intrapersonal and interpersonal skills can be described in the following way: intrapersonal skills (understanding oneself and own emotions, values, and abilities) create assumptions to develop the interpersonal skills (recognizing and understanding the feelings and moods of others, orienting in social situation, etc.). Both intrapersonal and interpersonal skills help a person to create adequate interaction with oneself and with social environment.

When describing social skills, researchers choose different criteria. In some occasions, for the explanation of social skills an *observable behavior* is selected as a reference point, which *meets social norms* and potentially should receive a positive social response; social skills, in F. M. Gresham's (2002) opinion, condition adequate actions. Authors

who hold this position describe social skills as a behavior that meets the norms, or as *compliance of instruction*, which helps the individual to communicate: to ask questions, ask for help, meet the needs, get along with others, maintain positive relations, protect one's own and other's self-esteem. Matson et al. (2008) and others define social skills as *observable* (for example, eyesight contact, gesticulation) and *measurable* (i. e., such that can be evaluated) *behavior*, by which an acceptance is sought in interpersonal exchange. Similar definitions of social skills are detected in the works of many authors. For example, J. Chadsey-Rusch (1992) defined social skills as a learnt, goal-oriented, societal norms guided behavior, which depends on a specific situation, social context; the author notes that societal behavior includes observable and unobservable, cognitive and emotional social proficiency elements, by which a positive or neutral response from other people is encourage, avoiding the negative one. Thus, social skills are analyzed from the social reasoning perspective (Cook et al., 2008). Authors emphasized an evaluative aspect of social skills, and highlighted positive effect of social behavior proficiency. This is shown by interpretations of social skills by many authors. Social skills are *socially acceptable behavior* which is described by an ability to understand social expectations and behave according to those expectations and situations; according to F. M. Gresham (2002), L. W. Stone et a.l (2002), social skills allow a person to communicate effectively, avoid unfavorable people's reactions, and receive important social results – acceptance, popularity, positive opinion about a person; social skills help to effectively communicate and avoid socially unacceptable response. With reference to these authors, a socially acceptable behavior meets societal expectations, social norms and, therefore, is favorably assessed.

In other cases, dynamism of social skills is accentuated; this manifests in *adequacy* of the chosen behavior *to the situation;* then, social skills are described as *personality variables*, which show person's flexibility, *sensitivity to the needs of others* (whether it would be based on empathy, or instrumental goals – Jarvin, Subotnik, 2006), *ability to orient in shifting situations*; social skills were described as *specific situational behavior* (different social skills are important in different situations), *goal-oriented* behavior (Norton, Hope, 2001). F. M. Gresham (2002) explains social skills as verbal and nonverbal behavior that does not depend on the situation (environmental circumstances, person's or other interaction members' needs and expectations).

Besides, from a qualitative point of view, social skills are also described as a *level* or *extent* according to which a person demonstrated social awareness and ability to manage the social interaction (Hogan, Shelton, 1998). There are also descriptions of social skills as moderators which help to regulate interpersonal relations and reach personal goals (Elijah, 2009).

It is important to note that the quality of social skills relates both with *personal ability to initiate an interaction*, and to an adequate *feedback to the behavior of others* (Gresham, 2002). Majority of authors acknowledge that social skills manifest as an *adequate behavior* (i. e. abilities to choose actions that correspond to the situation and expectations, abilities to express positive and negative emotions, without loosing social support). Such skills are demonstrated in a great variety of interpersonal contacts and include adequate verbal and nonverbal reactions and thus a person understands under which circumstances and what behavior is going to receive the approval of the surrounding people.

STRUCTURAL COMPONENTS OF SOCIAL SKILLS

Theoretical analysis proves that *social skills* of each area *are composed of certain behavioral components* – i. e. *abilities* that help the individual to recognize social signals and respond to them adequately, to behave in a way that a potential to receive support from the environment would be maximal (Walker et al., 2002).

Social skills can manifest themselves in abilities of different levels – starting with elementary communication (for example, eyesight contact), social perception abilities (such as understanding and interpreting social signals), *specific behaviors, ways of interactions* (for example, active listening, mutual communication, ignorance, etc.), which are applied by the individual when performing a social task; and finishing with *communication skills* – i. e. effectively interact with others, adequately react, avoiding interpersonal conflicts, adapt to both simple, and complex situations (Matson et al., 2008). L. K. Elksnin and N. Elksnin (2000) and others are of a similar opinion: social skills manifest in learnt verbal and nonverbal (posture, eye contact,

intonation, mimic) *communication manners* and *abilities of sharing* (Morrison et al., 2001), *initiation of interactions* (Heimann et al., 1995).

C. Canney and A. Byrne (2006) classify social skills according to the areas of their expression:

- *foundation skills*, manifesting in social interactions as basic abilities (eye contact, keeping an adequate personal space, gestures, mimic);
- *interaction skills* – they consist of the following abilities: to solve conflicts, wait for one's turn, initiate and close the conversation; interact with authorities;
- *emotional skills* are necessary for personal and other's awareness, they manifest as abilities to recognize and acknowledge the feelings of others, ability of empathy understanding body language and mimic, ability to determine whether another person can be trusted;
- *cognitive skills* are necessary in more complex situations of social interaction (social perception, self-observation, understanding of social norms, and the choice of an adequate behavior in different situations).

As the classification shows, certain abilities constitute social skills of each area. Similar units of social skill expression (abilities) of various areas can be found in the works of many other authors. U. Cornish and F. Ross (2004) classified social skills into recognition (perception) of consideration and social signals (signs), interaction (ability to understand the signals that others show and to change one's own behavior accordingly), action (ability to adapt), etc. Such social abilities as *greeting, maintaining a conversation, making and maintaining a friendship, asking for help and instructing others* help to perform daily interactions. S. N. Elliot et al. (2001) note that social skills reveal themselves as abilities to share, create relations, ask for help, etc.

- R. B. Rubin and M. M. Martin (1994) discern the following areas of social skills and abilities: *communication skills*: *self-disclosure* ability; *social relaxation* ability (coping with negative reactions of others, one's own stress management);
- *assertiveness* ability – to protect one's own rights without denying the rights of others;
- *expressiveness* ability – to express thoughts, feelings in a verbal and nonverbal manner;
- *emotional skills*: *empathy* – awareness of other person's emotions; having interest in other person's words and feelings, taking care of another person; immediacy, openness shown in conversation – ability to speak (find a common topic, understand one another);
- s*upportiveness* – understanding other without condemnation; orientation to help the other in solving his/her problems, and not the control of the other; empathy, and not estrangement, demonstration of equality, and not superiority;
- *adjustability skills*: e*nvironmental control* ability which helps to reach one's own goals and meet one's own needs;
- *interaction management* abilities – understanding a linguistic intercourse and mastering the communication etiquette, for example, turning to the interlocutor; rituals of initiation, development, and closing of the conversation, etc.

R. M. Rapee et al. (2000) discern social skills that come into play in *nonverbal and verbal communication* manners: *body language* – eye contact, posture, mimic; *voice–quality* – tone and altitude of voice, speech pace, clarity and *interaction abilities*: *conversation* – greeting, introducing oneself, initiation of conversations; *expression of favor, benevolence, friendship* – offering help, invitation, asking to join, expression of gentleness, complementing the other, sympathy, when others are hurt or sad; *assertiveness* – protection of one's rights, asking for help of information, expressing one's needs, refusal, coping with annoyance, harassment, etc. J. Zins et al. (2004) distinguish the following components in the structure of social skills: *social comprehension* skills (understanding and interpreting social factors), *social behavior* skills (creation of positive relations, responsible decision-making; constructive and ethical management of difficult situations), and *emotion management* skills (recognition and control of emotions; sympathy and care for others).

In the works of many authors, social skills are basically studied as interpersonal and intrapersonal, even though they are not always treated this way. R. Raudeliūnaitė (2007) perceives intrapersonal skills as *self-awareness*, *self-evaluation*, and *self-control skills*; interpersonal – making a *verbal and nonverbal contact*, *mutual interaction, conflict resolution* skills. In the opinion of other authors, the following abilities are attributed to the *intrapersonal* skills: *self-esteem*, *emotional self-awareness*, *assertiveness*, *independence,* and *self-realization*; and *interpersonal* abilities – empathy, *social responsibility*, and maintaining

interpersonal relationships; *adaptability*, research of reality and compliancy to the rules, as well as problem solving; stress management – abilities of resistance to stress and control impulsiveness; positiveness, optimism (Bar-On, Parker, 2000).

Other authors discern essentially the same or similar components in the structure of social skills:

- *self-cognition* – ability to get to know and evaluate oneself, one's character, strengths and weaknesses (Gailienė et al., 1996) and/ or *self-awareness*, i. e. abilities to recognize emotions (emotional self-perception); fairly assess one's own strengths; have confidence in oneself (Goleman, 2001);
- *self-control* – abilities to control emotions, cope with stress, impulses; motivate oneself to overcome difficulties; determine and observe the progress of personal and academic goals; emotional control; trust in others; consciousness; adjustability; goal achievement; initiative (Goleman, 2001) and / or *control of emotions* (empathy, overcoming stress, etc.) – understanding of one's own and others' emotions and knowing, how they impact the behavior and health (Gailienė et al., 1996);
- *social awareness* – abilities to understand the environment by observing others; acknowledge individual and group differences and similarities; understanding the feelings of others; orientation in services; organizational consciousness (Goleman, 2001);
- *effective communication* – ability to initiate and maintain positive relations with the surrounding people; express oneself in verbal and nonverbal ways that are acceptable to the culture and situation (Gailienė et al., 1996), and *relation management* – abilities to initiate communication; resist an inadequate social pressure; constructively control conflicts (Goleman, 2001);
- *decision-making* – abilities to analyze information and experience, analyze alternative solutions and their outcomes; make the most rational and optimal decisions (Gailienė et al., 1996), and the ability to make decisions in conflict situations (Gevorgianienė, 1999).

A. Bellacket et al. (2004) distinguish the following components of social skills: *expressive behavior* – the content of speech and paralinguistic characteristics (speech pace, voice intensity, intonation); *nonverbal behavior* (eye contact, pose, mimic/face expression, distance from the interlocutor); *social perception* or *receptive behaviors* – attentiveness to signals, their interpretation, recognition of emotions; *interactive behavior*: reaction speed, social encouragement, turn-taking; *situation factors* – awareness of social traditions and

norms, following those norms, and their application in specific situations.

In the structure of social skills many authors discern verbal, nonverbal, and paralinguistic abilities; social perceptions; social information processing and decision-making; reaction that meets the norms, expectations of society and the situation; assertiveness; speech; control and expression of emotions (Kopelowicz et al., 2006), and other abilities.

As a result of scientific data systematization, the authors of this article grounded a structural model of social skills (see Figure).

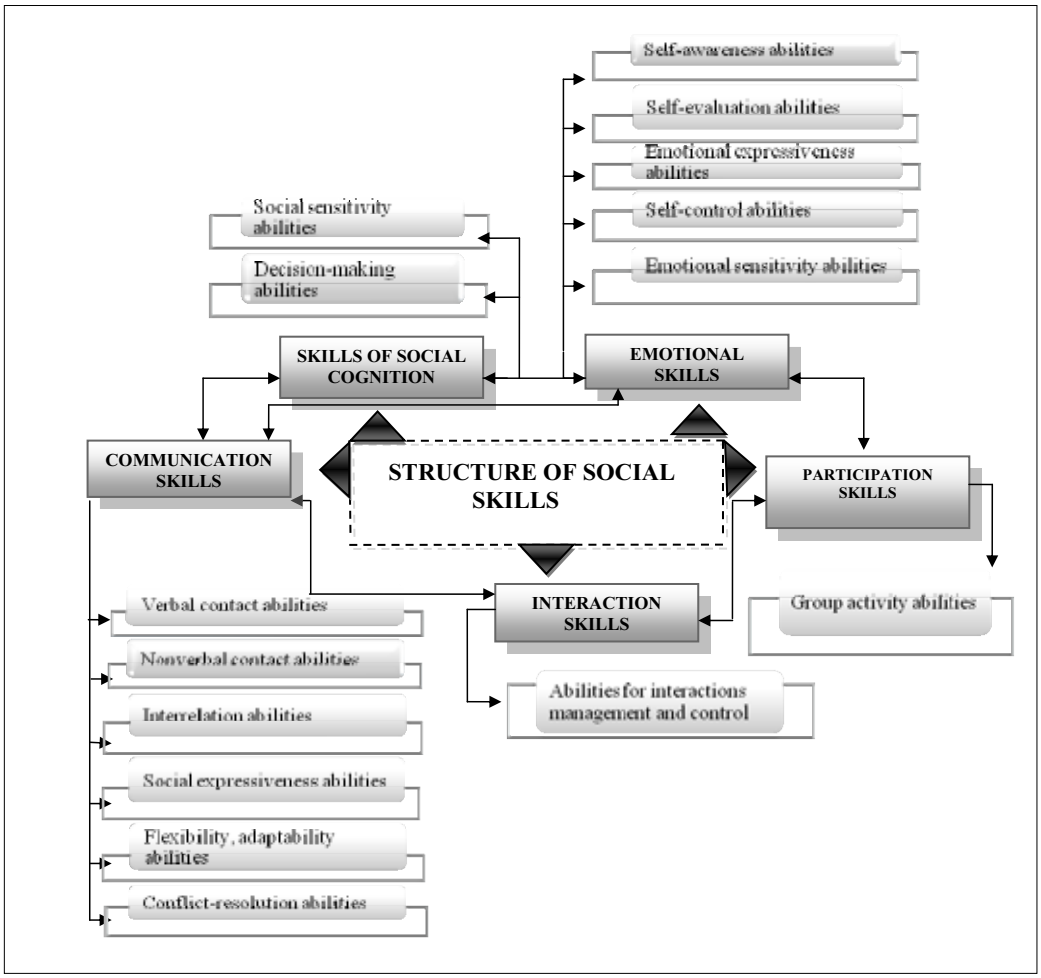
We think it is reasonable to classify social skills by functioning areas: *1) interaction skills*; *2) communication skills; 3) participation skills; 4) emotional skills*; *5) social cognition skills*. Social skills of each area are divided into smaller units – social abilities. The structural components of social skills and abilities are described below in more detail.

Interaction skills consist of management and control abilities of mutual interactions which include the management of one's own behavior, and the abilities to manage and control the interaction of other with him/her (for example, the ability to resist the negative effect and etc.). Thus, social interaction manifests in the effect that communicators make on one another.

Communication skills distinguish in a complex structure. Analyzing the structure of communication skills, it becomes clear that they consist of abilities of various complexity levels. In the works of various authors, communication skills are firstly related to the abilities to *initiate and maintain verbal and nonverbal contact* (Gevorgianienė, 1999; *Rapee et al.,* 2000; Bellack et al., 2004; Cornish, Ross, 2004; Canney, Byrne, 2006; Raudeliūnaitė, Paigozina, 2009).

On the other hand, nonverbal contact and communication abilities that are followed by a verbal communication are no less important, and, in some cases (for example, given there is a speech underdevelopment) nonverbal communication takes over and substitutes usual (verbal) communication.

Figure. **Structural model of social skill components**



However, communication skills manifest not only in the easiness of contact initiation, but also in more complex abilities of maintaining *interpersonal relations* (Gailienė et al., 1996; Cornish, Ross, 2004). *Social expressiveness* is also needed when communicating (*Rapee et al*., 2000; Cornish, Ross, 2004; Malinauskas, 2004), as well as, *flexibility* and *adjustability* abilities (*Rapee et al*, 2000; Goleman, 2001;Cornish, Ross, 2004), and *conflict resolution* abilities (Gevorgianienė, 1999; Cornish, Ross, 2004 et al.).

Theoretical analysis proves that co-operation skills are often mentioned next to communication skills. However, authors describe the structure of co-operation skills basically as activity abilities, and not social ones. For instance, activity and co-operation skills are such as activity planning, activity organization and evaluation, participation in group activity (Raudeliūnaitė, Paigozina, 2009).

Emotional and social cognition skills are integrating and overlapping, i.e., they manifest in various human communication and participation activities. Components of *emotional skills* are abilities of *self-awareness* (Gailienė et al., 1996; Bar-On, Parker, 2000; Goleman, 2001; Cornish, Ross, 2004) and *self-evaluation* (Raudeliūnaitė, 2007); those abilities help individual to understand oneself in social interaction situations; and *emotional expressiveness* (Malinauskas, 2004) or *self-revelation abilities* – they help to positively reveal oneself to others. It is important to understand others in communication situations and *emotional sensitivity* abilities are necessary in order to do this (Malinauskas, 2004); *self-regulation* (Bar-On, Parker, 2000), *self-management* or *self-control* abilities (Goleman, 2001; Raudeliūnaitė, 2007) help to behave adequately.

Emotional expressiveness and *emotional sensitivity* are the ones that integrate with communication abilities. According to R. Malinauskas (2004), emotional skills enrich and enliven verbal and nonverbal communication. The author states that *emotional expressiveness* belongs to the area of nonverbal information transfer and includes not only the ability to express the need for communication, but also shows the individual's ability to express emotions in a manner that is understandable and acceptable to the surrounding

people. *Emotional sensitivity* means the recognition of other's emotions, and *emotional control* – ability to control and regulate one's emotional states and their nonverbal expression, as well as to mask one's emotional state, and avoid a spontaneous burst of emotions (Malinauskas, 2004).

Thus, emotional skills manifest in two ways – on the one hand, they aid the person to understand oneself and to cope with his/her emotions, also to control oneself while communicating and participating in a common activity with others; on the other hand, emotional skills help to understand the partners of communication or a common activity.

Analyzing H. Bless et al. (2004), J. I. M. Carpendale and C. Lewis (2006) and other authors' works we identified social cognitive skill component in the structure of social skills. Cognition skills undoubtedly condition the quality of person's social functioning (firstly, communication and participation in activities). Their basis is social norms which regulate behavior and knowledge (cognitive level). The practical level of social cognition skills is *social sensitivity* which aids to decode social signals (abilities of *perception of social signals)*, assess the situation (*social situation evaluation abilities*), by comparing it to the knowledge about social norms (*cognition abilities of social norms*), as well as it helps to make decisions about a behavior that would be adequate to the situation, and when needed, to solve problems *(decision-making abilities*). So, s*ocial sensitivity* is as ability to understand (decode) verbal signals, understand and follow social norms which regulate adequate social behaviors (Malinauskas, 2004), and *problem-resolution ability* is related to cognitive abilities. Besides, according to D. P. Hallahan and J. N. Kauffman (2003), social cognition skills (to understand and memorize requirements for actions and behaviors) relate to emotional skills (self-regulation, and self-control abilities). The basis for social sensitivity is abilities of social norm awareness, recognition and evaluation of emotional state of partners, etc. Both the knowledge of social norms and practical orientation to social norms in various social situations require a high level of social and emotional intellect.

Social cognition skills reflect person's orientation in social life, understanding the logics of interpersonal relations, expectations from the surrounding people's viewpoint and behavior control corresponding to expectations.

According R. Malinauskas (2004), social skills of each area reveal themselves by the ability to send and interpret verbal and nonverbal (body language, mimic, emotional) information, and to control the quality of one's own communication. Similar standpoint is found in R. Raudeliūnaitė's (2009) research. When analyzing components of social skills, the author chose communication (interaction, perception) and intercourse skills as an essential reference point.

In summary, it can be stated that communication skills are essential in the structure of social skills; however, communication skills are closely related to emotional and social cognition skills; besides, communication skills manifest in observable behavioral forms – interaction management and control abilities. So, *communication* induces the development of all other social skills: helps to learn ways to express socially acceptable behavior and emotions, control the expression of behaviors and emotions, constructively resolve conflicts and strengthen interrelationships. On the other hand, *communication* is both the *factor* and the *presumption of social skill formation*; communication and other social skills are the *result of social and educational interactions*.

CONCLUSION AND PERSPECTIVES

Analysis of scientific sources has proved that *social skills* are being studied from various point of view: as consistent *personality characteristics*; as *behavioral components;* as *a behavior*, which corresponds to societal expectations and adequately shifts depending on the context (peculiarities of the environment and individual), etc. Some authors named the same behavioral categories as social competence, others – as social skills, yet others – as social abilities. Scientists note that social skills help to orient in social situations with more success; however, the quality of social skills and social abilities can be individual, and this may cause an unequal level of social adjustability and social functioning.

Also diversity of social skill classification was discovered in various scientific sources. Social skills were *classified into categories* according to the *ways of their expression* (verbal, nonverbal), *areas of expression* (intrapersonal, interpersonal). It is typical that many scientists classify social skills into categories or types of skills according to their *level of complexity*. Describing the conception of social skills, scientists reveal different levels of their complexity: from basic (eye contact, limited verbal response to limited social stimuli from the

environment) to complex social skills (decision-making, leadership, etc.).

The variety of interpretations and classifications, possibly, can be explained by differing methodological regulations of research.

In our opinion, the concept and design of social skills is best explained in terms of system theory. System theory allows to analyze the complex structures, events and processes in different aspects and evaluate the relationships between system components (von Bertalanaffy, 2001; etc.). In addition, system theory emphasizes the complexity of human interaction with the environment and people's ability to not only to give up to the environmental impacts, but also the ability to change even a variety of environmental factors on them (von Bertalanaffy, 2001; Mulej, 2007).

Based on the analysis of scientific research, we revealed the multidimensionality of social skills' construct and a theoretical model of structure of social skills. We think that social skills can be interpreted as a complex multidimensional construct of integrated, overlapping and supplementing each other structural components of *1) interaction skills; 2) communication skills; 3) participation skills; 4) emotional skills;* and *5) social cognition skills.* Each of those structural components of social skills relate to each other by close systematic ties and the skills of every area consist of various smaller units – social abilities, which are important not only for one area of skills. Social abilities of each social skill component integrate and overlap into the more than one area of person's social functioning. *Communication* is both the *factor* and the *presumption of social skills formation*. So communication skills are essential in the structure of social skills. Communication and other social skills are the *result of social and educational interactions.*

Various individual's social functioning areas of an individual are inter-related components of social skills, such as interaction, communication, participation, emotional, social cognition skills. Therefore, based on system theory perspective, advances in one area of social skills, have an effect on other areas of social skills.

In perspective we believe that social skill structural model based on systems theory approach can be useful both for the social skill assessment purposes, as well as for educational purposes. Social skills structural model can explain and clearly show which personal social skills and abilities need more attention of educators. In the area of solving educational problems, the main attention must be given to training specific social abilities that are parts of various social skills.

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SOCIALINIŲ ĮGŪDŽIŲ SAMPRATOS IR STRUKTŪROS KOMPONENTŲ TEORINĖ ANALIZĖ

Margarita Jurevičienė[1], Irena Kaffemanienė[1], Jonas Ruškus[2]
Šiaulių universitetas[1], Šiauliai, Lietuva
Vytauto Didžiojo universitetas[2], Kaunas, Lietuva

SANTRAUKA

Tyrimo pagrindas. Socialinių įgūdžių tyrimų gausa rodo didžiulį visų šalių mokslininkų susidomėjimą šia problema, tačiau tokie tyrimai pasižymi nevienareikšme bei kontroversiška šių įgūdžių interpretacija ir iš esmės nepaaiškina jų struktūrinių ypatumų.

Tikslas – remiantis mokslinių šaltinių teorinės analizės duomenimis suformuluoti socialinių įgūdžių sampratą atskleidžiant socialinių įgūdžių konstrukto multidimensiškumą ir pateikti teorinį socialinių įgūdžių struktūros modelį.

Tyrimo metodas – teorinė analizė.

Aptarimas ir išvados. Atlikus mokslinių darbų teorinę analizę, atskleista ne tik socialinių įgūdžių aiškinimo įvairovės problema, bet ir nevienoda klasifikacija bei susijusių sąvokų interpretacijos nevienareikšmiškumas. Kai kurie autoriai tas pačias elgesio kategorijas įvardija skirtingai: vieni – kaip socialinę kompetenciją, kiti – kaip socialinius įgūdžius, dar kiti – kaip socialinius gebėjimus. Be to, aptinkamas ir prieštaringas socialinių įgūdžių klasifikavimo į grupes bei kiekvienos srities socialinių įgūdžių sandaros (sudedamųjų elementų) aiškinimas. Šio tyrimo metu susisteminus įvairių autorių pateiktas socialinių įgūdžių koncepcijas, pasiūlyta interpretuoti socialinius įgūdžius kaip asmens socialinės kompetencijos sudedamąją dalį. Straipsnio autorių nuomone, socialiniai įgūdžiai – sudėtingas multidimensinis konstruktas, sudarytas iš tarpusavyje integruojančių (persidengiančių) ir vienas kitą papildančių struktūrinių komponentų–įgūdžių: 1) interakcijos; 2) bendravimo; 3) dalyvavimo; 4) emocinių; 5) socialinės kognicijos. Kiekvieną iš šių socialinių įgūdžių struktūrinių komponentų sudaro atitinkamų socialinių gebėjimų kompleksai, kuriuos sieja glaudūs sisteminiai ryšiai. Socialiniai gebėjimai yra socialinių įgūdžių struktūriniai elementai.

Raktažodžiai: interakcijos, bendravimo, dalyvavimo, emociniai ir socialinės kognicijos įgūdžiai.

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Corresponding author **Margarita Jurevičienė**
Šiauliai University
Vilniaus str. 88, LT-76285 Šiauliai
Lithuania
Tel +370 68357173
E-mail margarita.jureviciene@gmail.com

PSYCHOSOCIAL ADJUSTMENT OF FIRST YEAR GYMNASIUM STUDENTS DEPENDING ON GENDER

Šarūnas Klizas[1], Irina Klizienė[2], Vitas Linonis[2], Daina Miliauskienė[3]
Lithuanian Academy of Physical Education[1], Kaunas, Lithuania.
Kaunas University of Technology[2], Kaunas, Lithuania
Special School of Prienai[3], Prienai, Lithuania

ABSTRACT

Research background and hypothesis. The data of students' national academic achievements confirmed that high achievements were related to good well-being at school. Most attention should be paid to first year gymnasium students because especially great differences were established in the academic achievements of those who evaluated school microclimate favorably and unfavorably. We hypothesized that the level of psychosocial adjustment of female first year gymnasium students would be higher than that of male students.

Research aim. The aim of the present study was to establish psychosocial adjustment of first year gymnasium students depending on their gender.

Research methods. The sample included 362 first year gymnasium students, girls (n = 198) and boys (n = 164). They were 14–16 years of age. The Rogers and Dymond's questionnaire was chosen for the evaluation of *psychosocial adjustment* (Rogers, Dymond, 1954). It was translated into the Lithuanian language and adapted for the Lithuanian population (Klizas, 2009). Besides the psychosocial adjustment subscale, we analyzed other subscales (*self-esteem, evaluation of others, emotional comfort, integrity, domination, avoidance of problem*) as well which helped reveal the person's psychosocial adjustment.

Research results. Analyzing the level of gymnasium students psychosocial adjustment in the aspect of gender, we established statistically significant difference in the avoidance of problems ($t = –3.19$; $p < 0.05$). We established that the level of negative evaluation of others for boys and girls was statistically significant ($\chi^2 = 10.71$; $df = 2$; $p < 0.05$). The evaluation of the level of emotional discomfort for boys and girls revealed a statistically significant difference in the aspect of gender ($\chi^2 = 12.49$; $df = 2$; $p < 0.05$).

Discussion and conclusions. We established that psychosocial adjustment of first year gymnasium students was of low level. Such components of psychosocial adjustment as adjustment, evaluation of others, emotional comfort, integrity, domination and avoidance of problems were of low level, and only self-esteem was moderate. In the aspect of gender, we revealed a statistically significant difference in the avoidance of problems ($p < 0.05$). The avoidance level of girls in the first year of the gymnasium was higher than that of boys. But for boys, the levels of adjustment, evaluation of others, emotional comfort, integrity, domination were higher than those of girls. Self-esteem for girls was higher than that of boys; however, no statistically significant difference was found.

Keywords: school (adjustment) microclimate, emotional comfort, avoidance of problems.

INTRODUCTION

Psychosocial adjustment of a personality as a special phenomenon of an individual in social interrelations covers multiple aspects in itself, some of which are related to the standards of the society while others are connected with the behavioral norms of the personality. All of them are equally important for the peculiarities of the personality values and its needs (Malinauskas, 2006). During the whole life of an individual, value orientation and development of needs

acquire particular traits which at some moments of human life contribute to efficient adaptation while sometimes they complicate the situation by involving specific peculiarities. The age group of adolescence is unique since it shows the "flash" of the development of social, psychological and physiological activeness of the personality (Barkauskaitė, 2000). Psychosocial adjustment may be determined as a mutual process taking place between an individual and his/her environment, and the active adjustment of an individual to the altering environment and conditions of living (Juodraitis, 2004). Psychosocial adjustment during adolescence may be interpreted as the strife of adolescents to discover their place, to alter in order to adjust, and to alter the place in order to adapt it to themselves. Thus, it is essential to explore the middle school age during which the "flash" of motoric needs takes place together with the active sexual maturation as well as rapid growth and development of all the organs and systems of the body.

On the basis of the exploration of publications and research at the recent time, one may claim that the issue of psychosocial adjustment of students of the age of adolescence raises increasing worries of pedagogues and the general society (Malinauskas et al., 2008). These students whose adaptation at school and among peers is not fluent and those who experience hard situations in their family and/or home environment, later on transfer their problems to the world of adults (Juodraitis, 2004). It has been established that schoolchildren experience difficulties while adjusting to the altered environment and they undergo adaptation crisis. The age period of the first year gymnasium students is adolescence, and in this period schoolchildren are most vulnerable by the social environment, so adjustment difficulties at school are linked to further adaptation of schoolchildren in the society. Personal ability to adapt to changes in life and good psychosocial adjustment under the conditions of constantly changing situations are the indicators of the quality of life. If this process is not successful, there is absolutely no balance between the individual and their environment, which interferes with the individual development and meeting their needs (Harrison, Jagelavičius, 1999). Students' well-being at school, i.e. their evaluation of school climate is an important part of school education quality. It is obvious that school that threatens and hinders students' motivation and promotes bullying is not a good school, even if the academic achievements of schoolchildren are high (Gudynas et al., 2009). Thus, the accessibility of general education should be analyzed in the context not only of schoolchildren's achievements, but also their psychosocial adjustment at school.

The analysis of other studies (Jia et al., 2009; Adeyemo, Ogundokum, 2010) and their publications suggests that the problem of schoolchildren's psychosocial adjustment at school still worries the majority of teachers and the society. Difficulties in psychosocial adjustment in the gymnasium can influence not only schoolchildren's academic achievements, but also their mental and emotional health. At present problems of schoolchildren's adjustment and anxiety are common. Well-being of a student is believed to be one of the most important factors deciding the level of their psychosocial adjustment, attitudes towards school and learning. Poor well-being and continuous anxiety lower child's intellectual abilities, working capacity, initiative, hinders communication with others, and thus provokes conflicts between the adolescent and the new environment (Parker, Neuharth-Pritchett, 2009). Research results have shown that successful school adjustment is determined by the safety of schoolchildren because when children feel safe and surrounded by warm and pleasant environment, the process of school adjustment will be smooth (Midgley et al., 2000). Success in psychosocial adjustment also depends on the relationship between schoolchildren and teachers (Barber, Olsen, 2004). Teachers who not only interest children in their subjects but themselves show interest in schoolchildren and their life at school have a positive effect on their mutual aims and methods of work. Help for students is the indicator of teachers' behavior at school of utmost importance. It helps to understand the changes in schoolchildren's learning, personal and interpersonal relations after changing school. For this reason teachers have to help first year gymnasium students to perceive that in a new community it is very important to know every member in the classroom, the organization culture, values, and community aims because all those things ensure faster adaptation in a new environment (Barber, Olsen, 2004).

The data of students' national academic achievements confirmed that high achievements were related to good well-being at school. If students felt well at school (they liked to be and learn there, they did not feel lonely, they were liked by other students, they had possibilities to discus

school rules and they felt in their own place), their academic achievements were statistically significantly higher compared to those students who did not feel so well (Bigelienė, Uginčienė, 2008). Most attention should be paid to first year gymnasium students because especially great differences have been established in the academic achievements of those who evaluated school microclimate favorably and unfavorably (Gudynas et al., 2009).

The aim of the present study was to establish psychosocial adjustment of first year gymnasium students depending on their gender.

We hypothesized that the level of psychosocial adjustment of female first year gymnasium students would be higher than that of male students.

RESEARCH METHODS

Using the strategy of random sampling we selected first year gymnasium students from three city and three regional gymnasiums. The sample included 362 first year gymnasium students, girls (n = 198) and boys (n = 164). They were 14–16 years of age. While organizing the research we distributed 419 questionnaires. We received 392 questionnaires as 27 students refused to participate in the research. After the initial calculations and the application of the falsity scale estimates, 362 questionnaires were suitable for the analysis (30 questionnaires were eliminated from the analysis as unsuitable).

We obtained oral permission to carry out our research from the gymnasium administration, teachers and students. The survey was conducted in the morning, during the lessons. Before the research the students were explained the aim of the research and the order of filling in the questionnaire. The procedure of filling in the questionnaire took place in the classroom and lasted about 40 minutes. The questionnaires were filled in personally, and no help was needed from the researcher.

