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ORIGINAL RESEARCH PAPER

BILATERAL BIOMECHANICAL ASYMMETRY DURING 30 SECONDS