Instruments. The Rogers and Dymond's questionnaire was chosen for the evaluation of *psychosocial adjustment* (Rogers, Dymond, 1954). It was translated into the Lithuanian language and adapted for the Lithuanian population (Klizas, 2009). The Rogers and Dymond's questionnaire consisted of 101 items and the range of responses was a 7-point scale. The respondents had to choose one answer out of seven possible variants: *This is definitely not about me – 0; This does not look like me – 1; I doubt that this could be applied to me – 2; I do not dare to apply it to me – 3; This is similar to me, but I am not sure – 4; This is similar to me – 5; This is definitely about me – 6*. The results were evaluated as follows: up to 68 points – low level of adjustment, 68–170 points – moderate level of adjustment, and higher than 170 points – high level of adjustment.

The main subscale, which best revealed the nature of psychosocial adjustment, was "adjustment" subscale (internal validity of this subscale (Cronbach's alpha) was 0.76). The subscale included the 67 items of the questionnaire. Besides the psychosocial adjustment subscale, we analyzed other subscales (*self-esteem, evaluation of others, emotional comfort, integrity, domination, avoidance of problems*) as well which helped reveal the person's psychosocial adjustment. The subscale "self-esteem" consisted of 18 items. Cronbach's alpha of the subscale "self-esteem" was 0.72 for the present sample. The subscale "dominance" consisted of nine items. Cronbach's alpha of the subscale "dominance" was 0.72 for the present sample.

Statistical analysis. Data analysis was performed using the Statistical Package for Social Sciences (SPSS) version 17. Kolmogorov-Smirnov test was applied for normality verification. The nonparametric *chi-square test was used* for the statistical analysis of the data. The distribution of the Rogers and Dymond's questionnaire data differed from the normal distribution statistically insignificantly. Consequently, t-test for independent samples was used for the significance of the difference between the means of groups. We chose the significance level of 0.05.

RESEARCH RESULTS

The authors of this method (K. Rogers and R. Dymond) designed their own model of psychosocial adjustment, thus besides the main adjustment subscale they included other subscales which in their opinion help reveal psychosocial adjustment of a person. For the validity of the subscales, correlation analysis was performed (Table), which produced statistically significant and theoretically meaningful correlations between subscales. Strong and statistically significant relation was found between adjustment and self-esteem subscales ($r = 0.86$; $p < 0.001$), as well as between adjustment and integrity subscales

($r = 0.83$; $p < 0.001$). Strong and statistically significant relation was established between the subscales of adjustment and evaluation of others ($r = 0.68$; $p < 0.001$), and adjustments and emotional comfort ($r = 0.76$; $p < 0.001$). We can claim that successful psychosocial adjustment is influenced by positive self-esteem and integrity, as well as experienced emotional comfort and evaluation of others. Week correlation was established between adjustment and wish to dominate ($r = 0.34$; $p < 0.001$). It should be noted that we established a negative essential correlation between adjustment and avoiding problems ($r = –0.41$; $p < 0.001$). It shows that when a person avoids problems, it is difficult to judge about successful psychosocial adjustment.

Statistically significant strong relations were established between personal self-esteem and emotional comfort ($r = 0.61$; $p < 0.001$), integrity ($r = 0.71$; $p < 0.001$), and the relation between self-esteem and evaluation of others was statistically significant and essential ($r = 0.5$; $p < 0.001$). We can argue that personality with positive self-esteem experiences emotional comfort, integrity, positively evaluates others and is not inclined to dominate, which ensures high levels of psychosocial adjustment.

Correlation analysis revealed that there were strong and very strong essential, statistically significant relations between all subscales of psychosocial adjustment, which suggests that in K. Rogers and R. Dymond's model of psychosocial adjustment, not only the main subscale of adjustment is important, other subscales are no less important as well: self-esteem, evaluation of others, emotional comfort, avoidance of problems, integrity and domination.

Analyzing the level of gymnasium students' psychosocial adjustment in the aspect of gender, we established statistically significant difference in the avoidance of problems ($t = –3.19$; $p < 0.05$). The level of avoidance of problems among the girls was higher (14.42 ± 4.79 points) compared to boys (12.78 ± 4.99 points). It was established that the levels of adjustment, evaluation of others, emotional comfort, integrity and domination for boys were higher than those for girls. Self-esteem for girls was higher than that for boys, but we did not establish statistically significant difference (Figure 1).

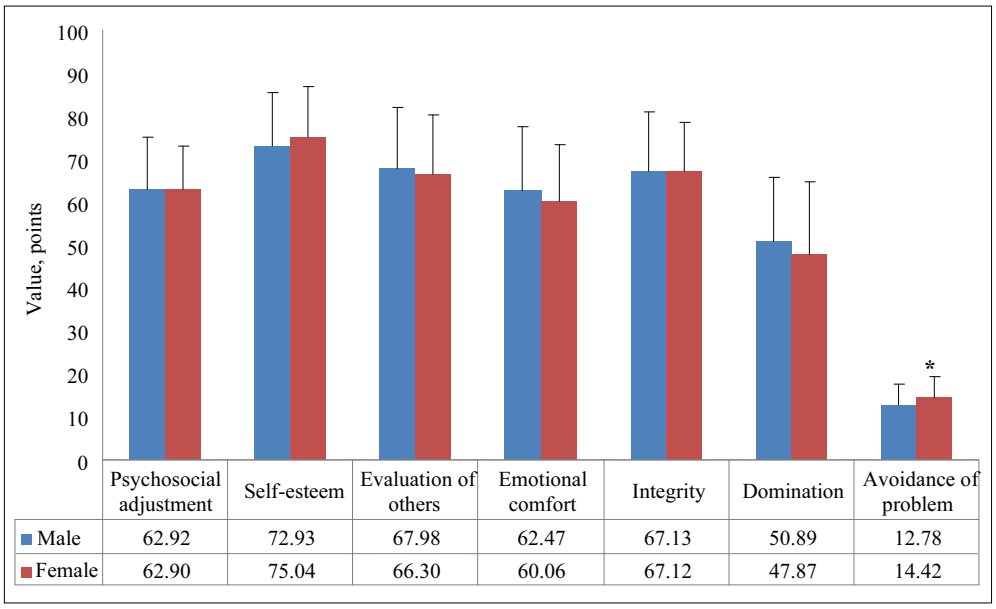
The differences in the levels of negative evaluation between girls and boys were statistically significant ($\chi 2 = 10.71$; $df = 2$; $p < 0.05$) (Figure 2). The average level of negative evaluation of others was more common among girls (56.6 %) compared to boys (40.2 %). Low level of negative evaluation of others dominated more among boys (59.8%),) compared to girls (42.9%).

The evaluation of the level of emotional discomfort for boys and girls revealed a statistically significant difference in the aspect of gender ($\chi^2 = 12.49$; $df = 2$; $p < 0.05$). The majority of girls (65.7%) experienced the average level of emotional discomfort, and the majority of boys (51.8%) – the low level of it. Almost half of the respondents (48.2%) demonstrated moderate level of emotional discomfort. Low level of emotional discomfort was characteristic of 33.8% of girls. High level of discomfort was expressed only by 0.5% of girls (Figure 3).

Table 1. **Inter-correlation indices of adjustment scales**

Adjustment subscales	Self-esteem	Evaluation of others	Emotional comfort	Integrity	Domination	Avoidance of problems
Adjustment	0.86(**)	0.68(**)	0.76(**)	0.83(**)	0.34(**)	–0.41(**)
Self-esteem	1	0.5(**)	0.61(**)	0.71(**)	0.21(**)	–0.26(**)
Evaluation of others	0.5(**)	1	0.47(**)	0.45(**)	–0.05	–0.32(**)
Emotional comfort	0.61(**)	0.47(**)	1	0.6(**)	0.35(**)	–0.33(**)
Integrity	0.71(**)	0.45(**)	0.6(**)	1	0.33(**)	–0.23(**)
Domination	0.21(**)	–0.05	0.35(**)	0.33(**)	1	–0.1
Avoidance of problems	–0.26(**)	–0.32(**)	-0.33(**)	–0.23(**)	–0.09	1

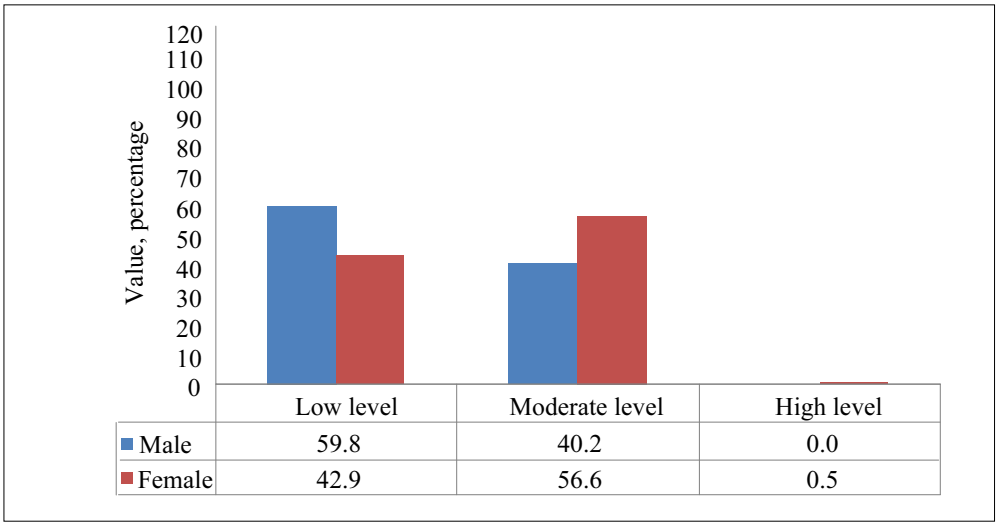
Note. ** – statistically significant difference ($p < 0.001$).



	Psychosocial adjustment	Self-esteem	Evaluation of others	Emotional comfort	Integrity	Domination	Avoidance of problem
Male	62.92	72.93	67.98	62.47	67.13	50.89	12.78
Female	62.90	75.04	66.30	60.06	67.12	47.87	14.42

Figure 1. **Levels of boys' and girls' psychosocial adjustment and its components (average in points)**

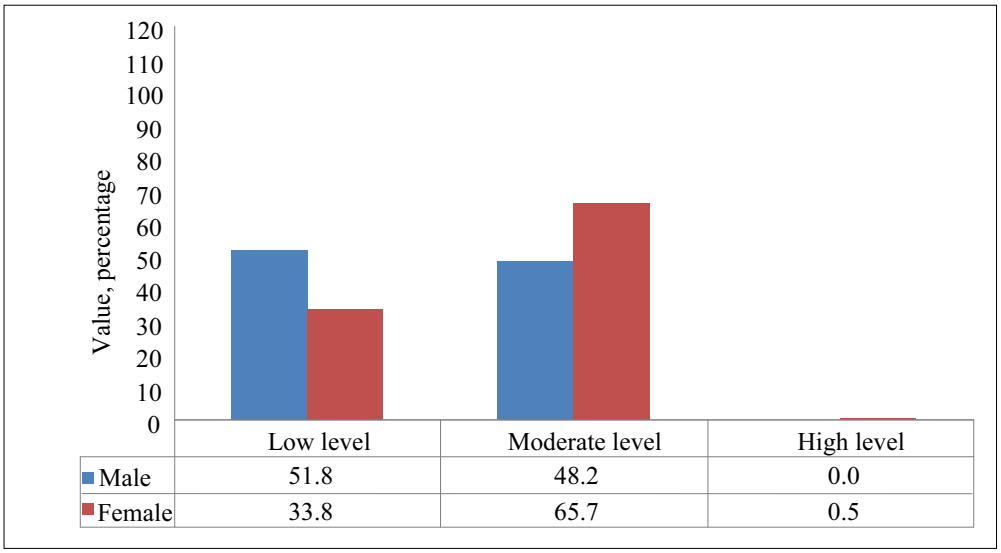
Note. * – $p < 0.05$ comparing the indices of boys and girls.



	Low level	Moderate level	High level
Male	59.8	40.2	0.0
Female	42.9	56.6	0.5

Figure 2. **Levels of negative evaluation of others for boys and girls, first year gymnasium students (percent)**

Note. $\chi^2 = 10.71$; df = 2; $p < 0.05$, comparing the levels of negative evaluation of others between girls and boys.



	Low level	Moderate level	High level
Male	51.8	48.2	0.0
Female	33.8	65.7	0.5

Figure 3. **Levels of emotional discomfort for boys and girls, first year gymnasium students (percent)**

Note. $\chi^2 = 12.49$; df = 2; $p < 0.05$, comparing the levels of emotional discomfort between girls and boys.

DISCUSSION

Aiming at revealing the peculiarities of gymnasium first year students' psychosocial adjustment we suggest that our research results do not reveal all the peculiarities of gymnasium first year students' psychosocial adjustment in the whole country, but it allows some insights into certain tendencies, helps reveal preconditions of organizing education which allow targeted process of enhancing psychosocial adjustment and foreseeing rational seeking of pedagogical aims.

Most education researchers have suggested that school plays an important role in the developmental trajectory of students (Jia el al., 2009). K. Osterman (2000) has demonstrated that a relationship exists between connectedness or belonging and academic outcomes. Boys' academic struggles caused by the transition to middle school might be related to feelings of connectedness to the new school. Boys may feel less connected to the new school and, therefore, might not realize themselves as fully academically as girls. At the same time, connectedness may be an adjustment variable that does not capture the decline in self-esteem of girls in transition. Research shows that school anxiety plays a role in determining academic success in boys, whereas work avoidance is an issue for girls (Freudenthaler et al., 2008).

In our research first year gymnasium students showed low levels of psychosocial adjustment (62.91 ± 10.91). There are studies (Barkauskaitė, Mišeikytė, 2006) where similar results have been obtained. The authors argue that difficult psychosocial adjustment of pupils influences unwillingness to learn at school, reduces self-confidence, the child can turn inwards, lose confidence in teachers, peers, even parents; however, smooth psychosocial adjustment is a strong factor determining pupil's academic success, helping the child develop the attitudes of security, attachment, willingness to achieve more and other attitudes (Barkauskaitė, Mišeikytė, 2006). Š. Šniras and R. Malinauskas (2006) maintain that the main things that adolescents lack are better self-esteem, dignity, ability to control emotions, overcome stress and anxiety, constructively solve conflicts and problems. The same results were obtained in our study as well. Self-esteem of adolescents was moderate, avoidance of problems was low. Students facing difficulties in communicating with peers due to various reasons experience seclusion, isolation from the environment while frequent failures in the everyday activity decrease their trust in their own powers (Ellickson, McGuigan, 2000). These students whose adaptation at school and among peers is not fluent and those who experience hard situations in their family and/or home environment, later on transfer their problems to the world of adults (Juodraitis, 2004). It has also been proved that for the proper social adaptation, one needs the support not only of the family, but also of friends (Morano, Cisler, 1993).

We found that the level of negative evaluation of others among first year gymnasium students was statistically significant ($p < 0.05$): the average level of negative evaluation of others was more common for girls than for boys. L. Bobrova (2009) suggests that boys adapt to social conditions with more difficulties compared to girls. Girls are more inclined to evaluate others and themselves, and they easier achieve the state of emotional comfort. L. Bobrova (2009) established strong statistically significant correlations between self-evaluation and emotional comfort, self evaluation and domination, domination and falsity. While evaluating the level of emotional discomfort for boys and girls, first year gymnasium students, we found a statistically significant difference in the aspect of gender ($p < 0.05$). Higher levels of emotional discomfort were more common for girls than for boys. C. Wootton (2001) argues that girls are more inclined to adapt than boys. They tend to talk about their problems that interfere with their peace. Boys tend to survive problems themselves because of stereotypes dominating in the society that men are strong, they cannot cry, which means that they cannot tell anybody about their problems. N. J. Wiles et al. (2008) established that children who met recommended levels for physical activity had fewer emotional problems one year later, although the magnitude of this difference was reduced after adjustment for confounders, particularly gender.

CONCLUSION AND PERSPECTIVES

We established that psychosocial adjustment of first year gymnasium students was of low level. Such components of psychosocial adjustment as adjustment, evaluation of others, emotional comfort, integrity, domination and avoidance of problems were of low level, and only self-esteem was moderate.

In the aspect of gender, we revealed a statistically significant difference in the avoidance of problems ($p < 0.05$). The avoidance level of girls in the first year of the gymnasium was higher than that of boys. But for boys, the levels of adjustment, evaluation of others, emotional comfort, integrity, domination were higher than those of girls. Self-esteem for girls was higher than that of boys; however, no statistically significant difference was found.

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PIRMOS KLASĖS GIMNAZISTŲ PSICHOSOCIALINĖS ADAPTACIJOS PRIKLAUSOMUMAS NUO LYTIES

Šarūnas Klizas[1], Irina Klizienė[2], Vitas Linonis[2], Daina Miliauskienė[3]
Lietuvos kūno kultūros akademija[1], Kaunas, Lietuva
Kauno technologijos universitetas[2], Kaunas, Lietuva
Prienų specialioji mokykla[3], Prienai, Lietuva

SANTRAUKA

Tyrimo pagrindimas ir hipotezė. Nacionalinių mokinių pasiekimų tyrimų duomenys patvirtino, kad aukšti mokinių pasiekimai susiję su jų savijauta mokykloje. Ypač reikėtų atkreipti dėmesį į situaciją pirmoje gimnazistų klasėje, kur nustatyti ypač dideli pasiekimų skirtumai tarp palankiai ir nepalankiai mokyklos emocinį mikroklimatą įvertinusių mokinių. Hipotezuojame, kad pirmos klasės mergaičių gimnazisčių psichosocialinės adaptacijos lygis aukštesnis nei bendraamžių berniukų.

Tikslas – nustatyti pirmos klasės gimnazistų psichosocialinės adaptacijos priklausomumą nuo lyties.

Metodai. Tiriamąją imtį sudarė 362 pirmų gimnazijos klasių mokiniai – mergaičių (n = 198), berniukų (n = 164). Respodentų amžius: 14–16 metų. Tyrimo metu naudota modifikuota K. Rogers ir R. Dymond metodika *psichosocialinei adaptacijai* tirti. Anketa adaptuota Lietuvos visuomenei tirti (Klizas, 2009). Metodikos autorių (K. Rogers ir R. Dymond) psichosocialinės adaptacijos modeliu be pagrindinio, psichosocialinę adaptaciją apibūdinančio rodiklio, pateikiamos subskalės (savęs vertinimas, požiūris į kitus, emocinis komfortas, integralumas, dominavimas, problemų vengimas), padedančios atskleisti psichosocialinę asmenybės adaptaciją.

Rezultatai. Analizuojant pirmos klasės gimnazistų psichosocialinės adaptacijos lygį lyties požiūriu, nustatytas statistiškai patikimas problemų vengimo skirtumas ($t = -3,19$; $p < 0,05$). Išsiaiškinome, kad pirmos klasės gimnazistų ir gimnazisčių neigiamo požiūrio į kitus lygis statistiškai patikimas ($\chi^2 = 10,71$; lls = 2; $p < 0,05$). Vertinant pirmos klasės gimnazistų berniukų ir mergaičių emocinio diskomforto lygį, nustatytas patikimas skirtumas lyties požiūriu ($\chi^2 = 12,49$; lls = 2; $p < 0,05$).

Aptarimas ir išvados. Nustatėme, kad pirmos klasės gimnazistų psichosocialinė adaptacija yra žemo lygio. Psichosocialinę adaptaciją sudarantys komponentai (adaptacija, požiūris į kitus, emocinis komfortas, internalumas, dominavimas, problemų vengimas) yra žemo lygio ir tik savęs vertinimas yra vidutinis. Išanalizavus pirmos klasės gimnazistų psichosocialinės adaptacijos lygį lyties požiūriu, nustatytas statistiškai patikimas problemų vengimo skirtumas ($p < 0,05$). Tirtų mergaičių gimnazisčių problemų vengimo lygis yra didesnis negu berniukų gimnazistų. Visgi berniukų adaptacijos, požiūrio į kitus, emocinio komforto, internalumo, dominavimo lygiai aukštesni negu mergaičių. Gimnazisčių mergaičių savęs vertinimas yra aukštesnis negu berniukų gimnazistų, tačiau statistiškai patikimo skirtumo nenustatyta.

Raktažodžiai: savijauta (adaptacija) mokykloje, emocinis komfortas, problemų vengimas.

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Corresponding author **Šarūnas Klizas**
Lithuanian Academy of Physical Education
Sporto str. 6, LT-44221 Kaunas
Lithuania
Tel +370 37 20 90 50
E-mail s.klizas@lkka.lt

COMPARATIVE ANALYSIS OF FEMALE ELITE BIATHLETES' SPORTS RESULTS IN WORLD CUP COMPETITIONS BEFORE THE WORLD CHAMPIONSHIP AND DURING THE WORLD CHAMPIONSHIP IN THE SEASON OF 2010–2011

Natalja Kočergina, Algirdas Čepulėnas, Aurelijus Zuoza
Lithuanian Academy of Physical Education, Kaunas, Lithuania

ABSTRACT

Research background and hypothesis. Modern training trend for biathletes is the increasing intensity of the training process in competition activities. Competition activities of elite biathletes while preparing for the main competition of the season have received little attention by researchers. Research hypotheses: The number of starts and sports results in the competitions before the main competition of the season for elite biathletes are related to sports results in the main competition of the season.

Research aim was to analyse the interaction of biathletes' sports results and the number of starts, and to establish the relation of this interaction between the results achieved in World Cup competitions and World Biathlon Championship.

Research methods. The data have been retrieved from the documents of the International Biathlon Union (IBU): protocols of the World Biathlon Championship of 2011 and World Biathlon Cup competition. We analysed the sports results of female biathletes who took the 1st–10th places in the World Biathlon Championship in individual events.

Research results. World elite biathletes participated in E.ON and IBU category competitions 16.2 ± 3.74 times before the World Biathlon Championship. The number of starts correlates with the places taken by biathletes in the general account of the World Biathlon Cup before the world championship (r = –0.83). In the individual races in the World Championship, all medals were won by eight skiers, and five of them were among the first ten skiers in the general standing of World Cup competitions before the world championship.

Discussion and conclusion. The preparation of elite biathletes for the most important competition of the season – World Biathlon Championship is grounded on the repeated participation in the World Biathlon Cup competitions. Biathletes, taking the 1st–10th places in the general account of the World Biathlon Cup, are real applicants for medals in the World Biathlon Championship.

Keywords: number of starts, taken places, correlation, sprint, pursuit, mass start, individual start.

INTRODUCTION

In the period of competitions, participation in competitions and the loads of competitive activities improve the body adaptation to competitive activities (Pustovrh et al., 1995; Suslovas, 1999; Платонов, 2004). For some elite athletes in cyclic branches of sport competitive loads become the loads of special athletic training in the period of competitions. During the last 10–15 years athletes' results have been rapidly improving due to the increase in the number of competitions in the competition calendar in that branch of sports, but because of frequent participation in the competitions, the leaders of the season cannot achieve the results which were planned for them in the main competitions (Olympic Games, World Championships) (Суслов, 2002; Платонов, 2009).

In biathlon skiing races, predictions are confirmed only in 20–25% of cases (Платонов, 2009). The competition result in biathlon depends on the time to cover the skiing distance and on accurate shooting. During the competition, biathletes are affected by external factors (competition environment, competitors, spectators, weather conditions, and the terrain of the ski slopes) and internal factors (tension, anxiety, joy, fear). Those irritants cause psychological reactions which improve or worsen the final outcomes (Schmolinsky, 2000). It is very difficult to evaluate the influence of athletes' athletic fitness component on their results in the competitions (Cholewa et al., 2005).

Modern training trend for biathletes is the increasing intensity of the training process in competition activities, individual optimization of competition activities according to individual training plan for the most important competition of the season – World championship (Cholewa et al., 2005; Преображенцев, 2007). Competition activities of elite biathletes while preparing for the main competition of the season have received little attention by researchers.

Research aim was to analyse the interaction of biathletes' sports results and the number of starts, and to establish the relation of this interaction between the results achieved in World Cup competitions and World Biathlon Championship. **Research object –** indices of competition activities of biathletes who took the 1st–10th places in the World Biathlon Championship of 2011.

RESEARCH METHODS

The data have been retrieved from the documents of the International Biathlon Union (IBU): biathletes' results in the competition of E.ON IBU category, protocols of the World Biathlon Championship of 2011 and World Biathlon Cup competition (Biathlon[1–4], http://www.biathlonworld3.de.html). We analysed the sports results of female biathletes who took the 1st–10th places in the World Biathlon Championship in individual events. The research sample included 20 high-capacity world biathletes. The data were processed applying *Microsoft Excel 2003* programme and special statistical programme *SPSS 12.0 for Windows*. We calculated arithmetic means, standard deviations (SD), coefficients of correlation (r). Regression analysis of the data was performed.

RESEARCH RESULTS

In the season of 2010–2011 there were 19 individual biathlon races in the women's programme in the World Biathlon Cup competition before the beginning of the World Biathlon Championship: 11 of them were middle and long distance races (pursuit – 10 km, individual start – 15 km, mass start – 12.5 km) and eight sprint competitions – 7.5 km. The first biathlete in the general account of the World Biathlon Cup competition was German biathlete H. A. She participated in competitions 19 times. In the World Biathlon Championship Biathlete H. A. did not win any medal in individual events, and her best result was only the fourth place in 10 km pursuit race. In other distances she took the 13th, 20th, and the 46th places (Table). In the World Biathlon Championship the best biathlete was M. K. who won two gold medals and one silver medal. Before the world championship she participated in competitions 17 times and in general she was in the fifth place. It is interesting to note that biathletes B. T. and S. V. won silver and bronze medals in the World Biathlon Championship, but in the general account of World Biathlon Cup competition they took only the 18th and the 19th places, and before that they had participated in competitions 19 and 14 times. World elite biathletes participated in E.ON and IBU category competitions 16.2 ± 3.74 times before the World Biathlon Championship. The number of starts correlates (Figures 1, 2 and 3) with the places taken by biathletes in the general standing of the World Biathlon Cup before the world championship ($r = –0.83$), the places taken in the general standing of pursuit races ($r = –0.75$), and sprint ($r = –0.57$). In the individual events in the World Biathlon Championship the medals were won by biathletes who had taken the 2nd, 3rd, 4th, 5th, 6th, 18th, and 19th places in the general standing of World Biathlon Cup. Research results suggest that the number of starts in different distances in the World Cup competitions is related to the places taken by biathletes in the classification standing of those distances. Correlations between biathletes' taken places in different distances in World Cup competitions before the World Biathlon Championship and the places taken in the World Biathlon Championship are given in Figures 4 and 5 .The places taken by biathletes in the World Cup competitions (in all distances) correlate with the 1–10th places taken in the World Biathlon Championship: with the places in pursuit competitions $r = 0.70$, and with the places in sprint $r = 0.20$ (Figures 6 and 7).

Table. **Places taken and number of points of biathletes in 1st–10th places during the World Biathlon Championship 2011 and the number of starts in E.ON IBU category competitions before the World Biathlon Championship**

Initials, s. n.	Places taken in World Championship				Number of days since the last start E. ON Category IBU competitions before the start in World Championship	Final standing of the Biathlon World Cup competitions before the beginning of the World Biathlon Championship									
	7.5 km Sprint	10 km Pursuit	15 km Individual start	12.5 km Mass start		General standing according to the results in all competitions		Sprint		Pursuit		Individual start competitions		Mass start competitions	
						Place	Number of starts	Place	Number of starts	Place	Number of starts	Place	Number of starts	Place	Number of starts
N. M.	1	2	5	1	19	5	15	3	6	7	4	16	2	3	3
M. K.	2	1	28	4	19	2	19	1	8	1	5	4	3	15	3
K. A.	3	6	9	10	42	14	14	8	6	18	3	30	3	12	3
Z. O.	4	12	–	6	42	13	14	16	6	16	3	1	3	26	2
E. H.	5	3	1	7	19	3	19	4	8	3	5	6	3	5	3
J. E.	6	10	7	15	42	20	14	5	6	20	3	24	3	2	2
B. T.	7	5	10	3	19	4	17	17	7	4	4	9	3	23	3
D. M.	8	15	6	8	19	11	19	14	8	8	5	13	3	11	3
G. M.	9	7	–	14	19	15	19	9	8	10	5	60	3	19	3
S. V.	10	24	11	16	19	10	19	13	8	9	5	3	3	14	3
H. A.	20	4	46	13	19	1	19	2	8	2	5	5	3	1	3
G. J	17	8	–	28	44	50	13	47	6	47	3	–	–	–	–
W. D.	28	9	–	21	48	74	4	61	3	67	1	–	–	–	–
B. M.	44	–	–	9	19	8	18	10	8	15	4	2	3	4	3
B. T.	–	–	2	12	23	18	19	19	8	17	5	20	3	20	3
S. Vit.	18	17	3	24	42	19	14	18	6	23	3	12	3	22	2
G. T.	14	18	30	5	19	9	19	7	8	11	5	10	3	8	3
D. D.	26	35	19	2	19	6	19	6	8	5	5	29	3	6	3
S. N.	16	16	4	17	19	29	17	27	8	25	5	28	3	39	1
V. V.	55	34	8	30	20	51	13	52	7	41	4	54	2	–	–
X ± SD					26.55 ± 11.38		16.2 ± 3.74		7.05 ± 1.32		4.1 ± 11.12		2.89 ± 0.32		2.71 ± 0.59

Note. E.ON IBU – World Cup competitions of the International Biathlon Federation.
Pursuit – pursuit races when the start is given according to the time of slippage from the athlete winning the sprint races.

Figure 1. **Relationship between biathletes' places in the general standing in the Biathlon World Cup competitions before the World Biathlon Championship and the number of their starts in World Cup competitions**

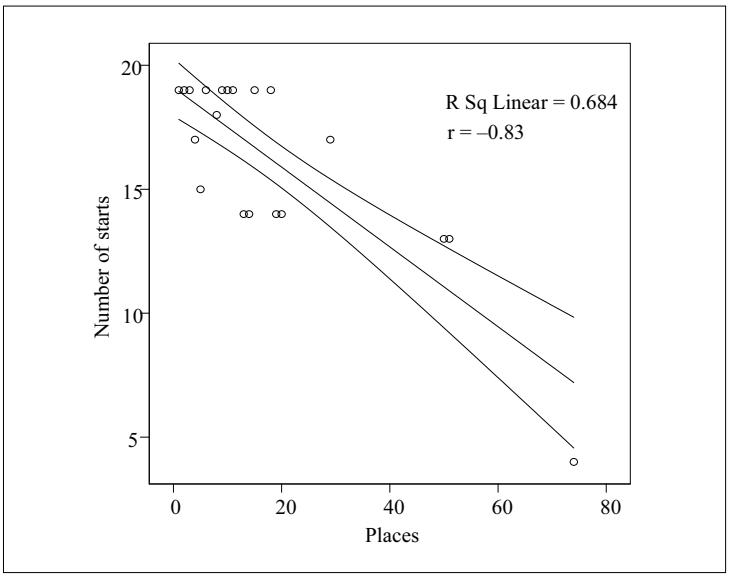


Figure 2. **Relationship between biathletes' places in the general standing in the Biathlon World Cup pursuit races before the World Biathlon Championship and the number of their pursuit starts in World Cup competitions**

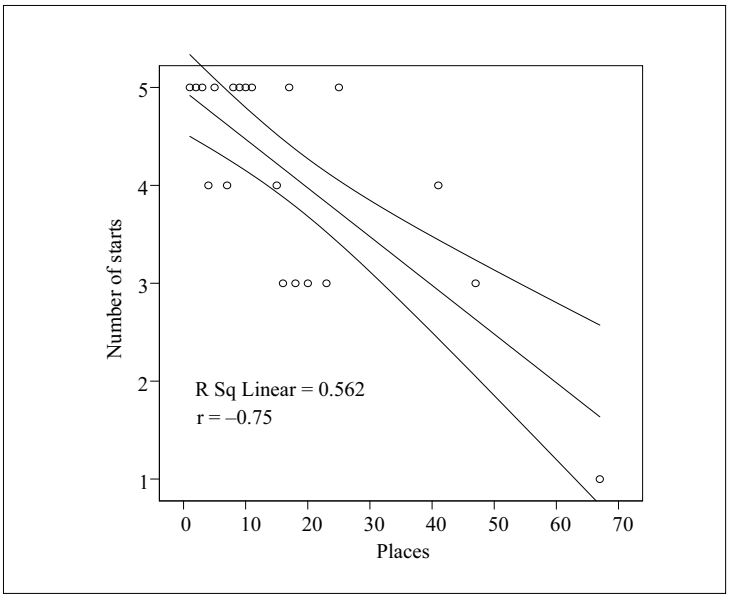
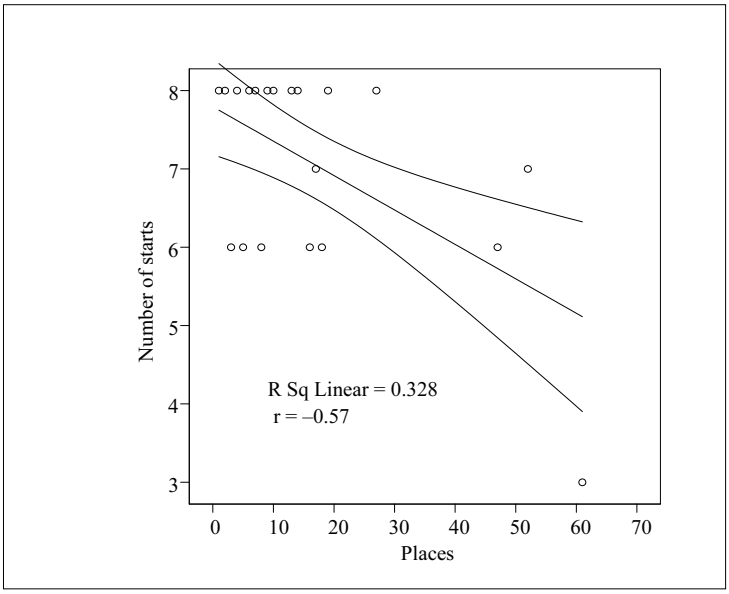


Figure 3. **Relationship between biathletes' places in the general standing in the Biathlon World Cup sprint competitions before the World Biathlon Championship and the number of their sprint starts in World Cup competitions**



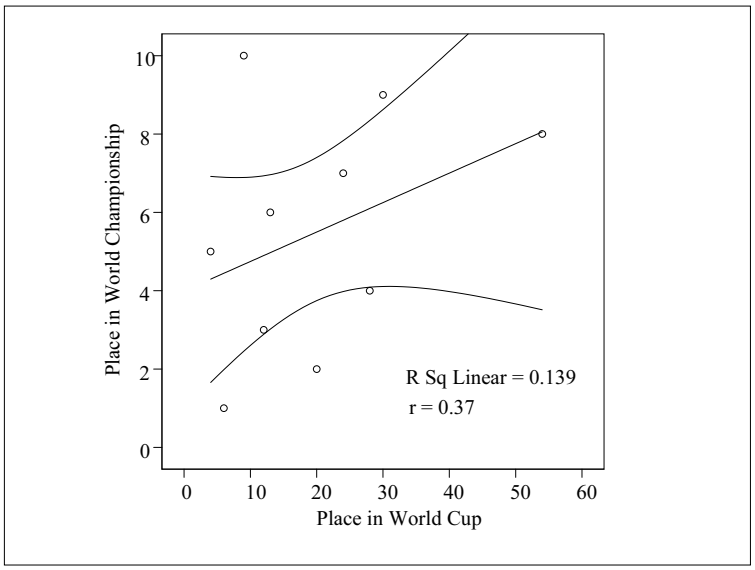


Figure 4. **Relationship between biathletes' 1st–10th places in the individual start competitions in World Biathlon Championship and the places taken in the general standing in the Biathlon World Cup individual competitions before the World Biathlon Championship**

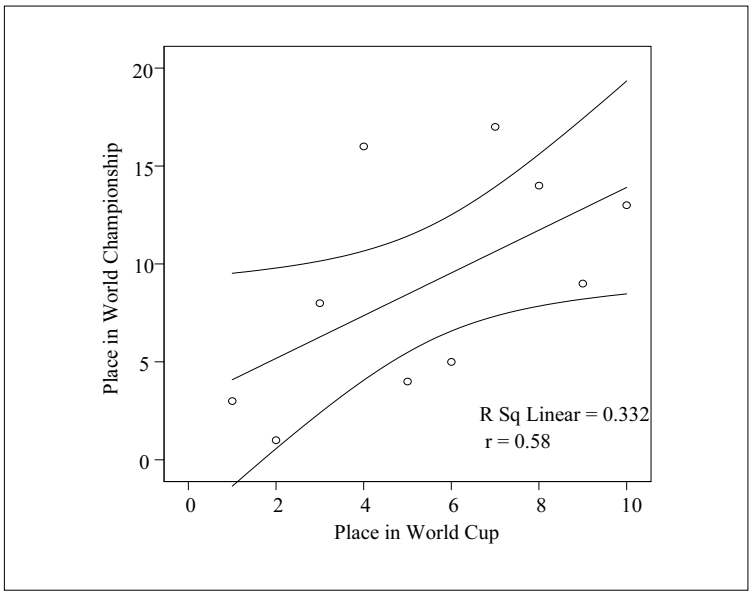


Figure 5. **Relationship between biathletes' 1st–10th places in the general standing in the Biathlon World Cup sprint competitions before the World Biathlon Championship and the places taken in sprint in the World Biathlon Championship**

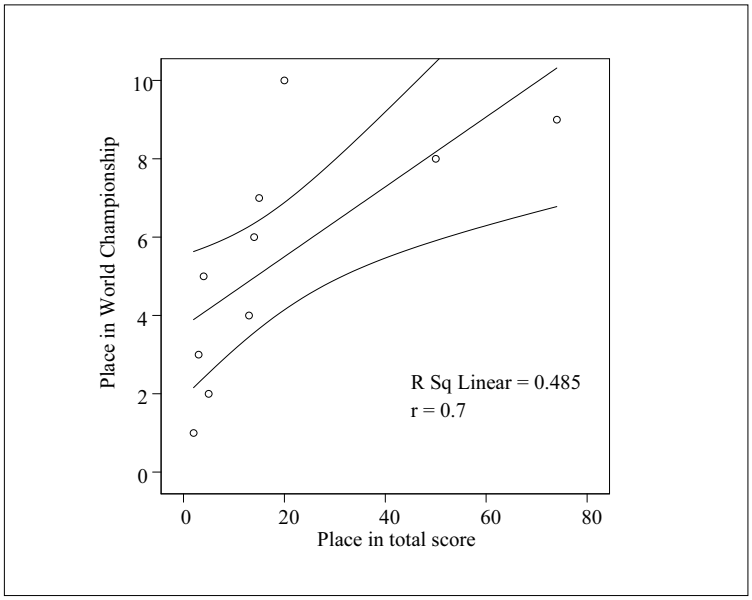
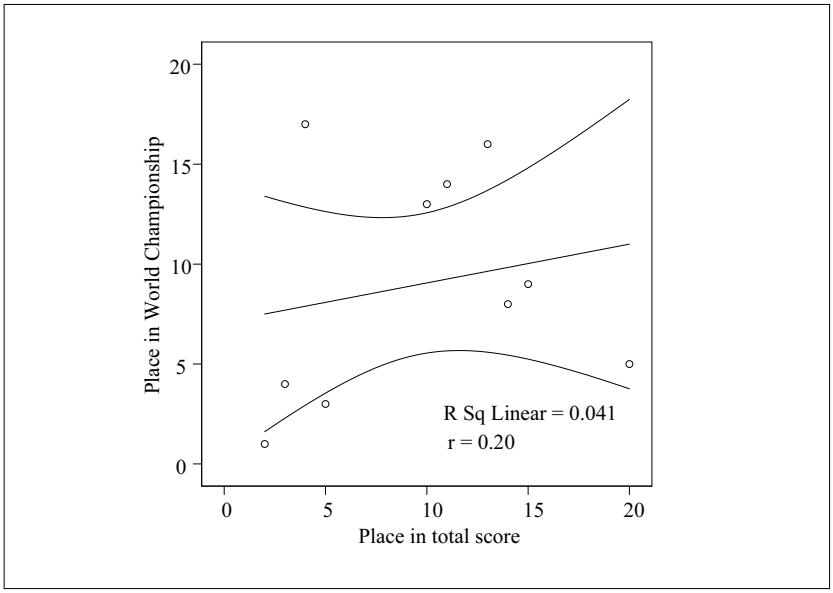


Figure 6. **Relationship between biathletes' 1st–10th places in the pursuit competitions in the World Biathlon Championship and the places in the general standing in the Biathlon World Cup competitions in all distances before the World Biathlon Championship and the places taken in pursuit**

Figure 7. **Relationship between biathletes' places in the general standing in the Biathlon World Cup competitions in all distances before the World Biathlon Championship and places taken in sprint in the World Biathlon Championship**



DISCUSSION

In biathlon the time of the run includes the time the biathlete spends on the course without the time spent for shooting. The most important factor influencing running time includes the level of physical fitness as well as technical and tactical preparation (Cholewa et al., 2005).

Because of the complexity of tasks in the biathlon, achieving a world class level by a talented athlete requires 8–12 years of systematic training aimed at developing a high level of physical and psychomotor fitness as well as great skiing and shooting skills (Rundel, Szmedre, 1998; Ryguła, 2002). It is evident that creating proper external conditions allows for the development of the internal potential of a particular athlete, which guarantees the achievement of world class results (Rundell, Bacharach, 1995).

Good sports shape of an athlete is related to the appropriately chosen number of starts and their distribution in the mesocycles of the competition period (Bompa, 1999; Suslovas, 1999; Платонов, 2009). Appropriately planned competitions considering the terms of relevant competitions help acquire the sports shape (Платонов, 2009).

Research results (Table) show that female biathletes who won medals in the World Biathlon Championship had participated 14–19 times in biathlon competitions before the championship. Biathlete N. M. having won two gold and one silver medals had 15 starts before the beginning of the championship. Elite biathletes are universal, and they participate in sprint, individual start, mass start and pursuit races. The majority of elite biathletes did not participate in any competition 19 days before the beginning of the World Championship E.ON IBU category competitions (Table).

The strategy of biathletes' preparation for the world championship corresponds to the approach of sports training periodization (Платонов, 2009) stating that frequent participation in competitions before the main competition of the season requires a special preparation phase for the main starts. Before the beginning of the world championship, elite biathletes participated in the competitions of different distances: sprint – 7.05 ± 1.32 times, pursuit – 4.10 ± 1.12 times, individual start races – 2.89 ± 0.32 times, mass start races – 2.71 ± 0.59 times (Table).

The correlations between biathletes' places in the general standing in the Biathlon World Cup competitions in different distances before the World Biathlon Championship and the places taken in the same distances in the World Biathlon Championship are weak – in individual start competitions 0.37, in sprint they are higher – 0.58. We established that the 1^{st}–10^{th} places taken by biathletes in the general classification (in all distances) during the World Cup competitions before the championship strongly correlated

(r = 0.70) with their places in pursuit competitions in the World Championship.

In the individual races in the World Championship, all medals were won by eight skiers, and five of them were among the first ten skiers in the general standing of World Cup competitions before the world championship. It is worth noting that in the 15 km individual start competition, the fourth pace was taken by S. N. who was only 29th in the general classification before the World Championship. We suggest that biathletes who have taken the 1–10th places in the general standing in the Biathlon World Cup competitions are real applicants to win medals in the World Biathlon Championship.

CONCLUSION AND PERSPECTIVES

The preparation of elite biathletes for the most important competition of the season – World Biathlon Championship is grounded on the repeated participation in the World Biathlon Cup competitions. The places taken in the general standing of the World Biathlon Cup are the indices of biathletes' mastery and stability. Biathletes, taking the 1st–10th places in the general standing of the World Biathlon Cup, are real applicants for medals in the World Biathlon Championship.

Modern training trend of elite biathletes is the individual optimization of competition activities according to individual training plan for the most important competition of the season.

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ELITO BIATLONININKIŲ SPORTINIŲ REZULTATŲ PASAULIO TAURĖS VARŽYBOSE IKI PASAULIO ČEMPIONATO IR REZULTATŲ ČEMPIONATE LYGINAMOJI ANALIZĖ PER 2010–2011 M. SEZONĄ

Natalja Kočergina, Algirdas Čepulėnas, Aurelijus Zuoza
Lietuvos kūno kultūros akademija, Kaunas, Lietuva

SANTRAUKA

Tyrimo pagrindimas ir hipotezė. Elito biatlonininkų šiuolaikinė treniravimo kryptis – treniravimo vyksmo intensyvinimas per varžybinę veiklą. Elito biatlonininkių varžybinė veikla rengiantis pagrindinėms sezono varžyboms dar mažai tirta. Tyrimu tikrinama hipotezė, kad elito biatlonininkių startų skaičius ir sportiniai rezultatai iki pagrindinių sezono varžybų turi sąveikos ryšių su sportiniais rezultatais pagrindinėse sezono varžybose.

Tikslas – išnagrinėti elito biatlonininkių sportinių rezultatų sąveiką su startų skaičiumi ir nustatyti sąveikos ryšį tarp rezultatų, pasiektų Pasaulio taurės varžybose iki pasaulio čempionato ir rezultatų pasaulio biatlono čempionate.

Metodai. Duomenys paimti iš Tarptautinės biatlono federacijos (IBU) dokumentų: 2011 m. pasaulio biatlono čempionato varžybų protokolų, Pasaulio biatlono taurės varžybų dokumentų. Analizavome sportinius rezultatus biatlonininkių, kurios pasaulio biatlono čempionate individualiose rungtyse užėmė 1–10 vietas.

Rezultatai. Pasaulio elito biatlonininkės iki pasaulio čempionato dalyvavo 16,2 ± 3,74 kartų E.ON bei IBU kategorijos varžybose.

Startų skaičius turi koreliacijos ryšių su biatlonininkių užimtomis vietomis Pasaulio taurės varžybų bendrojoje įskaitoje iki pasaulio čempionato pradžios (r = –0,83). Per pasaulio čempionatą individualios programos lenktynėse visus medalius laimėjo aštuonios biatlonininkės ir iš jų penkios Pasaulio taurės varžybų bendrojoje įskaitoje iki pasaulio čempionato pradžios buvo pirmajame dešimtuke.

Aptarimas ir išvados. Pasaulio elito biatlonininkių pasirengimas svarbiausiam sezono startui – pasaulio čempionatui pagrįstas dažnu dalyvavimu Pasaulio biatlono taurės varžybose. Biatlonininkės, Pasaulio biatlono taurės varžybų bendrojoje įskaitoje užimančios vietas pirmame dešimtuke, yra realios pretendentės laimėti medalius pasaulio čempionate.

Raktažodžiai: startų skaičius, užimtos vietos, koreliacija, sprintas, persekiojimo lenktynės, masinis startas, individualus startas.

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Corresponding author **Natalja Kočergina**
Lithuanian Academy of Physical Education
Sporto str. 6, LT-44221 Kaunas
Lithuania
Tel +370 61836017
E-mail kocergina@rambler.ru

SHOOTING PARAMETERS OF BIATHLETES IN VARIOUS AGE GROUPS IN 2011–2012 WORLD CHAMPIONSHIPS

Lina Kreivėnaitė
Lithuanian University of Educational Sciences, Vilnius, Lithuania

ABSTRACT

Research background and hypothesis. Physical fitness problems in biathlon are quite extensively discussed, but biathlon shooting in Lithuania is not analyzed enough. The special literature lacks information about the shooting parameters that leaders demonstrate in the world biathlon championships. Moreover, shooting parameters in different age and gender groups have not been analyzed enough. The hypothesis that shooting parameters in adult, youth and junior age group biathletes would differ was tested.

Research aim. The aim of our study was to analyze shooting parameters of biathletes in various age groups in 2011–2012 world championships and reveal fundamental differences in the aspects of age and gender.

Research methods. Research participants were youths (age: 17–18 years), juniors (age: 19–20 years) and adults (age: 21–41 years), male and female biathletes. The number of subjects was 2175. Descriptive statistical methods were used for data analysis.

Research results. Data analysis revealed the main differences in shooting parameters between adult, junior and youth groups, male and female biathletes. Also, comparison of shooting parameters between biathletes in various age groups and leaders in the same group was carried out.

Discussion and conclusions. Our research revealed that the highest shooting accuracy was observed in adult male and female biathlete groups ($p < 0.025$). The shooting accuracy of junior and youth female biathletes was higher than that in the junior and youth male groups ($p < 0.05$). The longest average shooting time was in youth group ($p < 0.001$). The shooting time of biathletes in adult group was the shortest. We found that male biathletes in various age groups performed shots in less time compared to female biathletes ($p < 0.05$). Research results revealed that shooting parameters among leaders statistically significantly differed comparing them with the average shooting parameters in the group ($p < 0.05$).

Keywords: biathlon, shooting accuracy, shooting time.

INTRODUCTION

Biathlon is complex winter sport which combines cross-country skiing with rifle marksmanship. Cyclical cross-country load in biathlon combines with acyclic actions in the fire range which requires complicated movement coordination (Pöhlmann, 1986). It is known that skiing time has bigger influence on final result in comparison with shooting efficiency in biathlon (Cholewa et. al., 2005). However, final competition results and success in biathlon are decided not only upon the ability to ski fast but also the ability to shoot accurately (Skernevičius et al., 2005). Also, a biathlete makes big difference being able to change in competition in skiing – shooting activities and control psychical tension, especially in a shooting range (Сорокина, 2010).

Shooting in biathlon is a complicated motor activity which requires position stability, high concentration and psychomotor skill levels with preliminary rapid preparation actions to assure fast and accurate shooting in both positions. Moreover, shooting in biathlon is highly influenced by various internal and external factors. The main internal factors are psychophysical, technical, tactical and

psychological. The main external factors are social, climatic and factors which are related to sports equipment (Hofman et al., 1992; Nitzsche, 1998; Grebot et al., 2003; Sattlecker et al., 2006; Grebot, Burtheret, 2007). Only a few studies have been directed towards shooting tasks in biathlon which mainly are concerned with physiological factors. From a scientific point of view it is important to analyse statistically the results of shooting obtained during recent world biathlon championships.

RESEARCH METHODS

Research was carried out by analysing official protocols of youth, junior and adult biathletes' shooting parameters in 2011–2012 world biathlon championships. The shooting parameters analysed were shooting accuracy (%) and shooting time (s).

For data analysis we chose biathletes who were participating in youth (age: 17–18 years) 691, junior (age: 19–20 years) 545 and adult (age: 21–41 years) 939 groups, men and women. They were named as subjects. The overall number of subjects in our study was 2175.

The study was accomplished by analysing official protocols of youth, junior and adult biathlon world championships in 2011–2012 year (www.biathlonworld.com, www.Hora2000.com).

Statistical analysis. All the data were expressed as average (x), standard error (Sx), standard deviation (S) and variance (V) of the mean. Hypothesis concerning the difference between means was verified using Stjudent *t* test for independent and dependent variables. The difference between the means was regarded as statistically significant when error probably with respect to criteria was $p < 0.05$.

RESEARCH RESULTS

Data analysis revealed that overall shooting accuracy of adult female group amounted to 76.8%. The shooting accuracy of biathletes in junior female group was 71.8%, while for woman in the youth group – 70.6%. Testing shooting accuracy in various age male groups educed that adult biathletes reached 77.4% shooting accuracy. Also, shooting accuracy of junior male biathletes was 70.4%. Biathletes in youth male group reached 67.3% of the shooting accuracy level (Table 1).

The analyses of the results of shooting time revealed that adult women biathletes spent on

Table 1. **Shooting accuracy of various age groups, men (M) and women (W), in prone and stand positions**

Age group	Youth		Junior		Adult	
Gender	M	W	M	W	M	W
Average of leaders' accuracy (%)	87.5	88.8*	91.7	93.3	92.2*	95.8
Sx	1.3	1.0	2.1	1.5	1.1	1.0
S	2.2	2.8	3.6	2.6	3.2	3.1
V	2.5	3.2	3.9	2.8	3.5	3.2
Average of group accuracy (%)	67.3	70.6	70.4	71.8	77.4	76.8
Sx	1.4	1.5	1.4	1.4	1.2	1.2
S	22.5	22.1	19.6	20.2	17.9	18.8
V	33.4	31.2	28.4	28.5	23.2	24.8

Note. Sx – standard error, S – standard deviation, V – variance of the mean; * – Biathletes who achieved 1st–8th places in youth women and adult men groups were considered as leaders. In other groups leaders' results calculation was based on data from biathletes who took 1st–3rd places.

Table 2. **Shooting time of various age groups, men (M) and women (W), in prone and stand positions**

Age group	Youth		Junior		Adult	
Gender	M	W	M	W	M	W
Shooting time in prone position (s)	42.4	45.5	39.8	41.8	34.7	37.9
Sx	0.8	0.9	0.7	0.7	0.4	0.4
S	7.7	7.6	6.1	5.4	4.9	4.7
V	18.2	16.7	15.4	13.1	14.1	12.5
Shooting time in stand position (s)	37.2	41.3	34.7	39.9	31.4	34.9
Sx	0.6	0.8	0.5	0.7	0.4	0.4
S	6.3	6.8	4.9	5.5	4.7	3.9
V	16.9	16.3	14.1	13.9	14.9	11.3

Note. Sx – standard error, S – standard deviation, V – variance of the mean.

average 36.4 s for a shot. Average shooting time of junior women biathletes was 40.8 s. Also, youth women group reached the average shooting time of 43.4 s. The data analysis of men group biathletes' shooting time showed that adult biathletes spent 33.1 s on shooting. Also, the analysis revealed that biathletes in junior male group demonstrated the shooting time of 37.3 s and youth male biathletes performed shots in 39.8 s (Table 2).

DISCUSSION

Scientists M. D. Hoffman et al. (1992), M. D. Hofman ansd G. M. Street (1992), K. Rundell and D. Bacharach (1995), B. Paugsachova (2000), F. Manfredini et al. (2002), J. Cholewa et al. (2005), B. Paugsachova et al. (2010) claim that the final result of the competition mostly depends on $V0_2max$ and upper body muscle power of biathlete in skiing event, also shooting accuracy and time in shooting event. The study of J. Cholewa et al. (2004) obtained results which clearly indicated a decrease in the level of efficiency in shooting parameters in biathlon in the seasons of 1997–2003. However, K. Nitzsche's (1998) research on the shooting parameters in 1969–1996 seasons determined that the shooting parameters had a tendency to increase. Our study agrees with the previously mentioned thesis that success in shooting event is highly influenced by shooting accuracy and time because our data analysis revealed that biathletes who occupied leader positions demonstrated significantly higher shooting accuracy levels and shorter shooting time than their group on average ($p < 0.05$) (Table 1, Figure 4).

The analysis of the research results showed that shooting parameters between various age group biathletes had statistically significant differences. Research revealed that the shooting accuracy in prone position was significantly higher than that in stand position among various age group women biathletes ($p < 0.01$). Biathletes in adult women group showed a significantly better average shooting accuracy than junior ($p < 0.025$) and youth group women ($p < 0.005$), in both prone and stand shooting positions. Moreover, the shooting accuracy in stand position of junior women group biathletes was significantly higher than that of youth biathletes ($p < 0.05$) (Figure 1).

The results obtained during the study showed that shooting accuracy in prone position was significantly higher than that in stand position among various age group men biathletes. Average shooting accuracy of adult men biathletes was significantly higher than that of junior ($p < 0.005$) and youth men biathletes ($p < 0.001$). Also, the analysis revealed that junior men group biathletes demonstrated higher average shooting accuracy than youth biathletes ($p < 0.05$) (Figure 2).

Results of A. Kryl (1987) and M. I. Shykunov (Шикунов, 1987) research revealed that average shooting time of adult group biathletes was 32.5 s ± 0.36 in prone and 30.2 s ± 0.24 in stand position. The analysis of our study established that the average time spent in shooting of biathletes in adult group was 36.3 s ± 0.4 was in prone and 33.2 s ± 0.4 in stand position (Figure 3). Although our data analysis revealed that shooting time was insignificantly longer than that in previous research of A. Kryl (1987) and M. I. Shykunov (Шикунов, 1987) it showed that shooting time was important for success in shooting event.

Our study showed that the longest shooting time was determined in youth group, while adult group

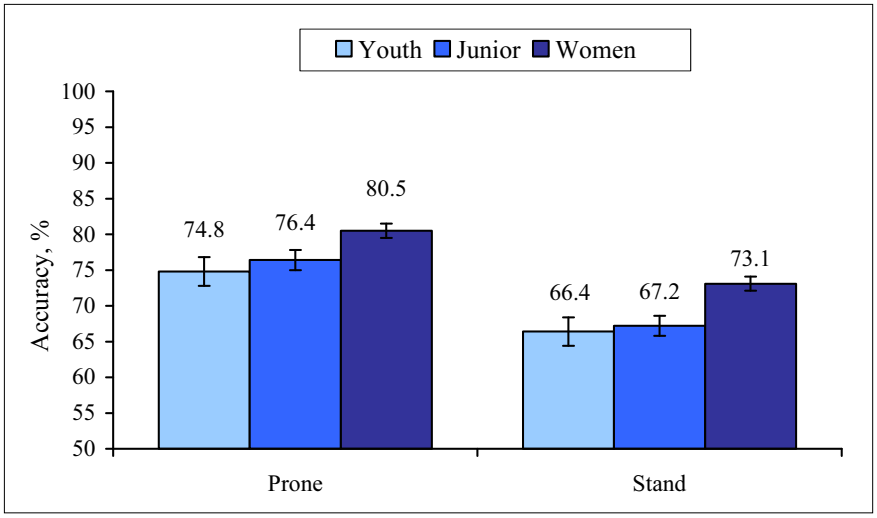


Figure 1. **Shooting accuracy of various age group women biathletes, in prone and stand positions (X ± Sx)**

Figure 2. **Shooting accuracy of various age group men biathletes, in prone and stand positions (X ± Sx)**

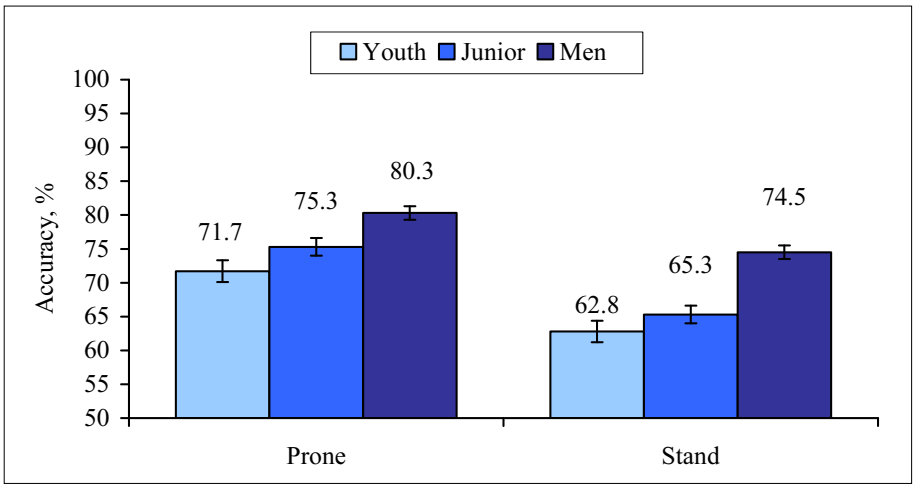


Figure 3. **Average shooting time of various age groups, men and women (X ± Sx)**

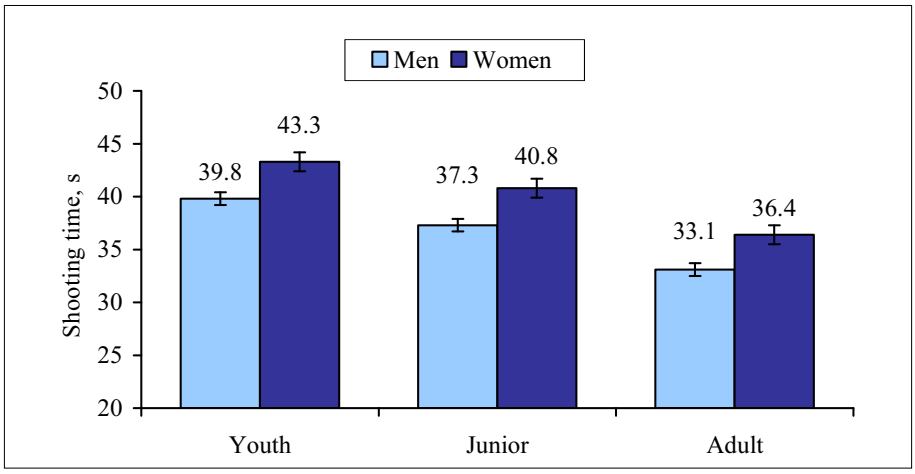
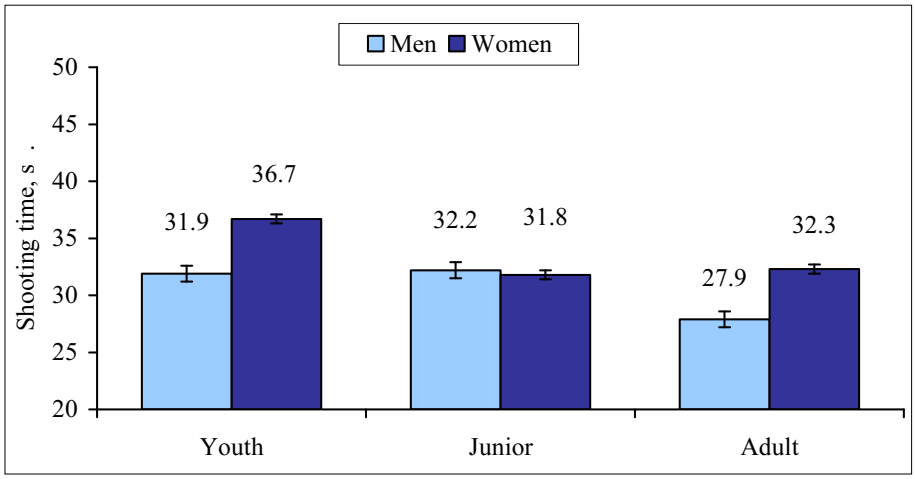


Figure 4. **Average shooting time of leaders in various age groups, men and women (X ± Sx)**



biathletes demonstrated the shortest shooting time ($p < 0.001$). Adult male group showed the shortest average shooting time in both stand (31.4 s) and prone (34.7 s) positions. We found that male biathletes in various age group showed shorter shooting time than women biathletes in various age groups ($p < 0.005$) (Figure 3). We observed a tendency that shooting time in prone position was longer than that in stand position ($p < 0.05$).

We compared the shooting time results in various age groups with the shooting time of leaders in the same groups. We found that biathletes who took award winning places demonstrated significantly shorter shooting time than of the biathletes in their groups ($p < 0.05$). Average shooting time of leaders in adult men and women group were 30.9 s ± 1.1 in prone and 29.3 s ± 0.9 in stand positions (Figure 4).

Some scientists (Pustovrh et al., 1995; Cholewa et al., 2004; Cholewa et al., 2005; Sattlecker et al., 2006) found no shooting significance to final competition results. However, our research revealed the tendency that the shooting time of biathletes who took leader places had significantly differed from the average shooting time of their group. This difference was most distinct in junior and youth groups.

Our research results suggest that shooting parameters in modern biathlon are becoming increasingly important. However, there is no information how to evaluate shooting parameters. For this reason, further studies should be carried out to construct reference assessment scales for shooting parameters.

CONCLUSIONS AND PERSPECTIVES

1 The highest shooting accuracy was determinate in adult male and female groups of biathletes. The average shooting accuracy level between youth and junior groups did not differ statistically significantly.

2. The longest average shooting time was in youth group. The shortest time of shooting was observed in adult group of biathletes. The shooting time of men in various age groups was shorter than that of women in the same group.

3. Shooting parameters of leaders in various groups were significantly better than the group average.

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SKIRTINGŲ AMŽIAUS GRUPIŲ BIATLONININKŲ 2011–2012 METŲ PASAULIO BIATLONO ČEMPIONATŲ ŠAUDYMO RODIKLIAI

Lina Kreivėnaitė
Lietuvos edukologijos universitetas, Vilnius, Lietuva

SANTRAUKA

Tyrimo pagrindimas ir hipotezė. Biatlonininkų fizinio parengtumo problemos yra gana plačiai išnagrinėtos, tačiau biatlono šaudymo klausimai Lietuvoje nėra analizuoti. Specialiojoje pasaulinėje literatūroje trūksta informacijos apie tai, kokių šaudymo rodiklių pasiekia pasaulio biatlono čempionatuose lyderių pozicijas užimantys biatlonininkai. Šaudymo rodikliai neišanalizuoti ir skirtingų amžiaus grupių bei lyčių požiūriu. Tyrimu tikrinama hipotezė, kad suaugusiųjų biatlonininkų šaudymo rodikliai skiriasi nuo jaunimo ir jaunių amžiaus grupių biatlonininkų.

Tikslas – išanalizuoti suaugusiųjų, jaunimo ir jaunių biatlonininkų 2011–2012 metų pasaulio čempionatų šaudymo rodiklius ir juos palyginti lyties bei amžiaus požiūriu.

Metodai. Duomenų analizei pasirinkti jaunių (amžius: 17–18 m.), jaunimo (amžius: 19–20 m.) ir suaugusiųjų (amžius: 21–41 m.) grupių biatlonininkų šaudymo rodikliai. Analizuoti tokie šaudymo rodikliai: laikas ir taiklumas. Stebėjimo vienetų kiekis 2011–2012 m. – n = 2175. Duomenų analizei atlikti taikyti matematinės statistikos metodai.

Rezultatai. Nustatyti suaugusiųjų, jaunimo ir jaunių amžiaus grupių biatlonininkų šaudymo rodikliai buvo palyginti lyčių bei amžiaus požiūriu. Taip pat palyginti skirtingo amžiaus biatlonininkų šaudymo rodikliai su atitinkamoje grupėje lyderių pozicijas užėmusių biatlonininkų šaudymo rodikliais.

Aptarimas ir išvados. Nustatyta, kad biatlonininkių moterų šaudymo taiklumas jaunių ir jaunuolių amžiaus grupėse yra didesnis nei atitinkamos grupės biatlonininkų vyrų ($p < 0,05$). Suaugusiųjų grupių biatlonininkų taiklumas didesnis nei jaunimo ir jaunių ($p < 0,025$). Šaudymo laiko vidurkis ilgiausias jaunių amžiaus grupėje. Suaugusiųjų grupės biatlonininkai šūvius atlieka per trumpiausią laiko tarpą ($p < 0,001$). Jaunių, jaunimo ir suaugusiųjų vyrų grupių biatlonininkų šaudymo laiko vidurkis yra trumpesnis nei moterų atitinkamai ($p < 0,05$). Lyderių pozicijas iškovojusių biatlonininkų šaudymo parametrai reikšmingai skyrėsi nuo atitinkamos grupės vidurkio ($p < 0,05$).

Raktažodžiai: biatlonas, šaudymo taiklumas, šaudymo laikas.

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Corresponding author **Lina Kreivėnaitė**
Lithuanian University of Educational Sciences
Studentų str. 39, LT-08106 Vilnius
Lithuania
Tel +37061962454
E-mail lina.biathlon@gmail.com

THE RELATION BETWEEN PHYSICAL ACTIVITY AND HEALTH AMONG HIGHLY AND MODERATELY ACTIVE STUDENTS

Vitas Linonis[1], Laura Daniusevičiūtė[1], Rasa Šulnienė[1], Loreta Šapokienė[1], Šarūnas Klizas[2], Vaidas Mickevičius[3]
Kaunas University of Technology[1], Kaunas, Lithuania
Lithuanian Academy of Physical Education[2], Kaunas, Lithuania
Kaunas Technical College[3], Kaunas, Lithuania

ABSTRACT

Research background and hypothesis. Lack of physical activity is influenced by a number of chronic non-infectious, mental (Corbin et al. 2001; Golden et al., 2004) and other diseases (Katzmarzyk et al., 2003). Students' physical activity and nutrition research remains relevant, especially for those students the future profession of which is not related to physical activity and health.

Research aim. The aim of the study was to estimate the relation between physical activity and health among highly and moderately active students.

Research methods. All the subjects (n = 327) were grouped according to their physical activity levels. The group highly physically active students – female athletes (n = 32) and male athletes (n = 79) who were physically active more than 3000 minutes per week. The group of moderate physical activity included females (n = 47) and males (n = 169) who were physically active 600–3000 minutes per week (Ainsworth, Levy, 2004). The respondents filled in anonymous questionnaires: the International Physical Activity Questionnaire (IPAQ). The questions dealt with the time being physically active in the last seven days. The survey took place in February–April, 2012.

Research results. The subjects in high physical activity group gave a subjective evaluation of their physical activity as high (53%) and moderate (32%). The subjects in the moderate physical activity group evaluated their physical activity as moderate (60%) and high (26%). All subjects in both groups indicated that their health was good. The headache symptoms, stomach, abdominal or back pains, sadness, depression, insomnia and dizziness were rare or not common at all to subjects in high (63%) physical activity group. Sadness, depression, nervous tension and irritability, and bad mood were common to subjects in moderate (59%) physical activity group. The subjects in high physical activity group had their meals three – four times per day (76%), but subjects in moderate group ate only two - three times per day (61%). Irregular lunch and dinner were common to subjects in moderate physical activity group (63%).

Discussion and conclusions. Research results showed that subjects in high and moderate physical activity groups gave correct subjective evaluations of their physical activity forms. Also subjects in high physical activity group had breakfast, dinner and supper on regular basis and they had balanced diets more often ($p < 0.05$).

Keywords: physical activity, health, nutrition.

INTRODUCTION

Lack of physical activity (PA) is related to a number of chronic non-infectious, mental (Corbin et al. 2001; Golden et al., 2004) and other diseases and premature mortality (Katzmarzyk et al., 2003). It is known that low levels of physical activity influence cardiovascular (Shephard et al., 1999), diabetes (HU et al., 2003), osteoporosis (Nguyen et al., 2000), cancers and other diseases (Thune, Furbenger, 2001), high levels of physical activity help control body weight

(Ross et al., 1998) and improve the quality of life (Acree, 2006). According to the recommendations of World Health organization (WHO), other health relevant governmental and public organizations, physical activity should last at least 30 minutes per day. It is known that children should be physically active no shorter than one hour per day (Harro et al., 2006). Boys' physical activity is usually higher than that of girls (Harro et al., 2006). Physical activity can be divided into shorter periods of time (shorter than ten minutes), which has a positive effect health (Corbin et al., 2001). Physical activity in Lithuania was mostly studied as an integral part of lifestyle in the field of biomedical and sociological research. Physical activity of Lithuanian schoolchildren and students was established as higher than the average in the European Union. The project data showed that leisure time activities including sports for at least 30 minutes four or more days per week in Lithuania increased since 1994, but in 2006 they were only 23 percent (Pomerleau et al., 2000). The study on health behaviors Lithuanian adults showed that only very few patients admitted that they were advised to increase their physical activity by their doctor (6.9%) or other health care specialists (1.6%), family members (24.1%), or other persons (10.2%) (Pomerleau et al., 2000). Studies have shown that even would-be medical and public health professionals have unbalanced diets, wrong eating habits and do not follow nutritional guidelines. Established (Škėmienė et al., 2007), even 40.0% of first-year female and 54.7% male doctors failed diet regimen. Not regularly ate 29.5% of third-year females and 46.3% males. R. Stucco and V. Dabravolskij (2009) for future public health professionals showed that 89.5% of males and 62.5% of girls fail to comply with dietary treatment, the difference between sex and diet, compliance is statistically significant. Students' physical activity and nutrition research remains relevant, especially if students' future profession is not related to physical activity or health. The aim of the study was to estimate the relation of physical activity and health among highly and moderately active students.

RESEARCH METHODS

The subjects. The study included 327 students of Kaunas University of Technology. All subjects were grouped according to their physical activity levels. High physical activity group involved females athlete (n = 32) and male athletes (n = 79) who were physically active more than 3000 minutes per week. Moderate physical activity group included females (n = 47) and males (n = 169) who were physically active for 600–3000 minutes per week (Ainsworth, Levy, 2004).

The questionnaire. The respondents got anonymous questionnaires: the International Physical Activity Questionnaire (IPAQ) – Short Form (Ainsworth, Levy, 2004). The purpose of the questionnaire survey was to obtain comparable data on health related physical activity. The questions dealt with the time being physically active in the last seven days. The questionnaire was divided into four parts according to physical activity: 1) vigorous physical activity refers to activity which requires much physical effort and makes breathing much harder than normal; 2) moderate activity refers to activity that requires moderate physical effort and makes breathing somewhat harder than normal; 3) walking, which includes activities at work and at home, walking to travel from place to place, and any other kinds of walking for recreation, sport, exercise, or leisure; 4) sedentary activity includes time spent at work, at home while doing course work and during leisure time, also time spent sitting at a desk, visiting friends, reading, sitting or lying while watching television. Following the guidelines of the International Physical Activity Questionnaire *(IPAQ — Short and Long Forms,* 2005), all respondents were grouped according to their physical activity levels: high, moderate and low physical activity. We also ascertained students' nutrition habits and frequency, subjective health assessments, complaints and the frequency of visiting doctors.

Testing schedule. The anonymous questionnaire survey was conducted in February–April, 2012. The subjects were randomly selected in Kaunas University of Technology. Before completing the questionnaire, subjects were explained the aim of the study and then they were asked to fill in the questionnaire. The researcher explained possible ambiguities. On average, filling in the questionnaires took about 15 minutes. The data were processed and analyzed using the statistical package *SPSS 13.0.* To check the hypothesis chi-square (χ^2) test was applied, the statistical inference confidence level was $p < 0.05$.

RESEARCH RESULTS

Female athletes admitted having vigorous physical activities two - three 3 days per week, male athletes – from three to five days per week. Female students had vigorous physical activities from one to three days per week, and males – from two to five days per week. The difference was statistically significant comparing the duration values of female athletes and females in moderate activity group ($p < 0.05$). The same significant difference was found comparing the duration values of male athletes and males in moderate activity group ($p < 0.05$; Figure 1).

Female athletes admitted having moderate physical activities up to two days per week, male athletes – five days per week. Females were having moderate physical activities from one to three days per week and males – two 2 days per week. The difference was statistically significant comparing the duration values of female athletes and females in moderate activity group ($p < 0.05$). The same significant difference was found comparing the duration values of male athletes and males in moderate activity group ($p < 0.05$; Figure 2).

Female athletes indicated walking up to seven days per week, male athletes – to seven days per week. Females walked to seven days per week and males – seven days per week ($p < 0.05$; Figure 3).

Female athletes indicated that they spent from four to six hours per day sitting. Male athletes sat from four to five hours per day. Females sat from four to five hours per day and males – from one to six hours per day (Figure 4). Females and males in moderate of physical activity group spent time more sitting than female and males athletes, the difference was statistically significant ($p < 0.05$; Figure 4).

The subjects in high physical activity group subjectively evaluated their physical activity as high (53%) and moderate (32%). The subjects in moderate physical activity group subjectively evaluated their physical activity as moderate (60%) and high (26%). All subjects in both groups thought

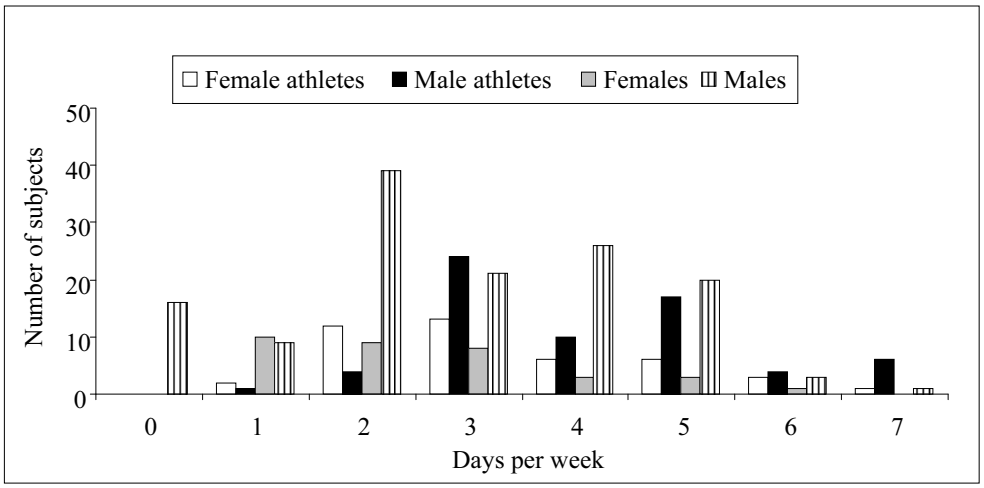


Figure 1. **The frequency of vigorous physical activities (weightlifting, digging, aerobics, or speed cycling)**

Note. $p < 0.05$.

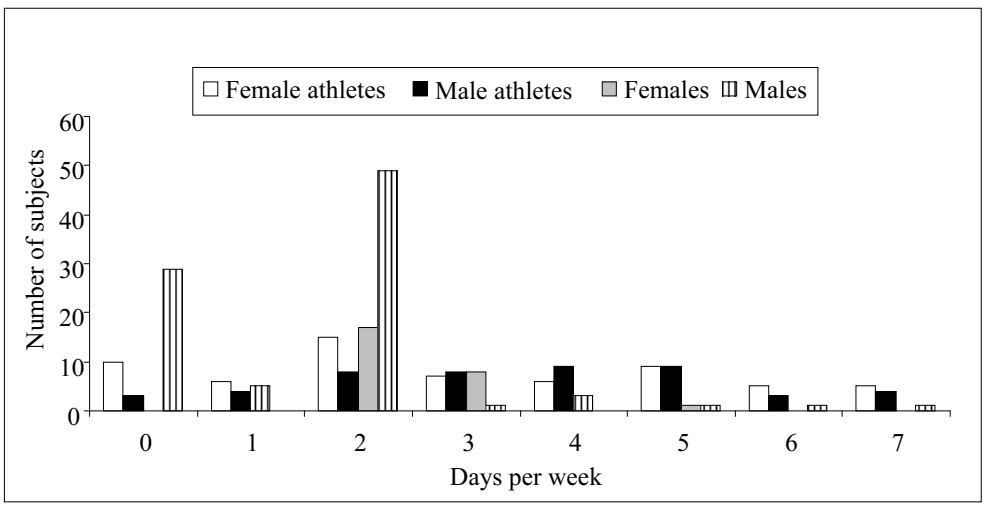
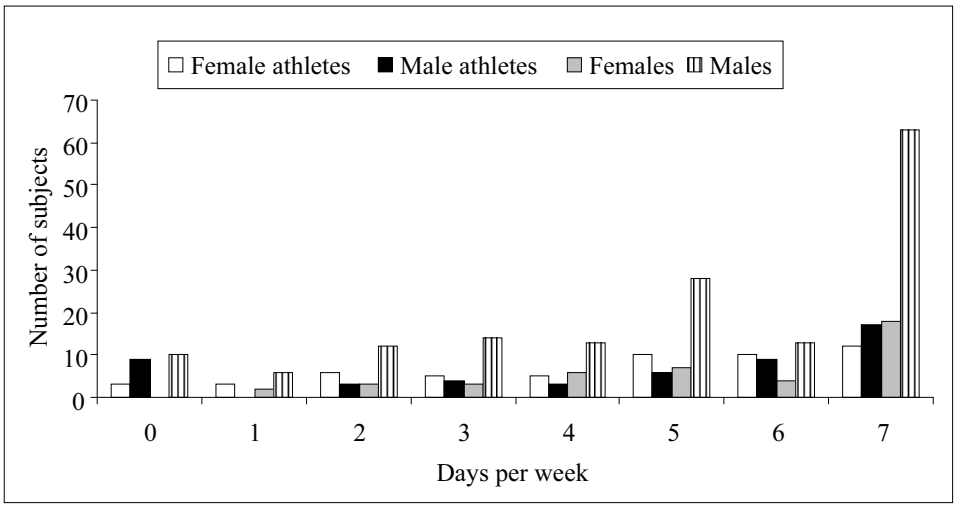


Figure 2. **The frequency of moderate physical activities (carrying light loads, cycling at a regular pace, or tennis)**

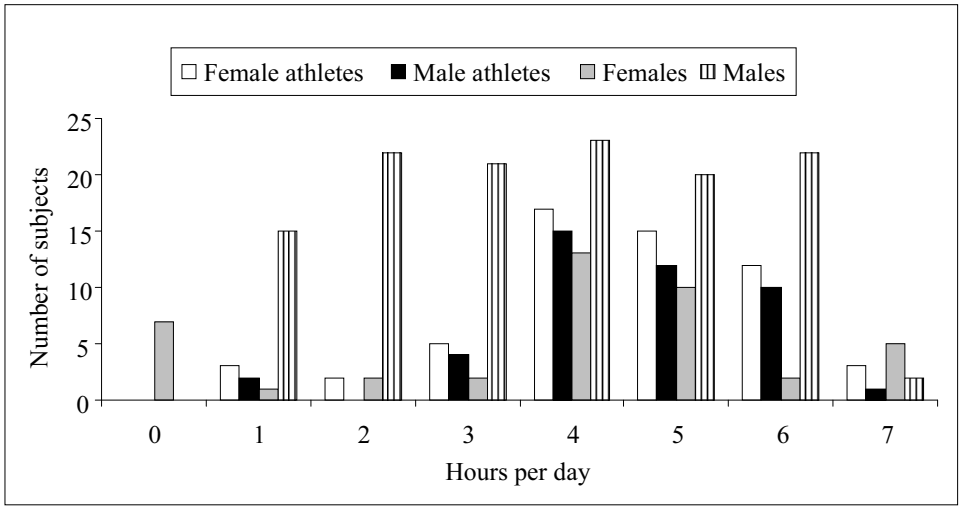
Note. $p < 0.05$.

Figure 3. **Frequency of walking, which includes activities at work and at home, walking to travel from place to place or any other kinds of walking for recreation, sport, exercise or leisure, as indicated by the subjects**



Note. $p < 0.05$.

Figure 4. **The hours of sitting per day as indicated by the subjects**



Note. $p < 0.05$.

their health was good. The headache symptoms, stomach or abdominal pain, back pain, sadness, depression, insomnia and dizziness were rarely or never occurring to subjects (63%) in high physical activity group. Sadness, depression, nervous tension and irritability, bad mood were common to subjects almost every month in moderate (59%) physical activity group. The subjects in high physical activity group had meals three - four times per day (76%), but subjects in moderate group ate two - three times per day (61%). Irregular lunch and dinner were common to subjects in moderate physical activity group (63%).

DISCUSSION

Less physically active students get tired sooner than physically active students and they are in poor health (Bray, Bora, 2004). R. Proškuvienė and M. Černiauskienė (2009) found that subjects rated their health as good, but many of them admitted having a lot of illness symptoms occurring over the last few months. High levels of occupation and lack of time during the studies have a negative impact on students' physical activity and nutrition. Our study revealed that only one-fifth of Kaunas University of Technology students characterized themselves as highly physical active. S. Poteliūnienė and co-authors (2006) found that first year students did not participate in regular physical activities, so it is of high importance to increase their physical activity and motivation to exercise. It is important to eat every day at the same time and to eat not fast (Škėmienė et al., 2007). Students do not have enough time to eat, their eating regime is disrupted (Škėmienė et al., 2007). While all first year students and one third of fourth year students said that their diets were healthy, just more than half of the respondents admitted having breakfast and dinner on regular basis. Other authors (Škėmienė

et al., 2007) also found that students had unbalanced diets: taking too much fat. We found that students regularly having breakfast, lunch and dinner were those in higher physical activity group. They also ate vegetables ($p < 0.05$), fresh fruits ($p < 0.05$) more often and they had balanced diets ($p < 0.05$). Our results were similar to those of other authors (Kriaučionienė et al., 2009). They found that people who followed healthy diet recommendations were physically active as well.

CONCLUSIONS AND PERSPECTIVES

Research results showed that subjects in high and moderate physical activity groups gave correct subjective evaluations of their physical activity forms. Also subjects in high physical activity group had breakfast, dinner and supper on regular basis and they had balanced diets more often ($p < 0.05$).

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FIZINIO AKTYVUMO IR SVEIKATOS RYŠYS TARP DIDELIO IR VIDUTINIO FIZINIO AKTYVUMO STUDENTŲ

Vitas Linonis[1], Laura Daniusevičiūtė[1], Rasa Šulnienė[1], Loreta Šapokienė[1], Šarūnas Klizas[2], Vaidas Mickevičius[3]

Kauno technologijos universitetas[1], Kaunas, Lietuva
Lietuvos kūno kultūros akademija[2], Kaunas, Lietuva
Kauno technikos kolegija[3], Kaunas, Lietuva

SANTRAUKA

Tyrimo pagrindimas ir hipotezė. Fizinės veiklos trūkumas turi įtakos lėtinių neinfekcinių, psichikos (Corbin et al 2001; Golden et al., 2004) ir kitų ligų atsiradimui (Katzmarzyk et al, 2003). Studentų fizinio aktyvumo ir mitybos tyrimai išlieka aktualūs, o ypač tiems studentams, kurių ateities profesija nėra susijusi su fizine veikla.

Tikslas – įvertinti didelio ir vidutinio fizinio aktyvumo studentų fizinio aktyvumo ir sveikatos ryšį.

Metodai. Buvo tirta 327 Kauno technologijos universiteto studentai. Visi tiriamieji suskirstyti pagal fizinio aktyvumo lygius. Didelio fizinio aktyvumo grupei buvo priskirtos moterys sportininkės (n = 32) ir vyrai sportininkai (n = 79), kurių fizinis aktyvumas sudarė daugiau nei 3000 minučių per savaitę. Vidutinio fizinio aktyvumo grupei buvo priskirtos moterys (n = 47) ir vyrai (n = 169), kurių fizinis aktyvumas sudarė 600–3000 minučių per savaitę (Ainsworth Levy, 2004). Respondentai gavo anoniminį klausimyną – 2005 m. Tarptautinio fizinio aktyvumo klausimyno (IPAQ) gairių trumpąją formą (Ainsworth Levy, 2004). Tiriamųjų klausta, kiek laiko jie buvo fiziškai aktyvūs per paskutines 7 dienas. Anoniminė anketinė apklausa atlikta 2012 metų vasario–balandžio mėn.

Rezultatai. Didelio fizinio aktyvumo grupės tiriamieji įvertino savo fizinį aktyvumą kaip didelį (53%) ir vidutinį (32%), vidutinio fizinio aktyvumo grupės tiriamieji – kaip vidutinį (60%) ir didelį (26%). Abiejų grupių tiriamieji įvertino savo sveikatą kaip gerą. Galvos, skrandžio ar pilvo, nugaros skausmus, liūdesį, depresiją, nemigą ir galvos svaigimą patiria retai arba niekados didelio (63%) fizinio aktyvumo grupės tiriamieji. Liūdesį, depresiją, nervinę įtampą ir dirglumą, blogą nuotaiką beveik kiekvieną mėnesį patiria vidutinio (59%) fizinio aktyvumo grupės tiriamieji. Didelio fizinio aktyvumo grupėje tiriamieji valgo 3–4 kartus per dieną (76%), vidutinio fizinio aktyvumo – 2–3 kartus per dieną (61%). Nereguliariai pietauja ir vakarieniauja vidutinio fizinio aktyvumo tiriamieji (63%).

Aptarimas ir išvados. Didelio ir vidutinio fizinio aktyvumo grupių tiriamieji subjektyviai pažymėjo, kad jie yra pasirinkę tinkamą fizinio aktyvumo formą. Didelio fizinio aktyvumo grupės tiriamieji reguliariau pusryčiavo, pietavo ir vakarieniavo, taip pat dažniau derino maisto produktus nei vidutinio fizinio pajėgumo studentai.

Raktažodžiai: fizinis aktyvumas, sveikata, mityba.

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Corresponding author **Laura Daniusevičiūtė**
Kaunas University of Technology
Donelaičio str. 73, LT-44029 Kaunas
Lithuania
Tel +370 600 65490
E-mail lauruka@yahoo.com

INCONSISTENCIES OF FOOT TYPE CLASSIFICATION

Raminta Sakalauskaitė[1], Danguolė Satkunskienė[1,2]
Lithuanian Academy of Physical Education[1], Kaunas, Lithuania
Kaunas University of Technology[2], Kaunas, Lithuania

ABSTRACT

Research background and hypothesis. Literature analysis shows that researchers try to determine which method used for foot type estimation is the most reliable, and look for correlations between directly received foot measurements (indexes, angles) ignoring assessment scales. Given different medial longitudinal arch (MLA) assessment scales, the comparison, discussion and conclusions of the obtained data might be unreliable.

Research aim of this study was to determine the reliability of foot type classification: a) to assess correlation links between results from various methods used to analyse foot; b) to identify foot type distribution according to medial longitudinal arch.

Research methods. The MLA of 182 feet was assessed using four prevalent foot type evaluation methods: the Chipaux-Smirak Index (CSI), the Staheli Index (SI), the Clarke angle (CLA) and arch index by D. S. Williams (WAI). Pearson's correlation was used to determine links between foot indexes.

Research results. Very strong link was found between CSI and SI footprint indexes, while medium negative correlation was determined between Clarke angle with Chipaux-Smirak (CSI) and Staheli (SI) indexes. Average amount of low arch foot assessed according to the foot type classification scales by the four methods was 64.0 (SD = 65.5), normal foot 92.25 (SD = 51.77) and high arch foot 25.75 (SD = 35.33).

Discussion and conclusion. Research showed that current foot arch classification was not reliable. The foot type classification scales presented by F. Forriol, L. T. Staheli, N. M. Clarke and D. S. Williams define different medial longitudinal foot arch distribution by testing the same pairs of feet despite the correlative link intensity between foot arch indexes.

Keywords: footprint, foot arch, assessment scale.

INTRODUCTION

Many methods are currently being used to classify the medial longitudinal foot arch (MLA). Literature review shows that no general consensus exists on the best method for foot type classification. Existing methods are typically based on the measurement of morphological parameters of the foot, mostly in the standing weight-bearing position, or during locomotion (Razeghi, Batt, 2002). Direct methods for MLA height assessment include taking radiographs, which provide a reliable method for evaluating the structure of the foot during weight bearing (Villarroya et al., 2009). Many research laboratories do not have access to such methods, therefore indirect methods that are used include footprint analysis, which is still the most popular method to analyse and assess the MLA (Cavanagh, Rodgers, 1987; Staheli et al., 1987; Forriol, Pascual, 1990; McCroy et al., 1997). However, controversial findings are published in literature. Some authors have reported that footprints are not good indicators for determining foot type (Hawes et al., 1992; Saltzman et al., 1995), whereas others consider that it is a reliable technique (Cavanagh, Rodgers, 1987; Staheli et al., 1987; Forriol, Pascual, 1990; McCroy et al., 1997).

Literature analysis shows that researchers trying to determine which method used for

foot type estimation is the most reliable, are looking for correlation between directly received foot measurements (indexes, angles) ignoring assessment scales that classify foot arch into three stages according to specific indications (normal, high and low arch). In our opinion, even if some of foot indexes correlate when applying various foot type classification methods, the results might be diverse. However, despite the method used the determined foot arch type must be the same.

The aim of this research was to determine the reliability of foot type classification: a) to assess correlation links between results from various methods used to analyse foot; b) to identify foot type distribution according to medial longitudinal arch.

RESEARCH METHODS

In our research, 182 feet of 91 subjects (44 female and 47 male) were measured to establish a mean and standard deviation for a reference population. The average age of subjects was 23.9 ± 5.1 years with an average weight of 74.5 ± 11.5 kg. All subjects who took part in this study were volunteers from a university population and the surrounding community. None of the subjects had lower-extremity abnormalities or injuries at the time of measurement. Subjects were informed about the course of the research. The National Bioethics Committee reviewed and approved the study protocol.

MLA was assessed using four prevalent foot type evaluation methods: the Chipaux-Smirak Index (CSI), the Staheli Index (SI), the Clarke angle (CLA) and arch index by Williams (WAI).

Foot measurements were taken using footprints and video recording. The footprints were used to estimate the foot arch using three methods (CSI, SI, CLA) and filming was used for the Williams method (AI).

Figure 1. **A Globus Berkemann plate**

Static footprints were taken from a standing position on a Globus Berkemann plate, one leg in a weight-bearing position. For the analysis of the CSI, SI and CLA, necessary lines were drawn with a pencil and two rulers on the footprints following the authors' instructions (Clarke, 1933; Staheli et al., 1987; Forriol, Pascual, 1990).

The Chipaux-Smirak Index (CSI) is the ratio between minimal width of the medial longitudinal arch area (b) and maximal width of the metatarsal print (a). (b) is parallel to (a). CSI = b/a. Five categories are described for the MLA classification according to CSI-0% – foot with elevated arch; 0.1–29.9% – foot with a morphological normal arch; 30–39.9% – intermediate foot; 40–44.9% – foot with a lowered arch; 45% or higher – flatfoot (Forriol, Pascual, 1990).

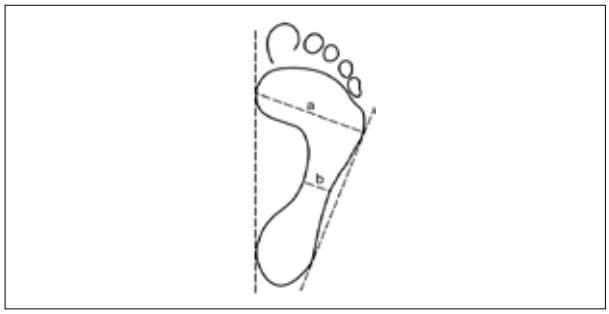


Figure 2. **The Chipaux-Smirak Index (Onodera et al., 2008)**

The Staheli Index (SI) is the ratio between minimal width of the medial longitudinal arch area (b) and maximal width of the heel print (c). (c) is parallel to (b). SI = b/c. The MLA is classified as follows: ≤ 0.43 – high arch; 0.44 – 0.89 – normal; ≥ 0.90 – low (Staheli, 1997).

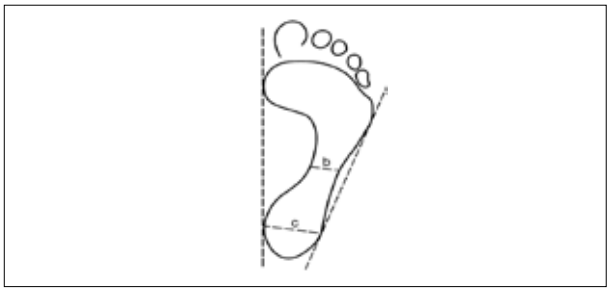


Figure 3. **The Staheli Index (Onodera et al., 2008)**

For calculation of **the Clarke's angle (CLA)** the line "AC" was drawn between point A and the apex of the concavity of the arch of the footprint (point C). The CLA is the angle between lines "AB" and "AC". The MLA is classified as follows: 55º is overarched; 42–54º normal MLA; 31–41º flattened; 30º and below is flatfoot (Clarke, 1933).

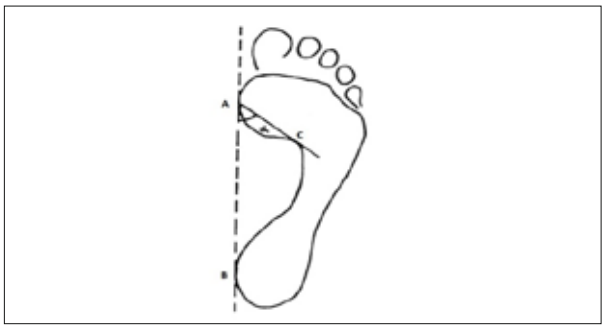


Figure 4. **The Clarke's angle (Onodera et al., 2008)**

Arch index by D. S. Williams (WAI) is dorsum height (DORS) divided by arch length (AL). Dorsum height was measured from the floor to the top of the foot at 50% of foot length. Foot length (FL) was measured from the most posterior portion of the calcaneus to the end of the longest toe. Arch length was measured from the most posterior portion of the calcaneus to the center of the first metatarsophalangeal joint. For Williams method, arch height was measured with the digital photographic method (Pohl, Farr, 2010). The MLA is classified as follows: ³ 0.357 – high arch; 0.356–0.275 – normal and ≤ 0.274 is low MLA (Williams, Mc Clay., 2000).

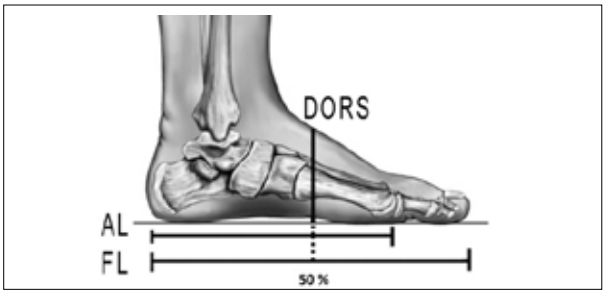


Figure 5. **The Arch Index by D. S. Williams**

The sagittal plane of foot placed in a weight-bearing position was filmed with a digital video camcorder Canon XM-1. Before filming four markers were attached to the skin in the following landmarks on the legs of each subject: 1) head of the first metatarsal, 2) dorsum midpoint between the most posterior portion of the calcaneus to the end of the longest toe, 3) most posterior portion of the calcaneus, 4) the end of the longest toe.

The fixed markers were manually digitized using the software SIMI Motion. Foot length and dorsum height were analysed from the side view. To check the accuracy of the systems used, an error analysis of point marking, repeated digitizing, and foot dorsum height and foot length measurements were conducted. The standard error of the relative mean difference was also calculated (1.1%).

All calculated indexes were tested for normality of distribution using SPSS 14 packet and the Kolmogorov-Smirnov test.

Aiming at comparing the classifications presented by different authors, the uniform assessment scale was used: 1 – low MLA, 2 – normal MLA, 3 – high MLA. The low, lowered and intermediate arch heights were designated to group 1. The elevated and high arch types were appointed to group 3 (Onodera et al., 2008). The number of low, normal and high MLA was calculated according to all scales mentioned above. Pearson's correlation was used to determine links between foot indexes. The significance level was $p < 0.01$. Mean and standard deviations of quantity of low, normal and high arch foot were calculated.

RESEARCH RESULTS

The foot arch indexes calculated by each selected methods were tested for normality of distribution. Probability plots (Q-Q plots; "Q" stands for quantile) of each variable are presented in Figure 6. Q-Q plots show that all foot arch indexes fit theoretical normal distribution. Only Clarke's angle does not match the test distribution (Kolmogorov-Smirnov test: $p < 0.05$).

Table shows strong link between CSI and SI footprint indexes, while medium negative correlation was determined between Clarke angle with Chipaux-Smirak (CSI) and Staheli (SI) indexes.

Distribution of foot measurements according to different methods used is provided in Figure 7. Average amount of low arch foot assessed according to the foot type classification scales by the four authors was 64.0 (SD = 65.5), normal foot 92.25 (SD = 51.77) and high arch foot 25.75 (SD = 35.33).

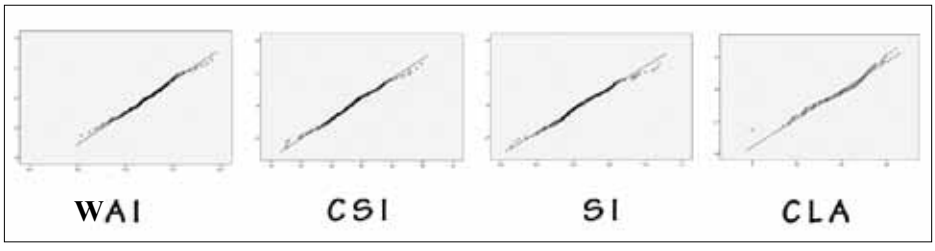


Figure 6. **Distribution of Q-Q Plots of Williams, CSI, SI indexes and Clarke's angle**

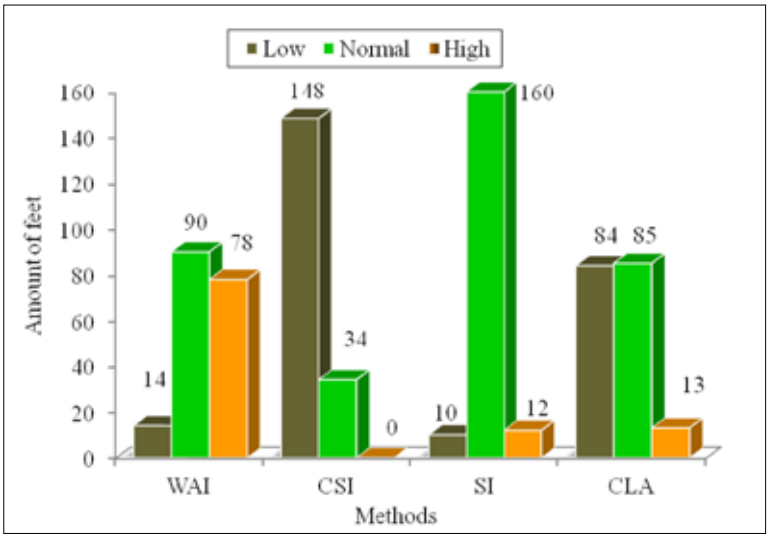
Note. The arch index by Williams (WAI), the Chipaux-Smirak Index (CSI), the Staheli Index (SI), the Clarke angle (CLA).

Table. **Correlation between different foot indexes**

		WAI	CSI	SI	CLA
WAI	Pearson's Correlation	1			
	Sig. (2-tailed)				
CSI	Pearson's Correlation	-0.311*	1		
	Sig. (2-tailed)	0.000			
SI	Pearson's Correlation	-0.326*	0.901*	1	
	Sig. (2-tailed)	0.000	0.000		
CLA	Pearson's Correlation	0.152	-0.622*	-0.599*	1
	Sig. (2-tailed)	0.040	0.000	0.000	

Note. The arch index by Williams (WAI), the Chipaux-Smirak Index (CSI), the Staheli Index (SI), the Clarke angle (CLA). * – Correlation is significant at the 0.01 level (2-tailed).

Figure 7. **Feet distribution by the different methods**



Note. The arch index by Williams (WAI), the Chipaux-Smirak Index (CSI), the Staheli Index (SI), the Clarke angle (CLA).

DISCUSSION

There are several methods to evaluate medial longitudinal foot arch, therefore researchers, as well as practitioners (orthopedists, physiotherapists), often raise the question which one of the methods should be used. Which one is the most reliable? Which one is the most accurate? Do the results of medial longitudinal arch evaluation differ depending on the method used?

It is considered that the most accurate method is to use X-rays, when usually two angles of the foot evaluating foot arch are measured: between the first metatarsal and the calcaneus inclination (Saltzman et al., 1995). Aiming at determining the reliability of footprint measurements, researchers look for correlative links between footprint and rentgenography indexes. U. Kanatli (2001) alongside with other scientists identified a medium correlative link between Staheli arch index (SI) and foot lateral talo-first metatarsal angle rentgenogram. A. M. Onodera et al. (2008) analysed children's feet at various ages and calculated the arch indexes of Cavanagh and Rodgers (AI), Chipaux-Smirak (CSI), Staheli (SI) and the Alpha (or Clarke) Angle (AA). The indices showed clear and significant correlations between each other (R above 0.75, $p < 0.001$) except for SI and AA with AI. In this research correlation method was applied in order to determine statistical link between different indexes evaluating foot arch provided by various measurement methods. The research showed that the most correlative indexes were the ones from footprint: there was a strong link between CSI and SI and a medium correlative link between Clarke angle and Chipaux-Smirak (CSI) and Staheli (SI) index.

The D. S. Williams method (2000) is based on the ratio of foot height and length; its reliability was tested by C. L. Saltzman et al. (1995) using the rentgenographic method. C. L. Saltzman et al. (1995) determined a strong correlative link between the ratio of foot arch height and length (h/l) and foot arch X-ray measurements. The correlative ratio between D. S. Williams' method and footprint measurements that we calculated in our research showed a weak link between the markers used to determine foot arch height. A. N. Onodera et al. (2008) conducted research where feet were evaluated according to different scales provided by various research methods. Having compared the number of high, low and normal feet (numbers where

obtained using different methods to compare the same feet) they discovered a statistically significant difference between Staheli (SI) and Chipaux-Smirak (CSI) footprint evaluation methods: out of 782 feet assessed to the CSI method normal feet constituted 52.9%, high – 4.3%, and low – 42.9%, and according to the SI method normal feet arches constituted 74.3%, high arches – 20% and low feet arches – 5.7%. The results obtained using CSI and SI methods in our research were also different. According to the CSI method, low arch feet were dominant and constituted 18.7%, whereas high arch feet were absent. Meanwhile the SI method showed that the dominant arch type was normal (87.9%), low arch feet constituted 5.5% and high arch – 6.6%. The results of our research based on SI method had a similar distribution with A. N. Onodera et al. (2008) analysis.

The results of Clarke and Williams methods were rather similar, as the number of feet with normal arch found using both methods were close (according to Clarke method, feet with normal arch constituted 46.7% and according to Williams method – 49.5%). However, the number of low and high arch feet were different. Based on Clarke method, low arch feet constituted 46.2%, high arch – 7.1%; whereas according to Williams method, the results where 7.7% and 42.8% accordingly. Having evaluated the distribution of feet obtained using all methods we can propose that the foot type classification scales presented by F. Forriol, L. T. Staheli, N. M. Clarke and D. S. Williams define different MLA distribution by testing the same pairs of feet.

Why was the distribution of foot arch type so diverse using each analysis method and did not correspond to normal distribution law, although all, except H. H. Clarke's angle, foot arch indexes calculated by each selected methods were tested for normality of distribution using Kolmogorov-Smirnov test? Analysis of foot evaluation scales, provided by the authors, has shown that they were composed differently. For example, according to the evaluation scale by Staheli, foot is considered to be normal when the impression indexes distribute between ± 2 SD from average. According to Chipaux-Smirak, the normal index is ± 1 SD from average, and according to Williams it is ±1.5 SD. Unfortunately, authors did not indicate what their scales were based on. We believe that not the indexes describing medial longitudinal arch but the evaluation scales could have had the influence on such a diverse number of foot with high, normal and low arch.

A. N. Onodera's (2008) children foot arch research conducted using several methods showed that the highest number of normal arch feet was received using SI method. Author argued that it was the result of criteria differences established by each author when classifying MLA.

Since there are no parameters of a normal foot structure and function, the establishment of the foot type have to be based on mathematical statistics using probability density function of the normal distribution. According to the normal distribution, the first quartile (that suffice low foot arch) cut off the lowest 25% of data, the second quartile (normal foot arch) cut data set in half (50% of data), and third quartile (high foot arch) cut off the highest 25% of data. Our opinion is that if evaluation scales are constituted according to normal distribution of quartile, the number of feet measured using different methods should conform.

CONCLUSIONS AND PERSPECTIVES

Research showed that current foot arch classification was not reliable. The foot type classification scales presented by F. Forriol, L. T. Staheli, N. M. Clarke and D. S. Williams define different medial longitudinal foot arch distribution by testing the same pairs of feet despite the correlative links intensity between foot arch indexes.

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PĖDOS TIPO KLASIFIKAVIMO NESUDERINAMUMAS

Raminta Sakalauskaitė[1], Danguolė Satkunskienė[1,2]
Lietuvos kūno kultūros akademija[1], Kaunas, Lietuva
Kauno technologijos universitetas[2], Kaunas, Lietuva

SANTRAUKA

Tyrimo pagrindimas ir hipotezė. Analizuojant literatūrą pastebėta, kad mokslininkai, norėdami nustatyti, kuris pėdos vertinimo metodas yra patikimiausias nusakant pėdos skliauto tipą, ieško koreliacijos ryšių tarp tiesiogiai išmatuotų ar paskaičiuotų pėdos rodiklių (indeksų, kampų), neatsižvelgdami į vertinimo skales. Turint skirtingas pėdos skliauto vertinimo skales, gautų duomenų išvados ir interpretacijos gali būti nepatikimos.

Tikslas – nustatyti pėdos tipo klasifikavimo patikimumą: a) įvertinti koreliacijos ryšį tarp pėdos rodiklių, tirtų skirtingais metodais; b) nustatyti pėdų pasiskirstymą pagal išilginio skliauto tipą.

Metodai. 182 pėdų vidinis išilginis skliautas buvo vertintas keturiais metodais: skaičiuojamas Chipaux-Smirak indeksas (CSI), Staheli indeksas (SI), Clarke kampas (CLA) ir skliauto indeksas pagal D. S. Williams (WAI). Tarp indeksų ir kampo buvo skaičiuotas Pirsono koreliacijos koeficientas.

Rezultatai. Labai stiprus koreliacijos ryšys aptiktas tarp CSI ir SI pėdos antspaudo indeksų, o vidutinis neigiamas ryšys buvo tarp Clarke kampo ir Chipaux-Smirak (CSI) bei Staheli (SI) indekso. Įvertinus pėdos skliautą keturiais metodais paaiškėjo, kad žemo skliauto pėdų vidutiniškai buvo 64,0 ± 65,5, normalių pėdų – 92,25 ± 51,77 ir aukšto skliauto pėdų – vidutiniškai 25,75 ± 35,33.

Aptarimas ir išvados. Atlikus tyrimą nustatyta, kad pėdos skliauto klasifikavimas yra nepatikimas. Nors koreliacijos ryšys tarp skirtingų metodų rodiklių buvo stiprus, pėdų pasiskirstymas pagal išilginį pėdos skliauto tipą buvo nevienodas.

Raktažodžiai: pėdos antspaudas, pėdos skliautas, vertinimo skalė.

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Corresponding author **Raminta Sakalauskaitė**
Lithuanian Academy of Physical Education
Sporto str. 6, LT-44221 Kaunas
Lithuania
Tel +370-37 209144
E-mail r.sakalauskaite@lkka.lt

PHYSICAL TRAINING OF CANDIDATES TO PROFESSIONAL MILITARY SERVICE IN LITHUANIAN ARMED FORCES

Aurelijus Savonis, Algirdas Čepulėnas
Lithuanian Academy of Physical Education, Kaunas, Lithuania

ABSTRACT

Research back ground and hypothesis. There is a basic military training course (BMT) carried out in the Lithuanian Armed Forces. The aim of this course is to train soldiers for military service that they were able to perform individual tasks and acquire basic military preparation. There is a lack of research dealing with the effect of physical training programmes in military training courses on the changes in soldiers' physical fitness. We hypothesize that in the course of military training physical fitness of would-be soldiers improves.

Research aim was to analyse the structure and content of the BMT programme and the effect of its implementation on the changes in physical fitness for would-be soldiers.

Research methods: literature review, analysis of military physical training programmes, physical fitness testing.

Research results. During the first testing only 26.8% of would-be soldiers achieved the standards of physical fitness complex test, and during the second testing the standards of the complex test of physical fitness were achieved by 89.5% of service people. In the period of the course VO_2max and Roufier index improved ($p < 0.001$). Indices of physical fitness and functional capacity improved more in the first half of the course. At the end of the course the results of adapted military physical fitness of service people were worse compared to the results of their general physical fitness.

Discussion and conclusions. The program of general physical training was effective, but more attention should be paid to the improvement of adapted military physical fitness programme aiming at better results. During the basic military training course physical fitness and functional capacity of candidates improved and at the end of the course it reached the normative level of physical fitness.

Keywords: physical fitness, adapted military physical fitness, basic military course, testing.

INTRODUCTION

Military service requires good health and physical fitness for soldiers. Professional military service admits persons who meet the health requirements and who have fulfilled the established physical fitness standards. There is a basic military training course (BMT) carried out in the Lithuanian Armed Forces. The aim of this course is to train soldiers for military service that they were able to perform individual tasks and acquire basic military preparation. The duration of the course is 12 weeks. The programme of the course has been developed on the basis of the Order of the Minister of National Defence of the Republic of Lithuania of 2008-07-28 No. 715, the Order of the Commander of the Lithuanian Armed Forces of 2006-09-01 No.V-1137 and the Order of 2011-05-20 No.V-505.

Physical training is one of main structural parts of soldiers' combatant training (Greičius et al., 1998; Skrebė, 2000; *Lietuvos gynybos politikos*

baltoji knyga, 2002).The analysis of physical fitness of various army troop soldiers' is a focus of many scientific studies (Radžiukynas, 1999; Sokołowski, 2002; Górski, 2007; Witkowski et al., 2007; Dobosz, Świercz, 2011). Only a minority of the scientific studies analyse the problems related to physical training of the Lithuanian professional soldiers and the peculiarities of physical fitness turn over of soldiers who represent different age groups during their time of service (Vilkas et al., 1994); Čepulėnas, Klenauskas, 2002; Ivaškiene, 2003; Trinkūnas, 2009). Physical fitness and the peculiarities of its changes during the BMT course among the volunteering candidates for professional military services in Lithuania have received inadequate attention in research literature. The aim of the research was to analyse the structure and the content of the BMT programme and the effect of its implementation on the changes in physical fitness for would-be soldiers.

RESEARCH METHODS

The research sample included 250 persons who participated in BMT course in 2011. BMT course was carried out in the Training Regimen of the Lithuanian Great Hetman Jonušas Radvila. Physical fitness was assessed using the following tests: bending and reaching arms in a lying position for 2 min (times), test for abdominal muscle strength on the Sit-ups for 2 min (times); endurance test – 3000 m run (min, s). Functional capacity was assessed by the indices of Roufier test and maximal oxygen consumption (VO_2max) which was established indirectly, performing a step test (*Karių fizinio rengimo metodinės rekomendacijos*, 2003). The testing was carried out at the beginning (testing 1), in the middle (testing 2) and at the end of BMT programme (testing 3). Eight control tests were performed: 8 km military march with 10 kg outfit: military obstacle course, grenade throw standing up, lying down, kneeling, and speeding up, military self-defence first-level test, swimming and overcoming obstacles in the water. Physical fitness results in each exercise were evaluated in points using the differentiated scale of evaluation according to age and gender (Table). At the end of BMT course would-be soldiers had to collect no less than 60 points in each test. The data were processed applying statistical programme *SPSS 12. for Windows*. We calculated arithmetic means ($\bar{x}$), standard deviation (±SD), Student (t) test criterion, and index p for statistical significance. The level of significance was set at 95% when $p < 0.05$.

RESEARCH RESULTS

The whole BMT course includes 645 hours. BMT physical training programme had 120 hours. According to the number of hours for each subject, physical training occupied the second position after tactical preparation, which had 248 hours. Physical training course included physical training theory (2%), general physical training (42%), and applied military physical training (56%). General physical training included learning correct performance of physical exercises (4%), strength development (23%), endurance development (25%), flexibility development 18%); speed and agility development (6%), testing physical skills (24%). Applied military physical training programme included technical training of overcoming military section obstacles 13%), preparation for a military march (6%), training military combat self-defence actions (41%), training combat grenade throws (7%), training military swimming 12%), applied military physical training testing (21%).

During the first physical fitness testing (Figure 1) only 26.8 % of would-be soldiers met the standards of all three control tests (each exercise was evaluated in no less than 60 points). The testing showed that would-be soldiers had weak abdominal muscles as the average point in sit ups exercise was 56.1 points (Figure 2).

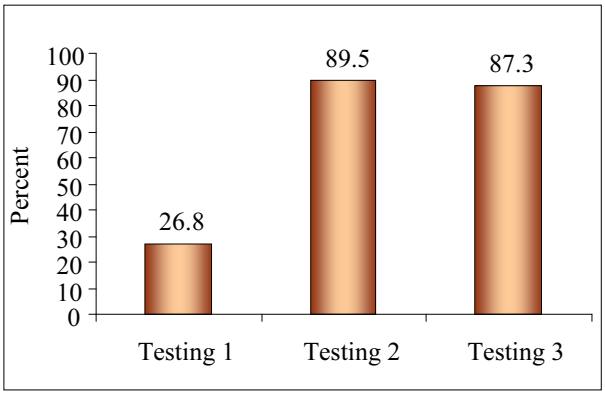


Figure 1. **Changes (percentage) in the performance of general physical fitness complex test standards during the BMT course**

No	Age group	Bending and reaching arms in a lying position 2 min, times		Sit-ups 2 min, times		3000 m run, s	
		Those who scored 60 points	Those who scored 100 points	Those who scored 60 points	Those who scored 100 points	Those who scored 60 points	Those who scored 100 points
1	18–21	42	71	53	78	15:00	12:06
2	22–26	40	75	50	80	15:42	12:06
3	27–31	39	77	45	82	16:06	12:24
4	32–36	36	75	42	76	16:48	12:24
5	37–41	34	73	38	76	17:24	12:42
6	42–46	30	66	32	72	17:48	13:12
7	47–51	25	59	30	66	18:36	13:30

Table. **Physical fitness test scores in different age groups**

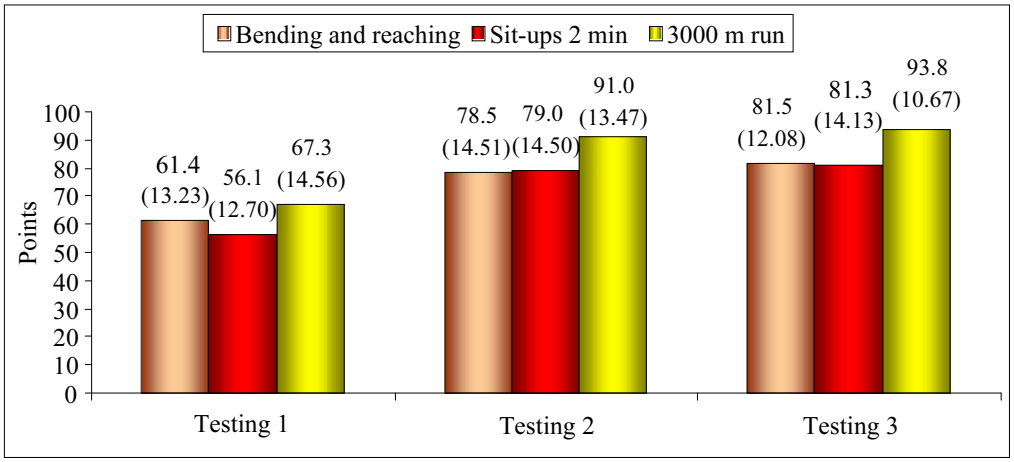


Figure 2. **Changes in general physical fitness of soldiers during the BMT course according to points ($\bar{x} \pm SD$) for each exercise**

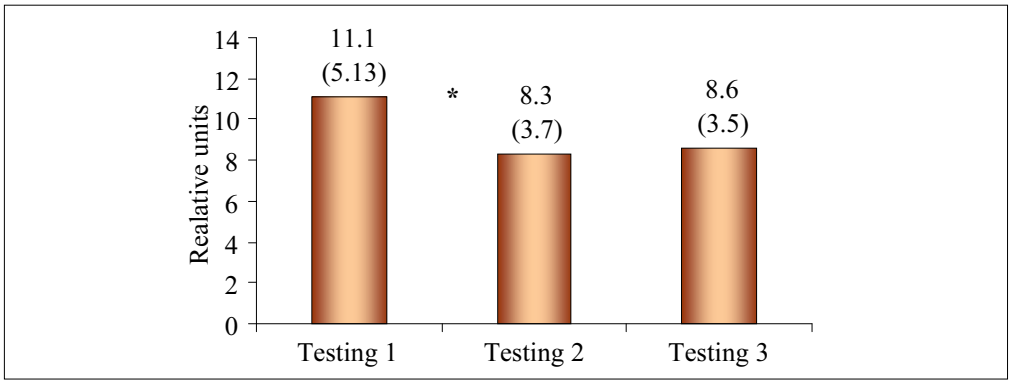


Figure 3. **Changes in the indices of Roufier test ($\bar{x} \pm SD$) during the BMT course**

Note. * – $p < 0.001$.

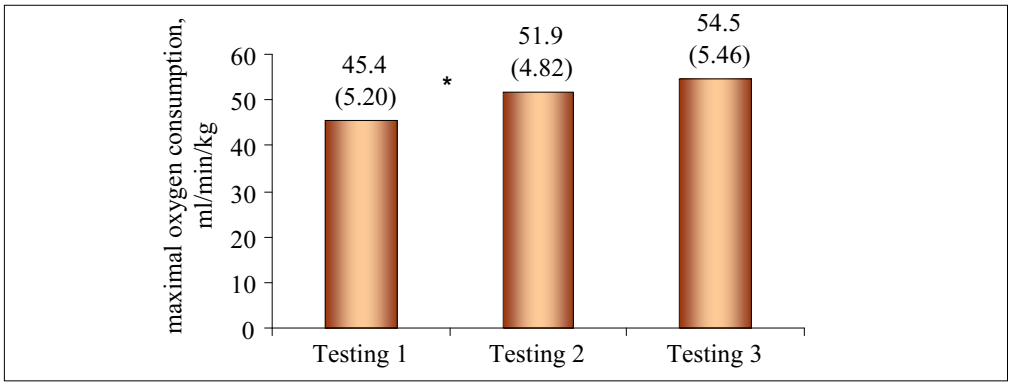
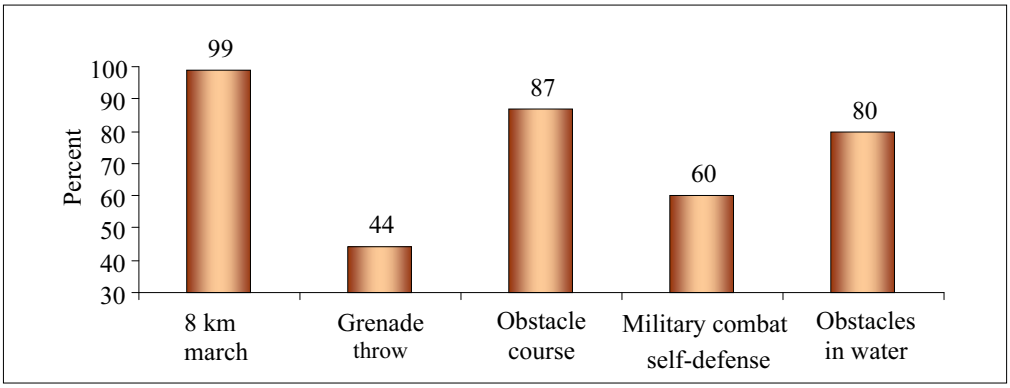


Figure 4. **Changes in maximal oxygen consumption indices ($\bar{x} \pm SD$) of soldiers during the BMT course**

Note. * – $p < 0.001$.

Figure 5. **Results of the performance of adapted military physical fitness standards in percent**



The points were awarded according to the subject's age following evaluation scale. During the tests they decreased to 87.8%. It can be explained by the fact that at the end of BMT programme the candidates were tired as their physical loads increased due to testing in the applied military physical training. Candidates to professional military service demonstrated low indices (Figure 3, 4) of functional body capacity (poor Roufier test and VO_2 max indices).

The results of applied military physical training testing (Figure 5) at the end of BMT programme were as follows: 98.5% of candidates carried out 8 km military march meeting the norms, 43% – grenade throws, 87.3% – overcoming military section obstacles, 60.5% – military combat self-defence, 79.8 % – swimming and overcoming obstacles in the water.

DISCUSSION

It is relevant to carry out tests of soldiers' physical fitness as well as optimize their physical training programs in accordance with the obtained results. The first testing of would-be soldiers showed that their physical fitness did not correspond to the levels required for soldiers in professional military service. The capacity of the cardiovascular system of would-be soldiers was evaluated by the indices of VO_2max and Roufier test. At the beginning of the course the VO_2max indices ($\bar{x}$) of service people amounted to 45.4 ± 5.20 ml/min/kg, and Roufier test index was 11.1 ± 5.13 relative units. These indices showed satisfactory and poor level (*Karių fizinio rengimo metodinės rekomendacijos*, 2003).

Lack of physical activity is characteristic of today's schoolchildren, especially at the age of 17–18, and this directly impacts physical fitness results of young men of military age (Greičius et al., 1998). Suitability for military service is determined not only by the person's health, but also the indices of physical fitness and physical capacity (Radžiukynas, 1999; Skrebė, 2000).

During the second testing, which took place in the middle of the course, the subjects showed improved physical fitness results. The standards of the complex test of physical fitness were achieved by 89.5% of service people. Flexibility improved most; its average point in 3000 m running was 91.0. Hand grip strength and abdominal muscle power increased as well and it amounted to 78.5 and 79.0 points (Figure 2). We should note that the improvement in the indices of physical fitness was greater in the first half of the course. If we compare the results of the second and the third testing, we will notice that the improvement was not so expressed. In the period of the course the VO_2max indices improved from 45.4 ± 5.20 ml/min/kg to 54.5 ± 5.46 ml/min/kg ($p < 0.001$), and Roufier index improved from 11.1 ± 5.13 to 8.6 ± 3.5 relative units ($p < 0.001$). Indices of functional capacity improved more in the first half of the course.

Some authors (Trinkūnas, 2009) suggest that physical fitness is better of persons called to the Army who are from villages, and not from the cities, but during BMT course persons improve their physical fitness more.

Testing of adapted military physical fitness at the end of the course showed (Figure 5) that the level of adapted military physical fitness of service people was lower compared to the standard requirements. As many as 53% of subjects failed in grenade throw test, 38.8% – in military self-defence, 10.5 % did not overcome obstacle course, and 17.2% failed in overcoming obstacles in water.

The performance of adapted military physical fitness tasks requires learning new complex movements and psychological stability in performing them (Skrebė, 2001). The formation and consolidation of technical skills require more time. The performance of adapted military physical fitness tasks is greatly affected by psychological stress due to difficult conditions of performance (Scahafer, 1992; Cox, 1994). Psychological tension is expressed in inability to control one's actions (Masiulis, 2006). We suppose that due to those factors the results of adapted military physical fitness of service people were worse compared to the results of their general physical fitness.

At the end of the course the results of adapted military physical fitness of service people were worse compared to the results of their general physical fitness. Some persons failed in achieving the standards of adapted military physical fitness.

CONCLUSIONS AND PERSPECTIVES

The programme of general physical training was effective, but more attention should be paid to the improvement of adapted military physical fitness programme aiming at better results.

During the basic military training course physical fitness of candidates improved and at the end of the course it reached the normative level of physical fitness. The majority of would be soldiers are still unable to meet some of the normative requirements of the applied military physical training.

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KANDIDATŲ Į LIETUVOS KARIUOMENĖS PROFESINĘ KARO TARNYBĄ FIZINIS RENGIMAS

Aurelijus Savonis, Algirdas Čepulėnas
Lithuanian Academy of Physical Education, Kaunas, Lithuania

SANTRAUKA

Tyrimo pagrindimas ir hipotezė. Lietuvos kariuomenėje vykdomi baziniai kariniai mokymai (BKM), kurių tikslas parengti profesinei karo tarnybai karius, gebančius atlikti nustatytas individualias užduotis ir įgyti pagrindinį karinį parengtumą. Trūksta mokslinių tyrimų, nagrinėjančių bazinių karinių mokymų fizinio rengimo programos vykdymo poveikį karių fizinio pajėgumo kaitai. Keliama hipotezė, kad per bazinius karinius mokymus būsimųjų karių fizinis pajėgumas gerėja.

Tikslas – išanalizuoti BKM fizinio karių rengimo programos struktūrą ir turinį bei nustatyti jos vykdymo poveikį būsimų karių fizinio pajėgumo kaitai.

Metodai: literatūros šaltinių studija, bazinių karinių mokymų fizinio rengimo programos analizė, fizinio parengtumo testavimas.

Rezultatai. Per pirmą testavimą tik 26,8% būsimųjų karių įvykdė bendrojo fizinio parengtumo kompleksinio testo normatyvą, o per antrą šį normatyvą įvykdė 89,5%. Per mokymų laikotarpį pagerėjo ($p < 0,001$) maksimalaus deguonies suvartojimo ir Rufjė indekso rodikliai. Fizinio parengtumo ir funkcinio pajėgumo rodiklių pagerėjimas buvo didesnis per pirmą mokymų pusę. Bazinių karinių mokymų pabaigoje kursantų taikomojo karinio fizinio parengtumo rezultatai buvo prastesni negu bendrojo fizinio parengtumo.

Aptarimas ir išvados. Bendrojo fizinio rengimo programa buvo veiksminga, tačiau reikėtų atkreipti dėmesį į karinio taikomojo fizinio rengimo programos tobulinimą siekiant geresnių rezultatų.

Per bazinius karinius mokymus būsimųjų karių fizinis parengtumas ir funkcinis pajėgumas pagerėjo ir jie pasiekė kursų pabaigai nustatytą fizinio parengtumo normatyvinį lygį.

Raktažodžiai: fizinis parengtumas, taikomasis karinis fizinis parengtumas, baziniai kariniai mokymai, testavimas.

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Corresponding author **Aurelijus Savonis**
Lithuanian Academy of Physical Education
Sporto str. 6, LT-44221 Kaunas
Lithuania
Tel +370 69809329
E-mail aurelijus.savonis@gmail.com

PECULIARITIES OF CENTRAL AND PERIPHERAL CHANGES AT ONSET OF DOSED AND MAXIMAL EXERCISE TESTS

Birutė Zacharienė, Jonas Poderys, Eugenijus Trinkūnas, Alfonsas Buliuolis
Lithuanian Academy of Physical Education, Kaunas, Lithuania

ABSTRACT

Research background and hypothesis. Since varying types of physical workloads activate different physiological system activity at different degree, during dosed and maximal exercises the total effects can highlight the properties of central and peripheral mechanisms and reveal significant synergies between the central and peripheral cardiovascular processes.

Research aim was to determine the peculiarities of central and peripheral indices of cardiovascular system while performing dosed and maximal exercise tests.

Research methods. Two groups took part in the study – sportsmen-sprinters (16) and sportsmen – endurance group (11). The participants of the study performed Roufier exercise and 30 s maximal jump test with maximal efforts. The 12-leads ECG was registered continuously and the changes of heart rate (HR), JT interval and ratio JT/RR were analysed. Near-infrared spectroscopy was employed for continuous registration of the changes in oxygen saturation (StO_2) and arterial blood flow.

Research results. The results obtained during the study showed increasingly changing ECG indices while performing exercise load in both athlete groups but there was no statistically significant difference between groups while performing maximal exercise, thus oxygen saturation and arterial blood flow was statistically significantly faster and decreased more in sprint athlete group.

Discussion and conclusion. Dosed and maximal exercise test indicated the peculiarities of cardiovascular function of athletes, although more differences between individual peculiarities of athletes can be revealed while performing a dosed exercise test and still more differences – while the maximal exercise tests are performed and during the recovery after exercising.

Keywords: dosed and maximal exercise test, cardiovascular system, endurance, sprint.

INTRODUCTION

The body's functional state and functional fitness and a number of studies of regulatory mechanisms of functional systems are carried out by monitoring the reactions induced by functional tests or exercises. The functional state of the body can be estimated by changes in functional parameters (Wilkinson et al., 2009) during the dosed maximal exercise tests. Muscle activity is the factor which may change cardiovascular system activity at the highest degree and most rapidly. Physical load resulting changes in body function are not the changes of the state in an individual body system, but it is a whole set of complex and interrelated processes (Biggiero, 2001). In such chain of processes concatenations of cardiovascular, the central and peripheral regulatory mechanisms play an important role (Delp, 1999; Jones, Pole, 2007). Due to increasing metabolic needs in the body many cardiovascular processes begin almost at the same time in order to ensure a sufficient supply of oxygen (Hughson, 2007). Changes in cardiovascular function shift in

accordance with the alteration of physical load to the maximum. No regulatory mechanism of blood flow work in isolation, it interacts with a whole system or performs as a part of regulatory system; hence it is important to perceive these interactions occurring during exercise.

Since varying types of physical workloads activate the processes of different physiological systems at different degrees, during dosed and maximal exercises the total effects can highlight the properties of central and peripheral mechanisms and reveal significant synergies between the central and peripheral cardiovascular parameters.

RESEARCH METHODS

The participants of the study were 27 men – 16 sprint (age – 18–24 years., BMI – 21.4 ± 1.8 kg/ m^2) and 11 endurance runners (age – 21–26 years, BMI – 20.2 ± 0.42 ± 1.5 kg/m^2). The study involved non-professional sportsmen engaged in the chosen sports not less than for two years. All participants performed two tests: Roufier exercise (30 squats per 45 s) and 30 s vertical jump test with maximal efforts. Using computerized ECG analysis system "Kaunas–load" during the Roufier exercise test and two min of recovery after the load, the 12 lead ECG was recorded. We analysed heart rate (HR), JT interval and JT/RR ratio. Oxygen saturation (StO_2) and blood flow in muscle (*m. vastus lateralis*) was recorded by near-infrared spectroscopy method.

Statistical analysis of the data. Analysis was conducted using statistical package *SPSS for Windows 17.0*. Standard statistical methods were used to calculate means and standard deviations (± SD). A one-way analysis of variance (ANOVA) was used to establish the differences between the measurements. The difference in mean was regarded as statistically significant when error probability with respect to criteria was $p < 0.05$.

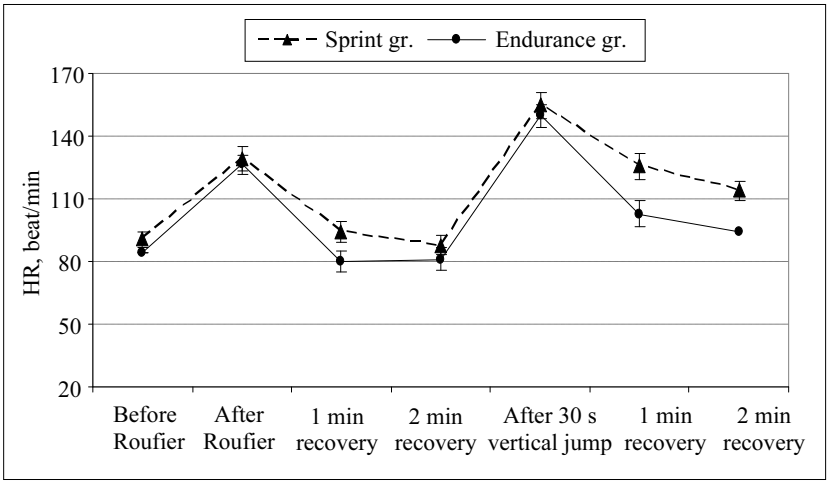
RESEARCH RESULTS

Figure 1 presents the dynamics of HR during Roufier exercise and 30 s maximal jump tests. Before Roufier HR was statistically significantly higher in sprint group 87.5 ± 4.0 beats/min, in endurance group – 84.4 ± 4.8 beat/min ($p < 0.05$). After Roufier exercise test in sprint group HR increased to 129.4 ± 5.9 beat/min, in endurance group – 126.4 ± 4.9 beat/min ($p > 0.05$). During the recovery process after two minutes of Roufier test workload the HR changes were statistically significant in both groups: in sprint group they recovered till 87.7 ± 4.4 beat/min, in endurance group – 81.2 ± 5.6 beat/min ($p < 0.05$). The HR recovery after 30 s vertical jump test was established in sprint group – 154.6 ± 6.4 beat/min, in endurance group – 149.7 ± 6.5 beat/min, and it was not statistically significant, $p > 0.05$.

Comparing JT interval changes during Roufier exercise test in both groups (Figure 2), we established that before the test it was statistically significantly higher in the endurance group (0.27 ± 0.01 s; sprint group – 0.25 ± 0.01 s; $p < 0.05$), but after Roufier exercise this index was simlar in both groups – 0.22 ± 0.01 s, and no statistically significant differences were found ($p > 0.05$).

Comparing values of JT/RR ratio changes we established that in sprint group they were higher – during Roufier exercise test 0.46 ± 0.01, in endurance group – 0.44 ± 0.01, after 30 s vertical

Figure 1. **Dynamics of HR during dosed and maximal exercise test**



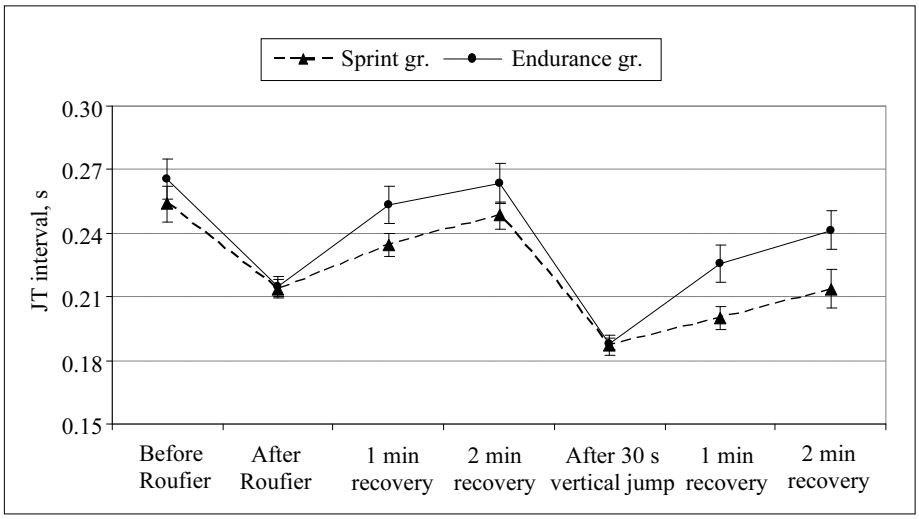


Figure 2. **Dynamics of JT interval during dosed and maximal exercise test**

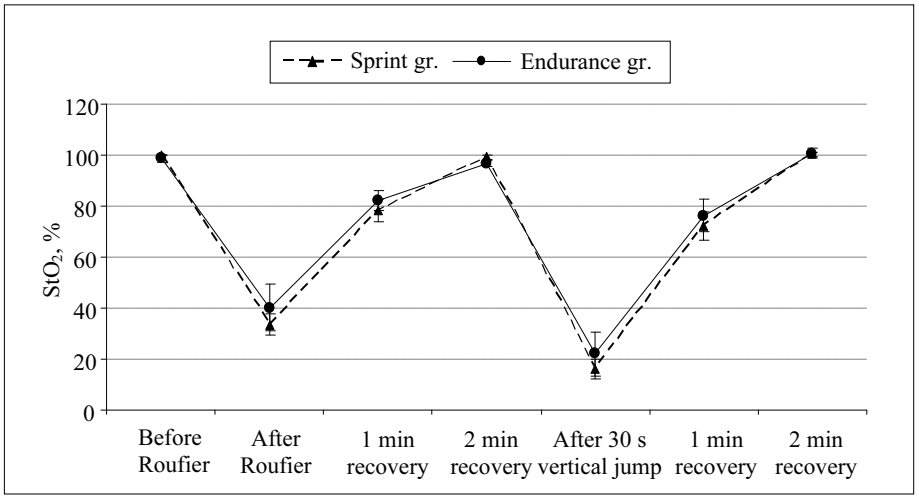


Figure 3. **Dynamics of StO_2 during dosed and maximal exercise test**

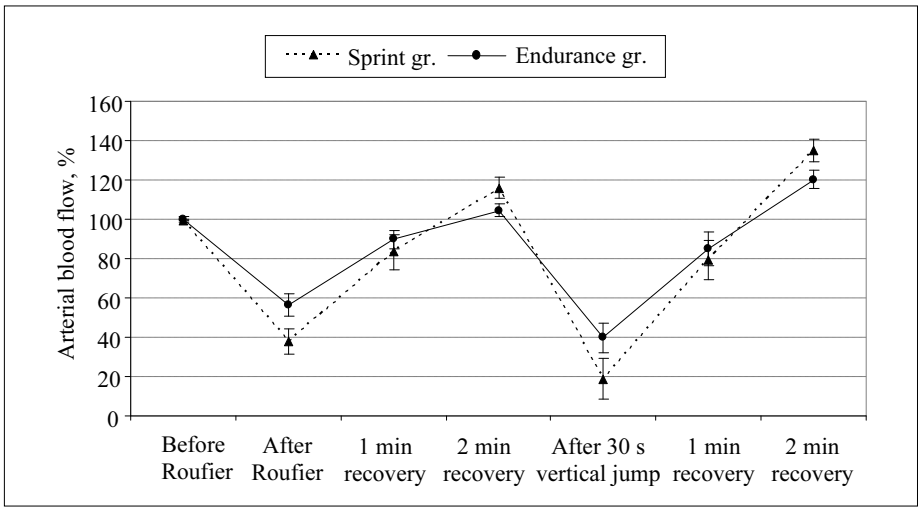


Figure 4. **Dynamics of arterial blood flow during dosed and maximal exercise test**

jump test JT/RR values were similar in both groups – 0.47 ± 0.01 ($p > 0.05$).

Figure 3 presents StO_2 dynamics. We assessed statistically significant ($p < 0.05$) oxygen saturation decrease to 72.9 ± 8.9% in endurance athlete group, in sprint group StO_2 from base line decreased to 76.1 ± 4.4% after Roufier exercise test. During the first minute after Roufier exercise test StO_2 recovered ($p < 0.05$). After 30 s vertical jump test StO_2 decreased to 94.7 ± 1.9% in sprint group, in endurance group – 84.7 ± 8.8% ($p < 0.05$).

After Roufier exercise test the arterial blood flow intensity decreased to 56.7 ± 8.6% in endurance group, in sprint group – 73.4 ± 8.3% (Figure 4). During the first minute after Roufier exercise test in sprint group, the arterial blood flow intensity increased more then in endurance group (17.6 ± 5.6% and 6.3 ± 2.8% above baseline), this difference was statistically significant ($p < 0.05$). After maximal exercise test, blood flow intensity decreased to 88.9 ± 9.8% from baseline in sprint group, in endurance group – 70.5 ± 7.7% from baseline ($p < 0.05$).

DISCUSSION

While evaluating changes of the central and peripheral cardiovascular functional parameters induced by maximal and dosed exercise tests, we observed specific tendency: when the load was low while subject performed dosed exercise test, a lot of differences could be found between individuals adapted to a different type of physical load. After the analysis of cardiovascular parameters of speed and endurance athletes during Roufier test and 30 seconds of vertical jumps test, higher degree increase of registered central (ECG) and peripheral (StO_2 and arterial blood flow) system parametric changes were observed in the speed group. Differences in heart rate (HR) and its changes during dosed exercise tests should be considered as a result of different level of training and different kinds of exercise. Many studies have revealed that evolution of cardiovascular adaptation depends on the type of physical load and the length of training experience (Карпман, 1987). Athletes who develop aerobic endurance have the largest hearts (Fagard, 1997, 2006). The larger the heart (left ventricular end-diastolic diameter), the lower the maximum HR (Martinelli et al., 2005). Training designed to develop speed and power is not a very strong stimulus for the hypertrophy of myocardium even if it takes several hours per day (Haykowsky et al., 1998). So, these are the features of adaptation to physical loads, and they can explain the differences observed in the dynamics of HR and other estimated ECG's parameters, considering the difference between the groups adapted to speed and endurance loads.

In this study we also assessed the changes of ECG's ST-segment depression rate during physical load. ST-segment is a significant indicator of cardiovascular functionality and it is associated with the occurrence of myocardial functional ischemic processes, the assessment of its rate during physical load reflects cardiac functional fitness and its capacity (Enoka, Duchateau, 2008). As it has been pointed by many researchers, the capacity of cardiac reserve is very much dependent on the fulfilment of its oxygen demand, or how fast and whether it is a sufficient increase in oxygen delivery to the heart during physical load (Yazigi et al., 1998; Jernberg et al., 1999; Vainoras, 2002). Insufficient and substandard supply of myocardium with blood causes the lack of oxygen in the heart. It can occur because of very high physical or emotional tension. Adequate blood supply of the heart is a very important parameter of its working capacity (Žemaitytė, 1996; Yazigi et al., 1998). If coronary blood flow is insufficient during physical load, it changes the balance of metabolic processes and electrical potentials in myositis and consequently the changes are recorded in ECG as ST amplitude changes. Significantly higher values of this parameter were found in the speed group, but we have considered estimated ST-segment deviations as functional ischemic rather than pathological changes because after the termination of the load these effects disappeared quickly.

The aim of muscle blood flow is to provide muscles with blood, which is possible because of the interaction between the central and peripheral mechanisms regulating blood flow. While our investigation established that in the group of speed during Roufier test as well as during 30 s vertical jumps test, oxygen saturation and arterial blood flow decreased faster and at a higher level. Different response of periphery of speed and endurance groups to the tests could be conditioned by an unequal level of training experience, duration

or type of physical load (Gocentas, Andziulis, 2004). It is known that endurance athletes have greater aerobic capacity than representatives of the speed-power group because of large-scale power-endurance load decrease in peripheral vascular tone regulatory options which are reimbursed by the central circulatory organ, the heart function – an increase in systolic blood pressure (Poderys et al., 1999; Šilinskas, 2000).

CONCLUSION AND PERSPECTIVES

Dosed and maximal exercise tests indicate the peculiarities of cardiovascular function of athletes, more differences between individual peculiarities of athletes can be revealed while performing a dosed exercise test, and more differences while the maximal exercise tests are performed – during the recovery after exercising.

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CENTRINIŲ BEI PERIFERINIŲ ŠIRDIES IR KRAUJAGYSLIŲ SISTEMOS RODIKLIŲ KAITOS YPATYBĖS ATLIEKANT DOZUOTO IR MAKSIMALAUS KRŪVIO MĖGINIUS

Birutė Zacharienė, Jonas Poderys, Eugenijus Trinkūnas, Alfonsas Buliuolis
Lietuvos kūno kultūros akademija, Kaunas, Lietuva

SANTRAUKA

Tyrimo pagrindimas ir hipotezė. Įvairaus pobūdžio fiziniai krūviai skirtingai aktyvina organizmo fiziologines sistemas, todėl atliekant dozuotus ar maksimalius fizinius krūvius jie gali atskleisti centrinių ir periferinių mechanizmų sąsajas, t. y. esmines sinergijas tarp ŠKS centrinių ir periferinių rodiklių.

Tikslas – nustatyti centrinių bei periferinių širdies ir kraujagyslių sistemos (ŠKS) rodiklių kaitos ypatybes atliekant dozuoto ir maksimalaus krūvio mėginius.

Metodai. Buvo tiriama 16 sprinto ir 11 ištvermės bėgikų. Visi tiriamieji atliko fizinio krūvio ir 30 s trukmės vertikalių šuolių mėginius. Tyrimo metu buvo nenutrūkstamai registruojama 12 EKG standartinių derivacijų. Analizuoti šie rodikliai: širdies susitraukimo dažnis (ŠSD), JT intervalo trukmė ir JT/RR intervalų santykis. Deguonies įsotinimas (StO_2) ir kraujotakos kitimas buvo registruojami nenutrūkstamai neinvaziniu artimosios infraraudonosios spektroskopijos būdu.

Rezultatai. Atliekant maksimalaus krūvio mėginius, registruojamų centrinių (EKG) rodiklių pokyčiai tarp grupių statistiškai reikšmingai nesiskyrė, o periferinių sistemų (StO_2 ir arterinės kraujotakos) pokyčiai buvo didesni greitumo grupėje.

Aptarimas ir išvada. Dozuoto ir maksimalaus fizinio krūvio mėginiai parodo sportuojančiųjų širdies ir kraujagyslių funkcinio parengtumo ypatybes, tačiau daugiau skirtumų galima nustatyti atliekant dozuoto krūvio mėginį, o stebint atsigavimo po krūvio ypatybes – po maksimalaus krūvio mėginio.

Raktažodžiai: dozuotas ir maksimalus fizinis krūvis, širdies ir kraujagyslių sistema, ištvermė, sprintas.

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Corresponding author **Birutė Zacharienė**
Lithuanian Academy of Physical Education
Sporto str. 6, LT-44221 Kaunas
Lithuania
Tel +370 61221220
E-mail biruseb@gmail.com

PHYSICAL THERAPY AND MATERNITY SUPPORT GARMENT: INFLUENCE ON CORE STABILITY AND LOW BACK PAIN DURING PREGNANCY AND AFTER DELIVERY

Pavelas Zachovajevas[1], Brigita Zachovajevienė[2], Jūratė Banionytė[3], Arvydas Siaurodinas[4]

Lithuanian Academy of Physical Education[1], Kaunas, Lithuania
Lithuanian University of Health Sciences, Institute of Sport[2], Kaunas, Lithuania
Kaunas Šilainiai Outpatient Clinic[3], Kaunas, Lithuania
Aleksandras Stulginskis University[4], Kaunas, Lithuania

ABSTRACT

Research background and hypothesis. Transversus abdominis muscle experiences extraordinary overstretching during gestation period and thus the ability of this muscle to stabilize spine decreases. These changes can cause chronic low back pain during pregnancy and after delivery. In order to solve this problem it is essential to apply proper and effective treatment methods. Hypothesis: physical therapy exercises are more effective than maternity support garment in low back pain treatment and core stability during pregnancy and after delivery.

Research aim was to evaluate the influence of physical therapy and maternity support garment on spinal stability and low back pain during pregnancy and after delivery.

Research methods. Study sample comprised 40 pregnant women. The assessments were made twice: at 28–35 weeks of gestation and 8–9 weeks after delivery. The low back pain was evaluated using SAS, core stability and transversus abdominis muscle activation were objectively tested using special device stabilizer and the presence of diastasis recti was tested as well.

Research results. Physiotherapy is 42.4% more effective than maternity support garment in low back pain control during pregnancy and after delivery ($p < 0.05$). The best results of transversus abdominis muscle activation were observed in physiotherapy group with maternity support garment whereas participants without physiotherapy could not properly activate this muscle. The diastasis recti after delivery occurred only in control group, and in the group with maternity support garment it occurred 36.7% less frequently than in the group where women did not use this garment.

Discussion and conclusions. 1. Perceived low back pain after delivery was less expressed in women wearing maternity support garment both among women attending and not attending physiotherapy exercises. Nevertheless, physical therapy was more effective in reducing low back pain than maternity support garment during pregnancy and after delivery. 2. Core stability after delivery improved among women attending physical therapy exercises, but in case of maternity support garment it improved better. In contrast, in case of not attending physiotherapy the spinal stability after delivery improved only for women wearing maternity support garment. 3. Core stability during pregnancy and after delivery was better among women attending physical therapy but not wearing maternity support garment compared to women not attending physical therapy but wearing maternity support garment. 4. Physical therapy and maternity support garment improves core stability during pregnancy and has a positive effect on activity of *rectus abdominis* muscles following delivery.

Keywords: obstetrics, transversus abdominis muscle, exercises.

INTRODUCTION

The changes in core stability during pregnancy are determined by both mechanical and hormonal factors. During the growth and development of uterus where the fetus is developing, the abdominal wall is gradually stretching and by the end of pregnancy the abdominal muscles are

stretched reaching the limits of their elasticity. The muscles do not adapt timely to change of conditions of pregnancy and due to insufficient physical activity the muscle force and stamina decrease and coordination declines too. This leads to deteriorated function of muscles, joints and core stability (Zachovajevienė, 2006).

In scientific literature researchers often emphasize transversus abdominis muscle (TrA) that controls intraabdominal pressure through tension of thoracolumbar fascia. Together with multifidi muscles, thoracic diaphragm and pelvic floor muscles TrA secures core and pelvic stability as functional entity (Lee et al., 2008). After pregnancy, the trunk retains unstable as long as the function of supporting units does not reach the prior levels.

Different researchers claim that across various populations 24–90% of pregnant women suffer from low back pain (Sneag, Bendo, 2007; Kalus et al., 2008), which means that this is quite a frequent condition. Therefore many people including medical staff suppose that this is normal and will pass away in certain time (Žuromskis, 2008). However, the majority of women suffer such levels of pain that not only impair their working efficiency, but the quality of life during and after pregnancy as well (Gustafsson, Nilsson-Wikmar, 2008). In Lithuania, much attention is paid to health of pregnant women, however, it is not sufficient, especially regarding women who suffer pains and have reduced mobility during the pregnancy. Thus, it is not only important to define the cause of pain, but also to provide adequate help and care by effective means in reducing low back pain.

There are many studies conducted in Lithuania and other countries that prove positive effect of physiotherapy exercises on pregnant women, especially aimed to reduce low back pain (Garshasbi, Zadeh, 2005; Shia et al., 2005; Mørkved et al., 2007; Zachovajevienė et al., 2010; Gustafsson, Nilsson-Wikmar, 2008). Similarly, there are several studies outside Lithuania that evaluated the effectiveness of maternity support garment in reducing of back and pelvic pain during the pregnancy (Catherine, 2003; Kalus et al., 2008). However, the majority of research assessed the effectiveness of physical therapy exercises or maternity support garment, but not both. Therefore it is very important to evaluate what is the synergistic effect of those two interventions applied for reduction of low back pain and core stability. Moreover, the research is mostly done only during the pregnancy and thus it is not clear what the outcomes following the delivery are.

The aim of the study was to evaluate the influence of physical therapy and maternity support garment on core stability and low back pain during pregnancy and after delivery. **Hypothesis:** physical therapy is more effective than maternity support garment in low back pain treatment during pregnancy.

RESEARCH METHODS

Study conduct and subjects. The study was conducted from July 2010 to April 2011. It included pregnant women who attended aquatic physiotherapy exercises in Kaunas city at P. Mažylis Maternity Hospital (department of physical medicine and rehabilitation) and at Šilainiai Outpatient Clinic as well as pregnant women undergoing gynecology check-ups but not attending physical therapy. The study included only nulliparous women.

Before the 1st measurement, the test of diastasis recti was performed in order to eliminate the subjects with this disorder from the study. The study enrolled pregnant women with body mass index of 18.5–24.9 before pregnancy. The women who underwent cesarean section for delivery were excluded from analyses. The researchers obtained the permission from Kaunas Regional Biomedical Research Ethics Committee and written informed consent from study subjects.

Measurement 1 was conducted in 28–35 weeks of gestation and the intensity of low back pain (assessed by SAS) as well as core stability (assessed by "Stabilizer") in back and side positions were tested. Measurement 2 took place in 8–9 weeks after delivery and repeated the procedures mentioned above, but it also included tests for the activity of TrA in abdominal position and test of diastasis recti.

The study started with 47 pregnant women of working age, without any pathology of pregnancy or musculoskeletal system. Among them, 24 were attending aquatic physical therapy exercises (3 times per week for 45 min) and 23 women were not. After delivery, three women from the former subgroup and four women from the latter were excluded from later analyses due to cesarean section, thus for Measurement 2 the total of 21 subjects in physical therapy gym group (2 times per week for 45 min) and 19 subjects without

physical therapy remained. These two groups were divided into two subgroups each – with and without maternity support garment. In total, this generated four subgroups of study including women:

- attending physical therapy exercises and wearing maternity support garment (during the whole period of research) (n = 9),
- attending physical therapy exercises but not wearing maternity support garment (n = 12),
- not attending physical therapy exercises but wearing maternity support garment (during the whole period of research) (n = 10),
- not attending physical therapy exercises and not wearing maternity support garment (n = 9).

Mean age of study subjects was 27.2 ± 3.9 years, gestation stage by Measurement 1 was 31.2 ± 2.7 weeks.

Measurements

Intensity of low back pain (SAS). Study participants were asked to describe and show the most painful point in back area and express the intensity of pain from 0 to 10 pts. The participants pointed the intensity of pain on the scale independently.

Spinal stability. Spinal stability and objectively measured activity of TrA was evaluated using "Stabilizer". **Testing.** The women were asked to perform raising leg movements slowly, with TAM extension and spinal stabilization before that. The women were lying on a flat surface (on a couch). The evaluation of TrA function and spinal stability *during pregnancy* (Measurement 1) was conducted in two positions:

- *Back position:* legs are knee bent, feet are on a surface. Device pillow is set below the waist. By expiration, the woman has to exert TrA and try to keep the waist as stable as possible moving slowly with one leg. In 5 seconds she has to bend the hip (knee bent position) and in 5 seconds to make a movement back. In the same way she repeats the motions with the opposite leg.
- *Side position:* bearing leg is knee bent, the opposite leg is straight. Device pillow is set at waist side, between iliac crest and ribs. In spinal stabilization by TrA contraction, a woman has to move the hip to line of the shoulder slowly and evenly in 5 seconds and then move back in 5 seconds. The motion should be based rather on hip joint than on lateral waist movement. Before the movement, stabilizer pressure is set at 40 mm Hg and during the movement the scale changes are observed. The measurement was performed twice and their arithmetic mean was used for the analyses.

The evaluations of TrA function and core stability *after delivery* (Measurement 2) were conducted in three positions. The first two positions were analogue to Measurement 1, while the third position was as follows:

Abdominal position performed lying on abdomen and making contracting movement of abdominal wall. A woman is asked to lie on belly with neck and head relaxed and kept at middle line of the body. Device pillow is set at lower abdomen so that the distal margin of pillow would converge with anterior iliac line. The "Stabilizer" pressure is set at 70 mm Hg. A woman is asked to contract her lower abdomen slowly without supporting movements of spinal cord, hips, shoulders or pelvis, and keep such position for 10 seconds with regular breathing.

Decreasing pressure on "Stabilizer" manifests in negative numbers, which shows improving TrA activity. The study results were considered as positive if the pressure on device decreased to -1 mm Hg (in ideal case to -10 mm Hg). However, if the pressure increased, this was observed in positive numbers on the device and showed improper contraction of TrA which in turn was considered as negative performance (Garnier et al., 2009). The measurement was performed twice and their arithmetic mean was used for analyses. Since assessment of spinal stability had both positive and negative values they were ranked to 5 ranges with certain values each (Table). Without ranking the sum of positive and negative values would have been zero and would distort the results of effect.

Table. **Ranked values of spinal stability**

mmHg	Rank	mmHg
[–2; 0] mmHg	0	[0; 2] mmHg
[–6; –3] mmHg	1	[3; 6] mmHg
[–13; –7] mmHg	2	[7; 13] mmHg
[–20; –14] mmHg	3	[14; 20] mmHg
[–28; –21]mmHg	4	[21; 28] mmHg

Diastasis recti. Testing: a woman had to lie down on her back with bent legs, then slowly raise her head and shoulder from the floor as if trying to reach the knees with hands – as long as lower edge of scapula was not touching the floor. The therapist

had to touch the woman's abdomen horizontally and diagonally at midline of abdomen to umbilicus. Result was considered as positive if at least two fingers were able to fit in the gap (Janušonienė, Bacevičienė, 2006).

Statistical analysis. Data were analyzed using statistical package *SPSS for Windows 16.0.* Quantitative variables were described in means ± standard error of the mean (SEM). Comparison of independent samples was performed using non-parametric Mann-Whitney-Wilcoxon test, comparison of related samples – using non-parametric Wilcoxon test. Quantitative variables were described in percent. Homogeneity of samples was assessed using chi-squared test, equality of distributions – using proportion equation test. Statistical significance was set at $p < 0.05$.

RESEARCH RESULTS

Low back pain and physical therapy attendance. The results of low back pain assessment revealed (Figure 1) that mean pain among pregnant women attending physical therapy but not wearing maternity support garment was about 8.4% (accordingly 4.58 and 5 points) lower than that of women not attending physiotherapy but wearing maternity support garment. After delivery at Measurement 2 this difference increased up to 42.4% (accordingly 2.42 and 4.2 points) ($p < 0.05$).

Effect of physical therapy and maternity support garments on core stability in pregnancy and after delivery. Similarly, comparison of results during pregnancy showed that among women attending physiotherapy but not wearing maternity support garment, the spinal stability was better than that of women not attending physiotherapy but wearing maternity support garment (Figure 2): in back position, rank difference raising right leg was 0.7 (17.5%), raising left leg – 0.78 (19.5%) ($p < 0.05$). After delivery the difference increased to mean rank of 1.27 (31.8%) and 1.18 (29.5%), respectively. Here smaller value of rank shows better stability.

The comparison of groups was made based on side position results of spinal stability (Figure 2). During pregnancy, women attending physiotherapy but not wearing maternity support garment also showed better results than women not attending physiotherapy but wearing maternity support garment: mean rank difference at right leg contraction was 0.8 (20%), at left leg – 0.68 (17%) ($p < 0.05$). After delivery the differences persisted and increased to 1.03 (25.8%) and 0.85 (21.2%), respectively ($p < 0.05$).

Activity of rectus abdominis muscles in abdominal position. Assessment of activity of rectus abdominis muscles was conducted in this study only once – after delivery. Mean values of pressure changes across study subgroups are presented in Figure 3. We found that the mean

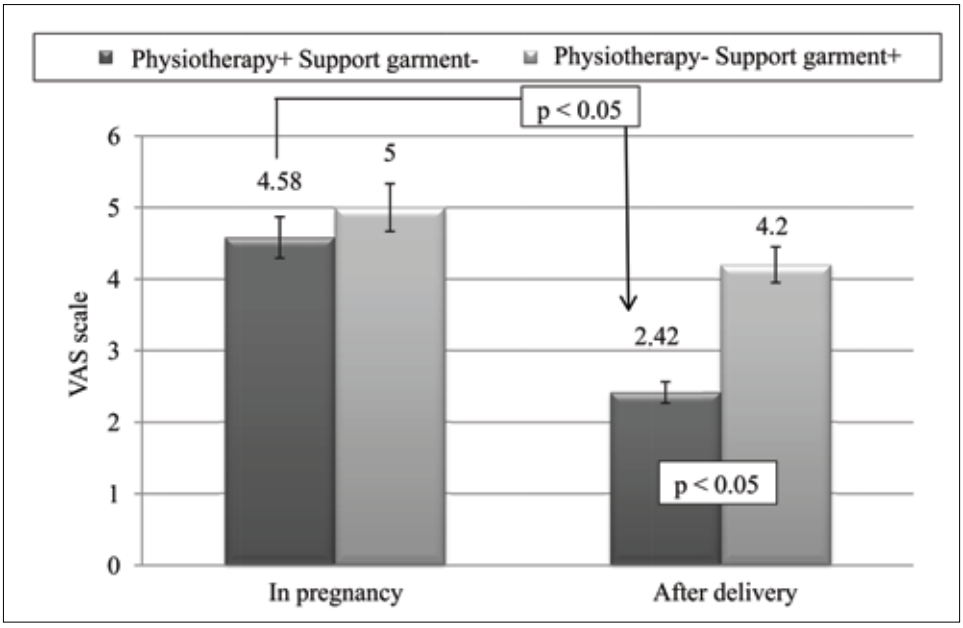

Figure 1. **Low back pain differences depending on presence (+) or absence (–) of physiotherapy and maternity support garment**

value among women attending physiotherapy and wearing maternity support garment was by 0.25 mmHg better than that among women attending physiotherapy but not wearing maternity support garment. With decreasing pressure, the activity of TAM increased. Among pregnant women who were not attending physiotherapy the pressure increased, which means that they were not able to activate their TAM. The pressure difference between women not attending physiotherapy and wearing maternity support garment was by 0.86 mmHg better than that among women not attending physiotherapy and not wearing maternity support garment.

Distribution of diastasis recti and maternity support garment. The diastasis recti after delivery was observed only among women who did not attend physiotherapy exercises (Figure 4). Among women not attending physiotherapy but wearing maternity support garment (n = 10), diastasis recti

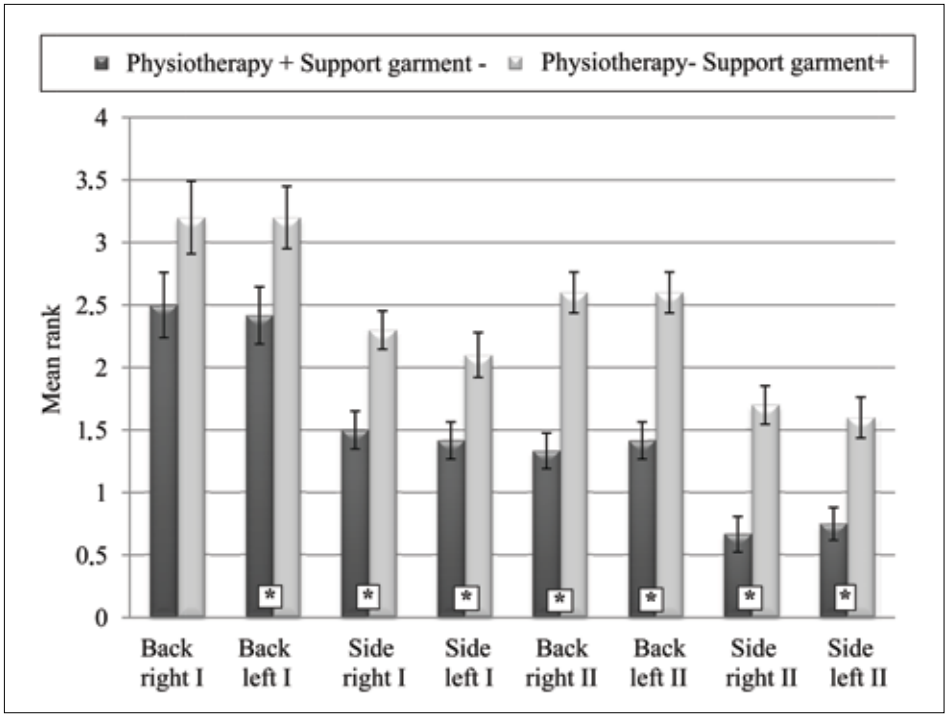

Figure 2. **Spinal stability differences depending on presence (+) or absence (–) of physiotherapy and maternity support garment**

Note. * – $p < 0.05$.

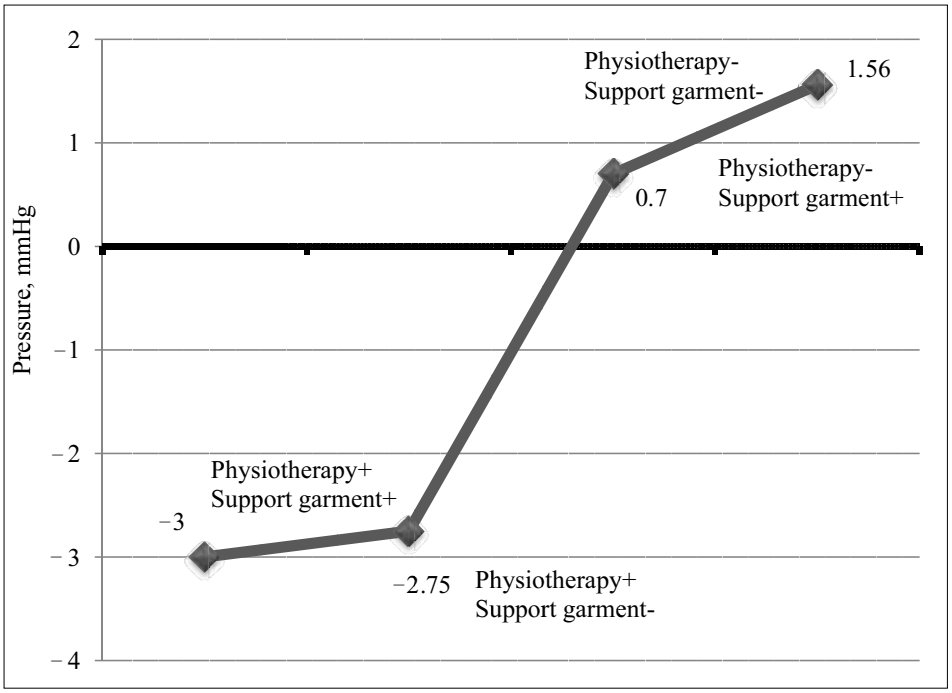

Figure 3. **Activity of rectus abdominis muscles depending on presence (+) or absence (–) of physiotherapy and maternity support garment after delivery: abdominal position**

was observed in 30% of cases compared to 66.7% of women not attending physiotherapy and not wearing maternity support garment (n = 9), i. e. the difference was 36.7% of points.

DISCUSSION

Comparison of low back pain assessment results between women who were attending physiotherapy but not wearing maternity support garment and women who were not attending physiotherapy but wearing maternity support garment showed that physiotherapy was more effective than maternity support garment in reduction of low back pain during pregnancy (by 8.4%) and after delivery (by 42.4%; $p < 0.05$).

Low back pain intensity differences between women wearing and not wearing maternity support garment were similar both among women attending physiotherapy and not attending physiotherapy ($p < 0.05$). Such results confirm the claims that wearing maternity support garment is effective for reduction of low back pains during pregnancy and after delivery. In general it can be stated that the most effective means of lowering low back pain during pregnancy and after delivery is physiotherapy and maternity support garment together.

Previously, in Lithuania there was one similar study conducted where low back pain intensity was assessed during pregnancy, before and after specific program of physical therapy. The authors found there that low back pain following the program reduced in intervention group ($p < 0.05$), but not in control group (Zachovajevienė et al., 2010). These results support the statements of scientists from a study in Korea (Shia et al., 2005). J. Gustafsson and L. Nillson-Wikmar (2008) applied specific program of physical exercises for the improvement of trunk muscles in women who suffered low back pain after delivery. Particular attention was paid to TrA and multifidi muscles. The results of that study showed that intensity of low back pain decreased for every woman under study and their activity increased.

Another study was conducted by A. Catherine who assessed the effect of maternity support garment on low back pain during the pregnancy. Her results demonstrated that maternity support garment was associated with statistically significant reduction of low back pain during rest time and daily activities (Catherine, 2003). Researchers in Australia also conducted a similar study comparing two different models of maternity support garment in order to reduce pain in spinal and pelvic back area during pregnancy (Kalus et al., 2008). Wearing maternity support garment for three weeks was associated with statistically significant reduction of low back pain in both model groups – from 6.1 to 4.5 pts and from 6.0 to 4.7 pts, respectively.

In our study the results on spinal stability showed that among women attending physiotherapy but not wearing maternity support garment the stability was better than that among pregnant women not attending physiotherapy but wearing maternity support garment both before and after delivery ($p < 0.05$). This supports the findings from other studies conducted in different countries. Positive effect of physical therapy was reported by A. Garshasbi and S. F. Zadeh (2005) and Lithuanian researchers who assessed the spinal stability also using stabilizer before and after specific physiotherapy program during pregnancy (Zachovajevienė et al., 2010).

TrA activity assessment after delivery showed that the best TrA activity was observed among women who were attending physiotherapy and wearing maternity support garment, while women not attending physiotherapy were not able to properly activate their TrA. Researchers from Ludwig Maximilian University of Munich also assessed TrA activity using stabilizer in abdominal position. Pressure change by at least -1 mm Hg was considered as positive. In contrast, increase of pressure showed improper TrA activity (Garnier et al., 2009).

In order to establish the association between diastasis recti and maternity support garment, we compared women not attending physiotherapy and we found that diastasis recti was by 36.7% points less common among women wearing maternity support garment compared to those not wearing it. However, this difference did not reach statistical significance. This could have happened due to very low sample sizes in subgroups (n = 10 and n = 9, respectively).Of note, the study analysis clearly showed that diastasis rectus was not observed in women attending physiotherapy. This supports positive effect of physiotherapy exercises in prevention of diastasis recti during pregnancy. Our results showed the trend that diastasis rectus is more prevalent in women without maternity support

garment compared to those wearing maternity support garments. Therefore, it is expedient to wear maternity support garment during pregnancy since it activates TAM and prevents diastasis recti. Additionally, this restricts trunk movements that can also influence diastasis recti.

CONCLUSIONS AND PERSPECTIVES

1. Perceived low back pain after delivery was less expressed in women wearing maternity support garment both among women attending and not attending physical therapy exercises. Nevertheless, physical therapy is more effective in reducing low back pain than maternity support garment during pregnancy and after delivery.
2. Core stability after delivery improved among women attending physiotherapy exercises, but in case of maternity support garment it improved better. In contrast, in case of not attending physical therapy the core stability after delivery improved only for women wearing maternity support garment.
3. Core stability during pregnancy and after delivery was better among women attending physiotherapy but not wearing maternity support garment compared to women not attending physiotherapy but wearing maternity support garment.
4. Physical therapy and maternity support garment improves core stability and low back pain during pregnancy and has a positive effect on the activity of rectus abdominis muscles following delivery.

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KINEZITERAPIJOS IR KORSETO POVEIKIS LIEMENS STABILUMUI IR APATINĖS NUGAROS DALIES SKAUSMUI NĖŠTUMO METU IR PO GIMDYMO

Pavelas Zachovajevas[1], Brigita Zachovajevienė[2], Jūratė Banionytė[3], Arvydas Siaurodinas[4]

Lietuvos kūno kultūros akademija[1], Kaunas, Lietuva
Lietuvos sveikatos mokslų universitetas, Sporto institutas[2], Kaunas, Lietuva
VŠĮ Kauno Šilainių poliklinika[3], Kaunas, Lietuva
Aleksandro Stulginskio universitetas[4], Kaunas, Lietuva

SANTRAUKA

Tyrimo pagrindimas ir hipotezė. Nėštumo metu skersins pilvo raumuo būna labai pertemptas ir jo gebėjimas stabilizuoti juosmeninę stuburo dalį bei dubenį mažėja. Pakitęs stabilizavimo mechanizmas gali sukelti lėtinį nugaros skausmą. Todėl labai svarbu suteikti tinkamą pagalbą taikant veiksmingas nugaros skausmo mažinimo priemones. *Hipotezė*: kineziterapija yra veiksmingesnė nei liemens korseto dėvėjimas gydant apatinės nugaros dalies skausmus bei liemens stabilumą nėštumo metu ir po gimdymo.

Tikslas – įvertinti kineziterapijos ir korseto poveikį liemens stabilumui bei apatinės nugaros dalies skausmui nėštumo metu ir po gimdymo.

Metodai. 28–35 nėštumo savaitę ir 8–9 savaitę po gimdymo buvo įvertintas visų tiriamųjų nugaros skausmo intensyvumo suvokimas (SAS), liemens stabilumas bei skersinio pilvo raumens aktyvumas testuojami „Stabilaizeriu“ ir testu įvertinta tiesiųjų pilvo raumenų diastazė.

Rezultatai. Kineziterapija yra 42,4% veiksmingesnė nei korseto dėvėjimas kontroliuojant nugaros skausmą nėštumo metu ir po gimdymo ($p < 0,05$). Geriausios skersinio pilvo raumens aktyvumo vertinimo reikšmės nustatytos lankančių kineziterapiją ir korsetą dėvinčių moterų grupėje, o nelankančios kineziterapijos tiriamosios negalėjo taisyklingai aktyvuoti šio raumens. Tiesiojo pilvo raumens diastazė po gimdymo buvo nustatyta tik nelankančioms kineziterapijos nėščiosioms, o dėvinčių korsetą moterų grupėje tai pasireiškė 36,7% mažiau atvejų nei nenešiojančių korseto grupės tiriamųjų.

Aptarimas ir išvados. 1. Nugaros skausmo intensyvumo suvokimas po gimdymo buvo mažesnis korsetą dėvinčių moterų tiek lankančių kineziterapiją, tiek nelankančių nėščiųjų grupėse ($p < 0,05$). Tačiau kineziterapija kontroliuojant nugaros skausmą yra veiksmingesnė, nei korseto dėvėjimas nėštumo metu ir po gimdymo ($p < 0,05$). 2. Lankančių kineziterapiją nėščiųjų liemens stabilumo vertinimo rezultatai po gimdymo pagerėjo korsetą dėvinčių ir nedėvinčių nėščiųjų grupėse ($p < 0,05$), tačiau tiriamųjų, dėvinčių korsetą, rezultatai buvo geresni ($p < 0,05$). Nelankančių kineziterapijos nėščiųjų liemens stabilumo vertinimo rezultatai po gimdymo pagerėjo tik korsetą nešiojusiųjų grupėje ($p < 0,05$). 3. Liemens stabilumas nėštumo metu ir po gimdymo buvo didesnis lankančių kineziterapiją be korseto nėščiųjų, nei nelankančiųjų kineziterapijos su korsetu ($p < 0,05$). 4. Kineziterapija ir liemens korseto dėvėjimas turi įtakos liemens stabilumui nėštumo metu ir teigiamai veikia skersinio pilvo raumens aktyvumą po gimdymo.

Raktažodžiai: akušerija, skersinio pilvo raumens aktyvumas, fiziniai pratimai.

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Corresponding author **Brigita Zachovajevienė**
Lithuanian University of Health Sciences, Institute of Sport
Jankaus str. 2, LT-50275 Kaunas
Lithuania
Tel +37069875901
E-mail brigitaz@medi.lt

FUNCTIONAL INTERACTION OF PELVIC FLOOR, DIAPHRAGM AND TRUNK MUSCLES AMONG MEN WITH PROSTATE CANCER

Brigita Zachovajevienė[1, 3], Laimonas Šiupšinskas[1], Pavelas Zachovajevas[2, 3], Daimantas Milonas[1], Loreta Lapinskaitė[1]

Lithuanian University of Health Sciences, Institute of Sport[1], Kaunas, Lithuania
Lithuanian Academy of Physical Education[2], Kaunas, Lithuania
Kaunas College[3], Kaunas, Lithuania

ABSTRACT

Research background and hypothesis. The absolute dominance of the isolated muscle presentation as the first and last word in muscular anatomy leaves the current generation of therapists unlikely to think any other way (Myers, 2009). *Hypothesis:* functional relationships could be found between pelvic floor, diaphragm, and trunk muscles in men with prostate cancer.

Research aim. The aim of the study was to evaluate functional associations between pelvic floor, diaphragm, and trunk muscles among men with prostate cancer.

Research methods. The study included 81 male volunteers diagnosed with prostate cancer with measurements conducted one day before radical prostatectomy. Pelvic floor muscle strength and endurance were measured using "Peritron 9300" device, the strength of diaphragm – with "MicroRPM", the strength of transversus abdominis muscle – with "Stabilizer". Trunk muscles were tested using tests for static postural endurance of abdominal and back muscles. Associations were estimated using Pearson's correlation coefficient (r).

Research results. Analysis of functional indicators of muscles demonstrated high linear associations between strength of pelvic floor and diaphragm ($r = 0.79$), between strength of diaphragm and exhalation muscles ($r = 0.78$), and between static endurance of abdominal and back muscles ($r = 0.72$). We determined moderate correlations between endurance of pelvic floor and strength of transversus abdominis muscle ($r = 0.59$), between strength of transversus abdominis and static endurance of abdominal muscles ($r = 0.69$), between strength of diaphragm and static endurance of abdominal ($r = 0.56$) and back muscles ($r = 0.51$), between the strength of exhalation muscles and static endurance of abdominal muscles ($r = 0.57$) and strength of pelvic floor ($r = 0.65$), between strength of pelvic floor and static endurance of back muscles ($r = 0.50$). Low correlations were found between strength of pelvic floor and transversus abdominis ($r = 0.31$) and static endurance of abdominal muscles ($r = 0.44$), between endurance of pelvic floor and exhalation muscles ($r = 0.37$), and finally between transversus abdominis and static strength of back muscles ($r = 0.39$). All correlations were statistically significant ($p < 0.01$).

Discussion and conclusions. The findings showed positive associations among different functional indicators of muscles: strength of pelvic floor correlates with endurance of pelvic floor muscles, static abdominal and back muscles, strength of diaphragm, and transversus abdominis muscles. The results of this study confirm that functional associations between pelvic floor, diaphragm, and trunk muscles exist.

Keywords: abdominal muscles, static postural endurance, respiration, core stability.

INTRODUCTION

The human locomotor system is, like nearly every other fascial structure in the body, constructed in doublebag fashion. Muscles are almost universally studied as isolated motor units**.** Such study ignores the longitudinal effects through this outer bag, as well as latitudinal

(regional) effects now being exposed by research. Now it is clear that fascia distributes to strain laterally to neighboring myofascial structures; so that the pull on the tendon at one end is not necessarily entirely taken by the insertion at the other end of the muscle (Myers, 2009).

It is generally assumed that fascia is solely a passive contributor to biomechanical behavior, by transmitting tension which is created by muscles or other forces, but there are recent hints which indicate that fascia may be able to contract autonomously and thereby play a more active role (Schleip, 2006).

The central nervous system coordinates the motor activities of all trunk muscles (including the diaphragm) during both postural and respiratory tasks. Modulation of intraabdominal pressure occurs through coordinated activity of the diaphragm, abdominal and pelvic floor muscles (PFM), and such modulation may be important for the control of spinal stability (Hodges et al., 2000 a).

The data also indicate that PFM activity is modulated during quiet breathing. However, this activity is more closely associated with the activity of the abdominal muscles than with changes in intraabdominal pressure (IAP). During quiet breathing in standing, PFM activity was modulated with respiration (Smith et al., 2006). It was hypothesized that PFM activity would be linked to periods of increased IAP to meet the demands of continence and control of pelvic viscera. During quiet breathing, IAP increases during inspiration in conjunction with diaphragm activity. However, as IAP is modulated during the respiratory cycle, it is likely that PFM activity may be modulated during other respiratory tasks, including quiet breathing (Hodges et al., 2007). P. Neumann et al. (2002) found that PFM are also likely to be active with respiratory tasks. It is well accepted that PFM activity accompanies coughing and resisted expiration.

Coactivation of the diaphragm and abdominal muscles causes a sustained increase in intraabdominal pressure, whereas inspiration and expiration are controlled by opposing activity of the diaphragm and abdominal muscles to vary the shape of the pressurized abdominal cavity (Hodges et al., 2000 a). Activation of the levator muscle during abdominal pressurization is important to this stabilization process. The integrity of the connection between the vaginal wall and tendinous arch also plays an important role. (Delancey et al., 2004). Functionally, the levator ani muscle and the endopelvic fascia interact to maintain continence and pelvic organ support (Ashton-Miller et al., 2007). S. J. Madill and L McLean (2006) stated that during voluntary PFM contractions, an increase in lower intravaginal pressure is not solely the product of PFM activation, but involves a specific coordination between the PFM, transversus abdominis (TrA), rectus abdominal, and internal oblique muscles (Madill, McLean, 2006). The TrA generated 224% more activity during the pelvic floor contractions than during the abdominal hollowing exercises that were aimed at isolating and maximally activating this muscle (Urquhart et al., 2005).

B. Junginger et al. (2010) revealed that bladder neck elevation occurred only during PFM and TrA contractions. They also reported that abdominal muscles in continent women contribute significantly to the development of lower intravaginal pressure during voluntary PFM contractions, particularly in the latter part of the contraction.

R. R. Sapsford et al. (2001 a) reported that the PFMs were activated in each of three exercises: abdominal hollowing, abdominal bracing, and abdominal bracing with breath hold and also that the abdominal muscles were recruited when a PFM contraction was performed. R. R. Sapsford et al. (2001 b) and P. W. Hodges et al. (2000 a) reported that with a maximal abdominal muscle contraction, the PFMs were activated to the same level as with a maximal voluntary PFM contraction. Similarly, P. Neumann and V. Gill (2002) found that it was not possible for continent women to fully contract their PFMs without contracting the TrA and the IO muscles as well.

PFM are likely to contribute to control of the spine and pelvis. Furthermore, PFM activity may also indirectly contribute to lumbopelvic control through an effect on tension developed in the thoracolumbar fascia; hoop tension of the fascia from contraction of the abdominal muscles is dependent on IAP. It is thought that synergistic activation from the abdominal muscles enhances a woman's ability to contract the PFMs (Madill, McLean, 2008).

K. Bø (2004) found that three physiotherapists who were well trained in isolating PFM contractions were not able to perform a maximal PFM contraction without a rise in EMG activity in the lower portion of rectus abdominal (RA) muscle. PFMs and the abdominal muscles contract synergistically in continent women and it may be

counterproductive to teach to contract the PFMs in isolation when performing PFM exercises.

L. Penning (2000) determined that functionally, the transversus abdominis, psoas, quadratus lumborum and lumbar multifidus have each been described as contributing to the control of lumbar segmental motion via either the maintenance of spinal equilibrium or the development of intersegmental stiffness.

In his book T. W. Myers (2009) presented the anatomical connections of all body muscles, also including diaphragm, pelvic floor and trunk muscles. Fascia is the structural connector of muscles, building the strong, pliable stuff which holds us together, forming the shared and communicative environment for all our cells.

Functional relations of abdomen and back muscles were described by numerous studies done by P. W. Hodges and others. The functional connections of pelvic floor and diaphragm are discussed in the scientific literature by M. D. Smith et al. (2006), P. Neumann et al. (2002). A number of studies were carried at analyzing the importance of pelvic floor muscles in women health and pathologies. Despite the anatomical differences there is a lack of evidence about the functional characteristics of pelvic floor in men.

The aim of this study was to evaluate functional associations between pelvic floor, diaphragm, and trunk muscles among men with prostate cancer. We hypothesized that between pelvic floor, diaphragm, and trunk muscles in men with prostate cancer there must be functional relationships.

RESEARCH METHODS

The study included 81 male volunteers diagnosed with prostate cancer. The study was conducted at Department of Urology, Hospital of Lithuanian University of Health Sciences Kauno Klinikos during 2010–2012. The study obtained ethical approval No. BE-2-61 by Kaunas Regional Committee for Biomedical Research.

Objectively pelvic floor muscles strength and endurance were measured using "Peritron 9300" device, the strength of diaphragm was estimated using "MicroRPM", the strength of transversus abdominal was assessed using "Stabilizer". The trunk muscles were tested using tests for static endurance of abdominal and back muscles. All measurements were conducted one day before radical prostatectomy surgery.

The assessment of pelvic floor muscle strength and endurance was done with a patient in left lateral position and knees drawn up at about 45°. For higher accuracy and repeatability participant had to be in the same position each session and the anal sensor had to be inserted at the same amount. For evaluation of pelvic floor strength, a person was asked to squeeze his muscles at maximum. The maximum result (in cm H_2O) was calculated as follows: within 1.8 second there were three readings recorded – every 0.6 seconds each. For the evaluation of pelvic floor endurance, a person was asked to squeeze and keep his muscles in maximal contraction as long as possible. The result of endurance was set as a time (in seconds) between maximal contraction and decrease of maximal contraction by more than 5%. The measurements of strength and endurance in two sessions and their arithmetic mean were used for analyses.

Strength of breathing muscles (in cm H_2O) was evaluated as maximum inhalation pressure (PImax) and maximum exhalation pressure (PEmax). The procedure was conducted in sitting position: a patient was asked to breathe in to maximum and exhale to maximum, and then vice versa. Result was recorded only when the person had maximum inhalation or exhalation shorter than 3 seconds. For accurate measurements the tube was essential.

The assessment of the strength of transversus abdominis muscle was performed in position lying on abdomen and making contracting movement of abdominal wall. The person was asked to lie on belly with neck and head relaxed and kept at middle line of the body. Device pillow was set at lower abdomen so that the distal margin of the pillow would converge with anterior iliac line. The stabilizer pressure was set at 70 mmHg. The person was asked to contract his lower abdomen slowly without supporting movements of spinal cord, hips, shoulders or pelvis, and keep such position for 10 seconds with regular breathing.

Decreasing pressure on stabilizer manifests in negative numbers which shows improving TrA activity. The study results were considered as positive if the pressure on device decreased to 1 mmHg (in ideal case to – 10 mmHg). If, however, the pressure increased, this was observed in positive numbers on the device and showed improper contraction of TrA and was defined as 0. The measurement was performed in two sessions and their arithmetic mean was used for analyses.

The static endurance of abdominal muscles was tested lying supine with bend knees and hips

45°. The person was asked to raise his head and shoulders with arms kept across the body and keep this position as long as possible. The static endurance of back muscles was tested lying prone. The person was asked to raise his head and shoulders with arms kept across the body and keep this position as long as possible. The static endurance of abdominal and back muscles at norm is 300 seconds (5 minutes). The measurement was performed in one session (due to fatigue) and the mean was used for analyses.

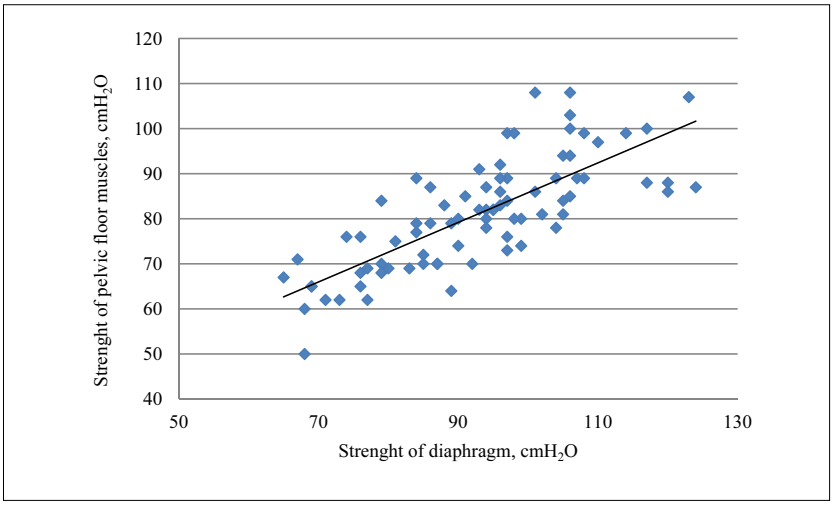
Statistical data analysis was performed using *SPSS for Windows 20.0* and *Microsoft Office Excel 2010* software. Functional associations were evaluated according to Pearson correlation coefficient r, where r = 0 is considered as no correlation, $0.0 < |r| \leq 0.3$ as very low correlation, $0.3 < |r| \leq 0.5$ – low correlation, $0.5 < |r| \leq 0.7$ – moderate correlation, $0.7 < |r| \leq 0.9$ – high correlation, and $0.9 < |r| \leq 1.0$ – very high correlation. Statistical significance level was set at 95% ($p < 0.05$).

RESEARCH RESULTS

The analysis of functional associations between the strength of **pelvic floor muscles** (PFM) and other muscles showed that it strongly and significantly ($p < 0.001$) correlated with the strength of diaphragm (r = 0.79). The association between PFM and diaphragm was linear and it is presented in Figure 1.

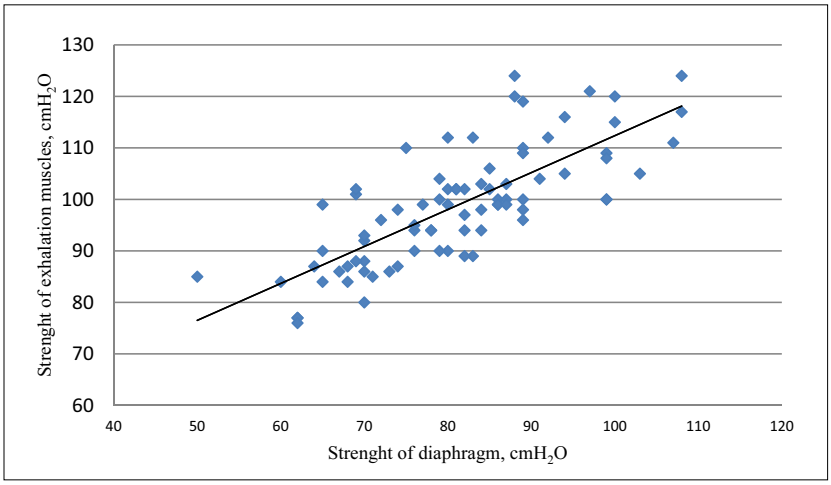
The association of strength between PFM and exhalation muscles was found to be at the level of moderate linear correlation (r = 0.65) and this was statistically significant ($p < 0.001$). Similarly, but lower moderate correlation (r = 0.50) was found between the strength of PFM and endurance of back muscles ($p < 0.001$). Even lower though statistically significant correlations were found between strength of PFM and endurance of abdominal muscles (r = 0.44; $p < 0.001$), strength of transversus abdominis muscle (r = 0.32; p = 0.004) and endurance of PFM (r = 0.29; p = 0.009). Thus,

Figure 1. **Correlation between strength of pelvic floor muscles and of diaphragm for the study subjects**



Note. r = 0.79, p < 0.001.

Figure 2. **Correlations between the strength of diaphragm and of exhalation muscles for the study subjects**



Note. r = 0.78; p < 0.001.

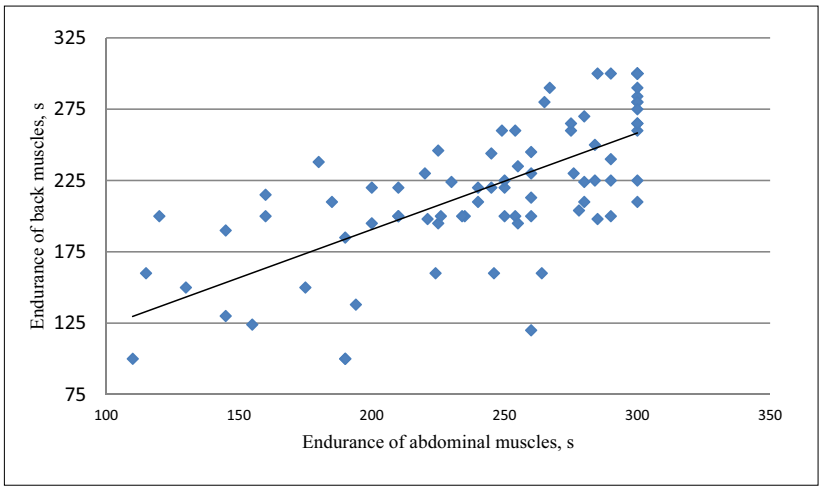


Figure 3. **Correlations between the endurance of back and abdominal muscles for the study subjects**

Note. r = 0.72; p < 0.001.

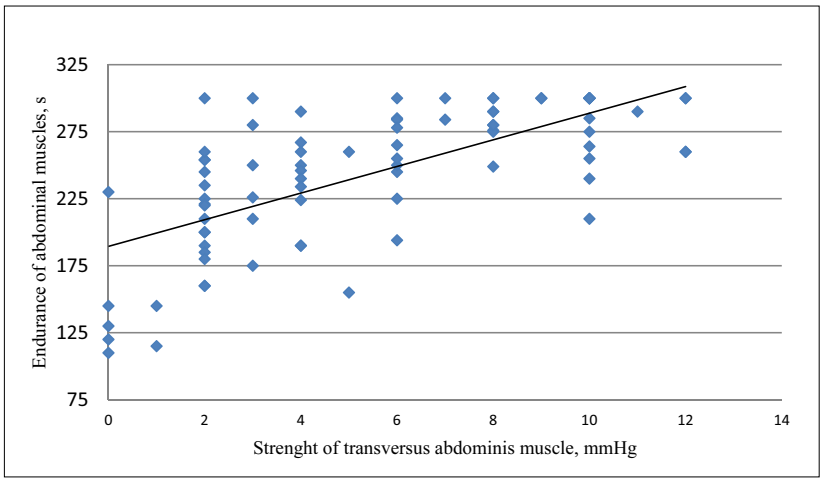


Figure 4. **Correlations between the strength of transversus abdominis muscle and endurance of abdominal muscles for the study subjects**

Note. r = 0.69; p < 0.001.

it can be concluded that with the increase of PFM strength, the strength of diaphragm, exhalation muscles, and transversus abdominis muscle increases too as well as endurance of abdominal, back, and pelvic floor muscles.

The evaluation of functional associations of **strength of diaphragm** showed that there was a strong positive linear correlation with the strength of exhalation muscles (r = 0.78) (p < 0.001), which is shown in Figure 2.

The strength of diaphragm muscle statistically significantly and positively correlated with endurance of abdominal (r = 0.56) and back (r = 0.51) muscles (p < 0.001).

Analysis of associations of **endurance of abdominal muscles** (Figure 3) revealed strong positive correlation with endurance of back muscles (r = 0.72) and this was statistically significant (p < 0.001).

Endurance of pelvic floor muscles showed functional association at moderate correlation level with transversus abdominis muscle (r = 0.59; p < 0.001). Meanwhile the correlation with the strength of exhalation muscles was low (r = 0.37), though statistically significant (p = 0.001). Similarly, low positive correlations were found between the endurance of PFM and the endurance of abdominal (r = 0.36) and back (r = 0.34) muscles, and still statistically significant (p = 0.001 and p = 0.002, respectively). In general, it can be stated that with the increase of endurance of pelvic floor muscles, the strength of exhalation muscles as well as endurance of abdominal and back muscles increases too.

Analysis of **strength of transversus abdominis muscle** revealed moderate (r = 0.69) statistically significant correlation with the endurance of abdominal muscles (p < 0.001), which is presented in Figure 4.

The correlation between endurance of back muscles and strength of transversus abdominis muscle was low (r = 0.39), positive and statistically

significant ($p < 0.001$). Similarly, low positive correlations were found with the strength of diaphragm ($r = 0.40$) and exhalation muscles ($r = 0.42$) ($p < 0.001$).

In our study, **strength of exhalation muscles** moderately correlated with the endurance of abdominal muscles ($r = 0.57$) and slightly weaker – with endurance of back muscles ($r = 0.48$) ($p < 0.001$).

DISCUSSION

Our study results demonstrated that the strength of pelvic floor muscles correlated with that of diaphragm. This means that the activation of diaphragm has influence on the activity of pelvic floor muscles and vice versa. This finding supports M. D. Smith et al.'s (2006) results showing that during quiet breathing in a standing position, PFM activity was modulated with respiration. Based on their own studies, P. W. Hodges et al. (2007) state that IAP is modulated during the respiratory cycle, while PFM activity is modulated during other respiratory tasks, including quiet breathing. Thus it can be stated that during the breathing, pelvic floor muscles undergo activation as a reaction to IAP. Our study shows that both the strength of transversus abdominis muscle and the endurance of static abdominal muscles correlate with the strength of diaphragm and exhalation muscles which supports the findings of abovementioned researchers. It can be concluded that during activation of breathing muscles the strength of pelvic floor muscles is also improving.

Additionally, our study estimated the associations between strength and endurance of pelvic floor and abdominal muscles. Our results also support the previous findings by P. Neumann and V. Gill (2002), and R. R. Sapsford et al. (2001) who suggested that synergistic activity of abdominal and pelvic floor muscles was important in terms of generating adequate urethral closing pressures. K. Bø et al. (1990) also found the high cross-correlation coefficients between the PFMs and the abdominal muscles that were computed from the 30 seconds series of repeated contraction data, which was likely the result of muscle synergistic action. This is a logical synergy as the PFMs close the pelvic outlet and these muscles and their associated fascia are the only structures within the pelvis capable of resisting gravitational forces and intraabdominal pressure.

S. J. Madill et al. (2006) reported that the high relative activation levels for TrA and internal oblique muscle are more closely tied synergistically to the PFMs than rectus abdominis and external oblique muscle. This finding is consistent with our study which found that TrA moderately correlated with the endurance of pelvic floor muscles. Coactivation of the abdominal muscles with the PFMs has also been previously reported by R. R. Sapsford et al. (2001). The results of this study showed that thickness of the TrA and internal oblique muscle changes during contraction of PFM. This indicates that there exists a coactivation between pelvic floor and abdominal muscles during PFM contraction. This finding is in accordance with EMG studies showing a co-contraction of abdominal muscles during PFM contraction reported by A. M. Arab and M. Chehrehrazi (2011). They also found that maximal contraction of the PFM was associated with the activity of all abdominal muscles which increases the IAP as well as TrA muscle.Our study findings also demonstrate that the activation of transversus abdominis muscle leads to activation of pelvic floor muscles. Similarly, endurance of abdominal muscles has also influence on endurance of pelvic floor muscles.

We found that the correlation between endurance of transversus abdominis muscle and that of abdominal muscles was moderately positive, which can be explained by synergy of those muscles. During the test of endurance of abdominal muscles, the activation of transversus abdominis muscle takes place too, therefore its condition has certain impact on the test results – the higher activity of transversus abdominis muscle, the higher endurance of abdominal muscles. These findings support the results of study by S. J. Madill and L. McLean. (2006).

A number of studies done by P. W. Hodges et al. (2003) and L. Penning (2000) have reported on the anatomical, biomechanical or neurophysiologic characteristics and relations of the transversus abdominis, psoas, quadratus lumborum and lumbar multifidus muscles in the context of spinal stability. In our study we found functional relationships between endurance of abdominal and back muscles. This can be explained by antagonistic nature of those muscle groups and in case of balance between those muscles they have influence on each other.

CONCLUSIONS AND PERSPECTIVES

1. The findings showed that functional indicators of muscles were directly associated with each other in men with prostate cancer.
2. The strength of pelvic floor correlated with endurance of pelvic floor muscles, endurance of abdominal and back muscles, strength of diaphragm and transversus abdominis muscles in men with prostate cancer.
3. The results of this study confirmed that functional relations between pelvic floor, diaphragm, and trunk muscles existed in men with prostate cancer.

We think that our findings have important clinical implications for PFM rehabilitation. First, the results of the study suggest that the contraction of PFM is associated with strength of diaphragm, status of abdominal muscles and activity of transversus abdominis muscle. Exercises of these muscles should be considered in the rehabilitation. Attempts to normalise the coordination between abdominal and PFM may be an important step in rehabilitation. This requires multifaceted assessment of the activity of PFM and abdominal muscles.

The second clinical implication is that the initial activation of PFM could be achieved by gentle contraction of transversus abdominis muscle in some men. This might be helpful in men who have problems with the perception of their pelvic floor and who are not able to contract their PFM because of decreased pelvic floor awareness.

In the future it would be interesting to analyse how such functional relationships change following surgery, when poor balance of muscles appears and how the muscles change throughout the rehabilitation process.

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PROSTATOS VĖŽIU SERGANČIŲ VYRŲ DUBENS DUGNO, DIAFRAGMOS IR LIEMENS RAUMENŲ FUNKCINĖS SĄSAJOS

Brigita Zachovajevienė[1, 3], Laimonas Šiupšinskas[1], Pavelas Zachovajevas[2, 3], Daimantas Milonas[1], Loreta Lapinskaitė[1]

Lietuvos sveikatos mokslų universitetas, Sporto institutas[1], Kaunas, Lietuva
Lietuvos kūno kultūros akademija[2], Kaunas, Lietuva
Kauno kolegija[3], Kaunas, Lietuva

SANTRAUKA

Tyrimo pagrindimas ir hipotezė. Žmogaus raumenys nėra izoliuoti vieni nuo kitų. Jungtys, egzistuojančios tarp raumenų, specialistus, dirbančius su žmogaus kūnu, skatina mąstyti kitaip (Myers, 2009). *Hipotezė:* tarp vyrų, sergančių prostatos vėžiu, dubens dugno, diafragmos ir liemens raumenų egzistuoja funkciniai ryšiai.

Tikslas – įvertinti dubens dugno, diafragmos ir liemens raumenų funkcines sąsajas tarp vyrų, sergančių prostatos vėžiu.

Metodai: Buvo tiriamas 81 savanoris vyras. Jiems buvo diagnozuotas prostatos vėžys. Matavimai atlikti dieną prieš prostatos šalinimo operaciją. Dubens dugno raumenų jėga ir ištvermė buvo matuojama naudojant perineometrą „Peritron 9300“, diafragmos jėga – “MicroRPM“, skersinio pilvo raumens aktyvumas – „Stabilizer“, o liemens raumenų statinė ištvermė įvertinta atliekant pilvo ir nugaros statinius atlikties testus. Funkcinės sąsajos (rodiklių priklausomybė) įvertintos skaičiuojant Pirsono koreliacijos koeficientą (r).

Rezultatai. Tarp dubens dugno ir diafragmos raumenų jėgos (r = 0,79), diafragmos ir iškvėpimo raumenų jėgos (r = 0,78) bei tarp pilvo ir nugaros raumenų statinės ištvermės (r = 0,72) nustatyta stipri tiesinė priklausomybė. Vidutinio stiprumo tiesinė priklausomybė nustatyta tarp šių raumenų: dubens dugno raumenų ištvermės ir skersinio pilvo raumens jėgos (r = 0,59), skersinio pilvo raumens jėgos ir statinės pilvo raumenų ištvermės (r = 0,69), diafragmos jėgos ir statinės pilvo (r = 0,56), nugaros raumenų (r = 0,51) ištvermės bei iškvėpimo raumenų jėgos ir statinės pilvo raumenų ištvermės (r = 0,57) bei dubens dugno jėgos (r = 0,65), tarp dubens dugno raumenų jėgos ir statinės nugaros ištvermės (r = 0,50). Silpna tiesinė priklausomybė nustatyta tarp dubens dugno raumenų ir skersinio pilvo raumens jėgos (r = 0,32) bei statinės pilvo ištvermės (r = 0,44), dubens dugno ištvermės ir iškvėpimo raumenų jėgos (r = 0,37) bei skersinio pilvo ir statinės nugaros raumenų ištvermės (r = 0,39). Visų funkcinių rodiklių koreliacijos statistiškai reikšmingos (p < 0,01).

Aptarimas ir išvados. Tyrimas parodė, kad raumenų funkciniai rodikliai tarpusavyje susiję: dubens dugno raumenų jėga koreliuoja su dubens dugno raumenų ištverme, statine pilvo ir nugaros raumenų ištverme, diafragmos ir skersinio pilvo raumens ištverme. Galima teigti, kad tarp dubens dugno, pilvo bei liemens raumenų egzistuoja funkcinės sąsajos.

Raktažodžiai: pilvo raumenys, statinė ištvermė, kvėpavimas, stabilumas.

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Corresponding author **Brigita Zachovajevienė**
Lithuanian University of Health Sciences, Institute of Sport
Jankaus str. 2, LT-50275 Kaunas
Lithuania
Tel +37069875901
E-mail brigitaz@medi.lt

LABORATORY ASSESSMENTS AND FIELD TESTS IN PREDICTING COMPETITIVE PERFORMANCE OF SWIMMERS

Ilona Judita Zuozienė, Jonas Poderys
Lithuanian Academy of Physical Education, Kaunas, Lithuania

ABSTRACT

Research background and hypothesis. The assessments of functional fitness of swimmers includes the analyses of the physical, physiological and biomechanical indices for scientific purposes. The hypothesis is that dynamical parameters registered while performing field testing tasks could be more informative than laboratory assessments in predicting the performance abilities.

The aim of the study was to compare the informativeness of field tests and laboratory assessments in predicting the possible performance of athletes in the 50 m distance.

Research methods. Twelve professional swimmers took part in three testing procedures. First, each participant performed a test in water to establish the traction force parameters and indices of muscle power and anaerobic capacity. Second, the subjects performed a control 50 m freestyle swim the best they could. Third, the indices of relative muscle power during jumping tasks, anaerobic capacity, and functional indices of cardiovascular system were assessed during laboratory testing.

Research results. Significant correlation was found between the results in 50 m swimming and traction forces while performing testing tasks in water or out of water with arms or arms and legs together. However, there was no statistically significant correlation between the results in swimming and the height of vertical jump. Still there exists significant correlation ($p < 0.05$) between the speed and force components as well as fatigability index and the competition result ($r = –0.47$; $r = 0.56$ and $r = 0.67$, respectively).

Discussion and conclusions. Dynamical parameters measured in the swimming pool while performing field tests are more suitable than the data of laboratory research for predicting the results of swimmers in the 50m freestyle swim. The vertical high jump tests and indices of ECG allow distinguishing the factors limiting the working capacity of athletes.

Keywords: swimming, functional fitness, field test.

INTRODUCTION

Various methodological approaches could be applied in assessing the level of fitness and functional state of athletes as well as in predicting their performance (Noakes, 2002; Barbosa et al., 2010; Cortesi et al., 2010). Still the specific nature of the various kinds of sports is a significant factor in selecting tests and control exercises (Bosco et al., 1983; Counsilman, 1982; Carl et al., 2010; Cortesi et al., 2010). Therefore, adapted tests, i. e. tests when the workload given during the testing corresponds to the specific manner of the sports action, are far more suitable for assessing special fitness of athletes in any kind of sports. The aim of this study was to compare the informativeness of field tests (testing indices obtained in the swimming-pool) and laboratory assessments for predicting the competitive performance of swimmers in the 50 m distance.

RESEARCH METHODS

The participants of the study were 12 male swimmers (age – 18.63 ± 0.6 years, body mass – 72.6 ± 2.57 kg). All swimmers were of Lithuanian national category level, specializing in sprint and middle distances (50, 100 and 200 m). The participants of the study took part in three testing procedures.

The first testing procedure consisted of establishing the indices of muscle power and anaerobic capacity with special field tests being applied. Maximum traction out of water in isometric regime in the middle of the pull (F_o); pulling force in water in tethered swimming: a) swimming by hand movements (F_h); b) swimming by leg movements (F_l) and c) swimming by absolutely coordinated movements of hands and legs (F_c) were investigated. On the basis of the measuring obtained, such relative indices as relative traction out of water (F(relat.) = F_o/body mass); relative pulling force in water (Fw (relat.) = F_c/body mass); force realization index FI = F_c/F_o x 100% and force coordination index (FCI = $F_c/(F_h + F_l)$ x 100%) were calculated. Performing swimming test with the duration of 30 s, the maximum force (Fmax and F30) generated in the distance and force endurance index (FEI30s = F30/Fmax x 100%) were calculated.

The second testing procedure consisted in the 50 m freestyle striving for maximum performance. The third testing procedure was aimed at assessing the working capacity and functional condition of swimmers with laboratory tests being applied. The program of laboratory research consisted of assessment of the indices of speed and force components of muscular contraction, power and anaerobic working capacity during the jumping tests (Poderys et al., 2008), as well research done in the functional condition of the body applying the computerized system "Kaunas–load" designed for the registration and analysis of 12-leads electrocardiogram (ECG). All jumping tasks were performed on the contact plate that allowed registering changes in the height and power of the jumps performed and to calculate the values of speed and force components (Poderys et al., 2007). The ECG was reordered continuously during 30-s vertical jump test and the next indices were taken for analysis: HR_{max}, JT_{max}, ST segment depression $JT_{recovery}$ during the first 2 minutes after workload, index of PWC_{170} and integral index of body functional state. The integral index of functional state was calculated according the dynamics or HR, JT interval and muscular performance during the testing workload (Vainoras, 2002).

In the process of the analysis of research results, correlations between the performance results achieved in the 50 m swim and other indices of were analysed.

RESEARCH RESULTS

The data obtained during the study showed that for predicting the results of swimmers in the 50 m freestyle, the results in field tests were the best predictors of competitive performance compared to those of laboratory research (Table). Though a greater number of indices were registered during the research carried out (*indices are given in "Research Methods"*), Table contains indices having logical meaning and significant for the substantiation of the conclusions formulated in the present paper. Smaller in extent but still statistically

Table 1. **Correlation values between the result achieved by the subjects in the 50m swim and other indices of fitness or functional state**

FIELD RESEARCH (TESTS IN THE SWIMMING POOL)					
Traction out of water	**Pulling force in water**			**30–s swimming test**	
	F_h	**F_l**	**F_c**	**$F_{max\ 30\ s}$**	**$FEI_{30\ s}$**
–0.71*	–0.84*	0.23	–0.66*	–0.74*	–0.76*
INDICES OF VERTICAL JUMPS					
Jump height	Relative muscle power	Speed component	Force component	Anaerobic working capacity	Fatigability during 30–s jumps
0.13	**0.21**	**0.47***	**0.56***	**–0.52***	**0.67***
ECG INDICES DURING ANAEROBIC 30–s WORKLOAD					
HR_{max}	JT_{max}	ST segment depression	$JT_{recovery}$	PWC_{170}	Integral assessment
0.14	–0.26	0.07	–0.47*	–0.33*	–0.42*

Note. * – statistically significant values of the correlation ($p < 0.05$).

significant was the correlation between the result achieved in the 50 m swim and some relative indices investigated, i. e. relative pulling force in water ($r = -0.56$, $p < 0.05$), relative traction out of water FCI ($r = 0.59$, $p < 0.05$). Correlation values presented in the Table indicate that field tests, i. e. the results of measuring and tests done, report athletic fitness more precisely than the data of laboratory research, as well as their possibilities to achieve high results in the 50 m swim.

The results of the present research, however, should no statistically significant correlation between the result in swimming and the height of the vertical jump ($r = 0.13$, $p > 0.05$). Still there exists significant correlation ($p < 0.05$) between the speed and force components as well as fatigability index and the competition result ($r = -0.47$; $r = 0.56$ and $r = 0.67$, respectively).

DISCUSSION

Field tests are carried out under the natural conditions and in sport they are used to analyse the effects of training, for talent identification, measuring an athlete's physiological capabilities and functional state (Young, 2001). The results obtained during this study showed that field tests, i. e. the results of measuring and tests done in the swimming pool, are more suitable than the data of laboratory research for predicting the results of swimmers in the 50 m freestyle swim. No doubt, such result was expected, but the main interest of this study was to compare the informativeness of various laboratory measurements.

Testing and measurement, are the means of collecting information upon which the performance evaluations and decisions should be done, but in the analysis it is necessary to take into account the factors that may influence the results. On the one hand, the sports results and their dynamics are the best indices of performance abilities of athletes, but on the other hand, not in all athletic events this approach could be applied in practice for themanagement of training (Young, 2001; Winter et al., 2007). Various testing procedures and various indices were applied for these purposes. Analysis of factors determining sports performance supports the notion that the power of muscular contraction is very important for the fast performance of push-up during the start (Counsilman, 1982; Barbosa et al., 2010; Cortesi et al., 2010). On the other hand, leg muscles make the greatest part of the whole muscle mass of the body. Thus it is believed that their force and speed estimates show the effect generated by these muscles and thus are one of the main factors determining effective swimmer start and all sports performance (Cortesi et al., 2010; Douda et al., 2010). The simplest and most frequently used index of explosive force is the maximal height of vertical jump (Christopher, 2000). Applying tests of vertical jumps allows one to easily adapt oneself to the obligatory metrological requirements (Bosco et al., 1983; Maud, Foster, 1995; Christopher, 2000; Poderys et al., 2007). The results of the present research, however, showed no statistically significant correlation between the result in swimming and the height of the vertical jump. Still there exists correlation between speed and force components, as well as fatigue index, and the competition result – these indices are significant and should be taken into account when performing laboratory research in the functional condition and fitness of swimmers.

The computerized ECG registration and analysis system Kaunas–load" have been applied for a long time for the assessment of functional fitness and functional state of members and candidates to the Lithuanian Olympic team of various kinds of sport, including swimmers (Korsakas et al., 2002; Poderys, 2003; Ezerskis, 2009). This system enables one to register a lot of functional indices of cardiovascular system during workloads and to carry out the integral assessment, as well as to perform the standardized assessment of important ECG indices. The present research pursued a specific and relatively narrow task, i.e. to assess the possibilities of athletes in the 50 m swim. It was only separate indices of CVS that correlated with the results shown in the 50 m swim to a smaller extent than the indices registered in the swimming-pool (Table). One cannot make absolute generalizations and assert, however, that these indices are of less importance. Function fitness of supplying systems is important in the events of all kinds of sports (Maud, Foster, 1995; Spencer et al., 1996; Vainoras, 2002). Comparing the results obtained in the process of our research or, to be more exact, the cardiovascular indices of the swimmers who showed the best and the worst results the individual differences in the indices of PWC170, the index of integral assessment, adaptation to the speed of the loads undertaken, the maximum change between the JT interval of ECG and the RR interval relation when performing vertical jumps for 30-s, as well as change in the JT interval and its recovery during the first two minutes were established. In general, the indices registered by the ECG registration and analysis

system "Kaunas–load" allowed distinguishing out the single and individual factors limiting the working capacity of athletes and providing individual recommendations aimed at managing the process of training.

CONCLUSIONS AND PERSPECTIVES

1. Field tests, i. e. the results of measuring and tests done in the swimming pool, are more suitable than the data of laboratory research in predicting the results of swimmers in the 50m freestyle swim.

2. The tests of vertical high jump used in assessing the power of muscular contractions do not allow predicting the possibilities of swimmers to achieve good results in the 50m swim. Still there exists correlation between speed and force components, as well as fatigue index and the competitive result – these indices are significant and should be taken into account when performing laboratory assessment of fitness for swimmers.

3. The dynamics of separate indices of ECG allows distinguishing the factors limiting the working capacity of athletes and providing individual recommendations important for the management of the training process. However, no significant correlation was found between integral or separate indices of cardiovascular system and swimming performance in 50 m swim.

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PLAUKIKŲ VARŽYBINĖS VEIKLOS PROGNOZAVIMAS PAGAL LABORATORINIŲ TYRIMŲ IR SPECIALIŲJŲ TESTŲ REZULTATUS

Ilona Judita Zuozienė, Jonas Poderys
Lietuvos kūno kultūros akademija, Kaunas, Lietuva

SANTRAUKA

Tyrimo pagrindimas ir hipotezė. Plaukikų parengtumui vertinti praktikoje ir mokslinių tyrimų metu dažnai analizuojami fizinių ir funkcinių galių, techninio parengtumo rodikliai. Tyrimu tikrinama hipotezė, kad dinaminių ir funkcinių rodiklių tyrimas adaptuotais testais specifinėmis sąlygomis yra informatyvesnis už laboratorinius tyrimus prognozuojant pasiekimų galimybes sprinto rungtyse.

Tikslas – palyginti adaptuotų praktinių testų (tyrimų, atliekamų baseine) ir laboratorinių tyrimų informatyvumą prognozuojant plaukikų 50 m nuotolio rezultatus.

Metodai. 12 profesionalių plaukikų vyrų tirti tris kartus: pirmą kartą traukio jėgos ir anaerobinio darbingumo rodikliai buvo nustatomi kompiuterizuota dinamografine sistema plaukiant; antrą – 50 m plaukiama laisvuoju stiliumi siekiant maksimalaus rezultato; trečią – įvertintas plaukikų darbingumas ir funkcinė būklė atliekant laboratorinius tyrimus.

Rezultatai. Tyrimas parodė, kad reikšmingai su 50 m plaukimo rezultatu koreliavo traukio jėga tiriant sausumoje, traukio jėga vandenyje plaukiant vien rankomis, visiškai suderintais rankų ir kojų judesiais, 30 s plaukimo testo metu pasiekta maksimaliąja traukio jėga. Koreliacija tarp plaukimo rezultato ir vertikalaus šuolio aukščio rodiklių nebuvo reikšminga, tačiau reikšmingai ($p < 0,05$) koreliavo plaukimo rezultatas su jėgos ir greitumo komponentais bei raumenų nuovargio rodikliu ($r = –0,47$; $r = 0,56$ ir $r = 0,67$ atitinkamai).

Aptarimas ir išvados. Plaukikų, plaukiančių 50 m laisvuoju stiliumi, rezultatams prognozuoti tinkamesni yra baseine atliktų testų ir matavimų rezultatai, nei laboratorinių tyrimų duomenys. Vertikalių šuolių testai ir EKG rodikliai yra naudotini vertinant plaukikų parengtumą ir funkcinę būklę, išskiriant darbingumą ribojančias grandis.

Raktažodžiai: plaukimas, funkcinis parengtumas, specialieji testai.

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Corresponding author **Ilona Judita Zuozienė**
Lithuanian Academy of Physical Education
Sporto str. 6, LT-44221 Kaunas
Lithuania
Tel + 370 37 302666
E-mail i.zuoziene@lkka.lt

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1.7. Žinios apie visus straipsnio autorius. Būtina pateikti garantinį raštą, patvirtinantį, kad straipsnis yra originalus ir niekur kitur nepublikuotas.

1.8. Gaunami straipsniai registruojami. Straipsnio gavimo paštu data nustatoma pagal Kauno pašto žymeklį.

2. Straipsnio struktūros reikalavimai

2.1. **Titulinis lapas.** Pateikiamas straipsnio pavadinimas, autorių vardai ir pavardės, darbovietės, nurodomas adresas susirašinėti.

2.2. **Santrauka.** Santraukoje (250 žodžių) svarbu atskleisti mokslinę problemą, jos aktualumą, tyrimo tikslus, uždavinius, metodus, pateikti pagrindinius tyrimo duomenis, jų aptarimą (lyginant su kitų autorių tyrimų duomenimis), išvadas. Santraukoje turi būti išskirti tokie poskyriai: Tyrimo pagrindimas ir hipotezė. Tikslas. Metodai. Rezultatai. Aptarimas ir išvados.

2.3. **Raktažodžiai.** 3–5 informatyvūs žodžiai ar frazės (negali būti nė vieno žodžio, esančio pavadinime).

2.4. **Įvadas.** Jame nurodoma tyrimo problema, jos ištirtumo laipsnis, sprendimo naujumo argumentacija (teorinių darbų), pažymimi svarbiausi tos srities mokslo darbai, tyrimo tikslas, objektas ir originali hipotezė.

2.5. **Metodika.** Šioje dalyje turi būti pagrįstas konkrečios metodikos pasirinkimas. Būtina aiškiai apibūdinti tiriamuosius, tyrimo metodų procedūras ir tyrimo eigą. Jei taikomi tyrimo metodai nėra labai paplitę ar pripažinti, reikia nurodyti priežastis, skatinusias juos pasirinkti. Aprašomi originalūs metodai arba pateikiamos nuorodos į literatūroje aprašytus standartinius metodus, nurodoma aparatūra (jei ji naudojama). Būtina nurodyti naudotus matematinės statistikos metodus (statistinį patikimumą, statistinę galią, pasikliautinąjį intervalą, dydžio efektą), paaiškinti, kaip buvo pasirinktas imties kiekis. Tyrimo metodai ir organizavimas turi būti aiškiai ir logiškai išdėstyti. Straipsnyje neturi būti informacijos, pažeidžiančios tiriamų asmenų anonimiškumą. Žmonių tyrimai turi būti atlikti remiantis Helsinkio deklaracijos principais.

2.6. **Tyrimo rezultatai.** Rezultatai turi būti pateikiami glaustai, nuosekliai ir logiškai nekartojant metodikos, pažymimas jų statistinis patikimumas ir galingumas. Šiame skyriuje nerekomenduojama aptarti tyrimo rezultatų. Rekomenduojame duomenis pateikti ne lentelėse, bet grafikuose.

2.7. **Rezultatų aptarimas.** Aptarimo pradžioje rekomenduojame pateikti pagrindinius originalius straipsnio teiginius (išvadas), kilusius iš tyrimo duomenų. Rezultatų aptarimą būtina struktūrizuoti išskiriant potemes (kiekvieną originalų atrastą teiginį rekomenduojame aptarti atskira poteme). Tyrimo rezultatai ir išvados lyginami su kitų autorių skelbtais duomenimis, įvertinami jų tapatumai ir skirtumai. Ypač svarbu pabrėžti tyrimo duomenų originalumą. Reikia vengti kartoti tuos faktus, kurie pateikti tyrimų rezultatų dalyje.

2.8. **Išvados ir perspektyvos.** Išvados turi būti formuluojamos aiškiai ir logiškai, vengiant tuščiažodžiavimo. Išvados turi būti pagrįstos tyrimo rezultatais ir patvirtinti arba paneigti tyrimo hipotezę. Svarbiausias išvadų reikalavimas – jos turi būti originalios pasaulyje. Būtina nurodyti tolesnių tyrimų perspektyvas.

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3. Straipsnio įforminimo reikalavimai

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Jeigu to paties autoriaus, tų pačių metų šaltiniai yra keli, būtina literatūros sąraše ir straipsnio tekste prie metų pažymėti raides, pvz.: 1990 a, 1990 b ir t. t.

Literatūros aprašo pavyzdžiai

Gikys, V. (1982). *Vadovas ir kolektyvas*. Vilnius: Žinija.

Jucevičienė, P. (Red.) (1996). *Lyginamoji edukologija*. Kaunas: Technologija.

Miškinis, K. (1998). *Trenerio etika: vadovėlis Lietuvos aukštųjų mokyklų studentams*. Kaunas: Šviesa.

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INFORMATION TO AUTHORS

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1.1. All papers submitted to the journal should contain original research not previously published (except preliminary reports or conference thesis). The material published in the journal should be new, true to fact and precise. The methods and procedures of the experiment should be identified in sufficient detail to allow other investigators to reproduce the results. It is desirable that the material to be published should have been discussed previously at conferences or seminars.

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

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Bergman, P. G. (1993). Relativity. In *The New Encyclopedia Britannica* (Vol. 26, pp. 501–508). Chicago: Encyclopedia Britannica.

Bjork, R. A. (1989). Retrieval inhibition as an adaptive mechanism in human memory. In H. L. Roediger III, F. I. M. Craik (Eds.), *Varieties of Memory & Consciousness* (pp. 309–330). Hillsdale, N J: Erlbaum.

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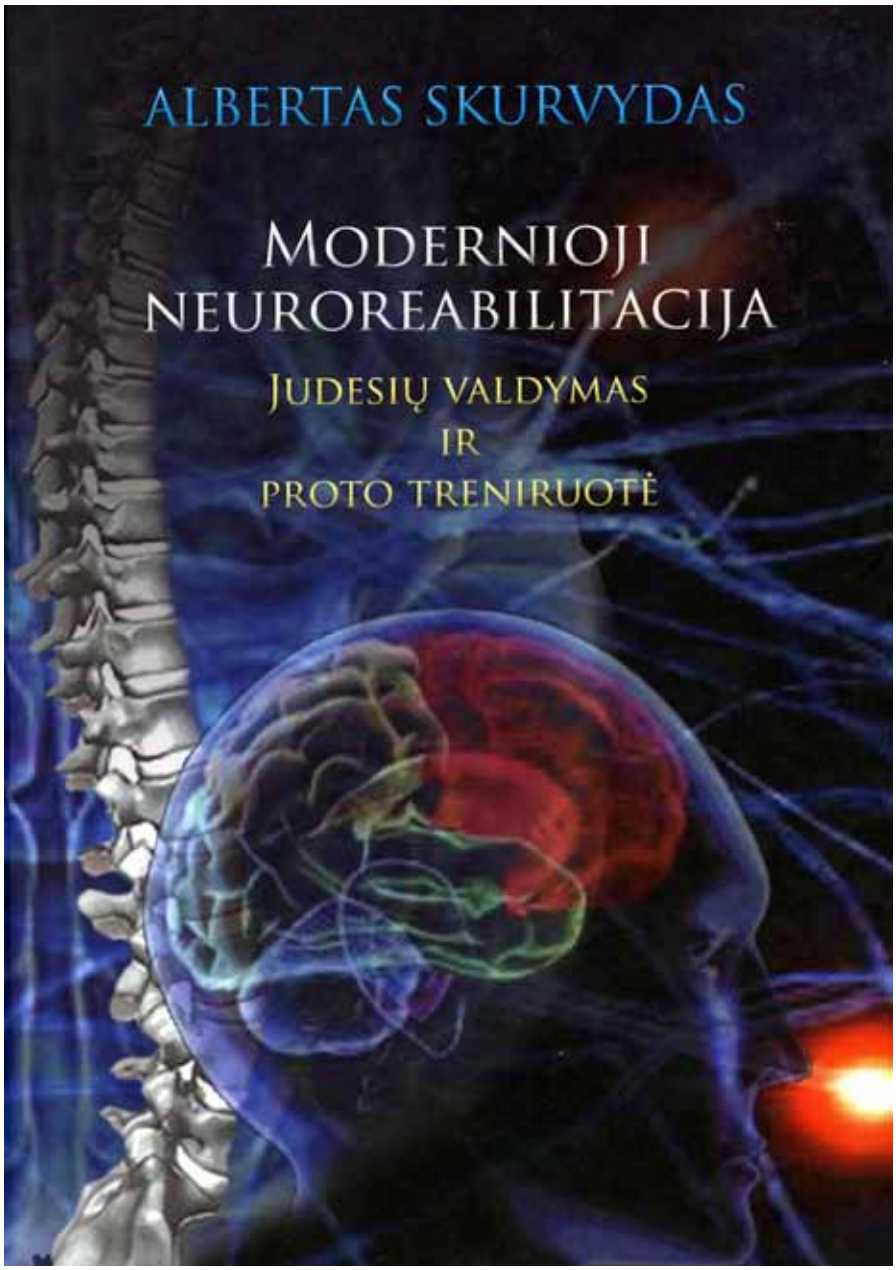
Town, G. P. (1985). *Science of Triathlon Training and Competition.* Champaign, Illinois: Human Kinetics.



Modernioji neuroreabilitacija remiasi fiziologijos, biomechanikos, anatomijos, psichologijos, neurologijos, judesių mokslo, kibernetikos ir farmakologijos pasiekimais. Neuroreabilitacijos modernumas grindžiamas tuo, kad galvos smegenis (ir nugaros smegenis) galima lavinti arba atkurti (reabilituoti) jų funkcijas, valingai atliekant įvairius pratimus, panaudojant robotus, neuroprotezus arba vartojant farmakologines medžiagas.

Nuoširdžiai sveikiname!
Congratulations!

Lietuvos kūno kultūros akademijos doktorantę **Laurą Daniusevičiūtę**, 2012 m. birželio 21 d. Lietuvos kūno kultūros akademijoje apgynusią biomedicinos mokslų (biologijos) daktaro disertaciją tema „Motorinės sistemos nuovargio priklausomumas nuo moterų menstruacinio ciklo fazės“.
Mokslinė vadovė doc. dr. Saulė Sipavičienė.

We congratulate **Laura Daniusevičiūtė**, the student of doctoral studies at the Lithuanian Academy of Physical Education, to have defended her thesis “Dependence of motor system fatigue on female menstrual cycle phase” (Biomedical Sciences, Biology) at the Lithuanian Academy of Physical Education on June 21, 2012.
Scientific advisor Assoc. Prof. Dr. Saulė Sipavičienė.

Lietuvos kūno kultūros akademijos doktorantę **Rasą Kreivytę**, 2012 m. birželio 29 d. Lietuvos kūno kultūros akademijoje apgynusią socialinių mokslų (edukologijos) daktaro disertaciją tema „Skirtingų mokymo(si) metodikų bei pagalbinių priemonių taikymo poveikis baudos metimų tikslumui”.
Moksliniai vadovai: prof. habil. dr. Stanislovas Stonkus,
prof. habil. dr. Albertas Skurvydas.

We congratulate **Rasa Kreivytė**, the student of doctoral studies at the Lithuanian Academy of Physical Education, to have defended her thesis “Effect of applying different teaching and learning methods and aids on the accuracy of free throws” (Social Sciences, Educational Sciences) at the Lithuanian Academy of Physical Education on June 29, 2012.
Scientific advisors: Prof. Dr. Habil. Stanislovas Stonkus,
Prof. Dr. Habil. Albertas Skurvydas.

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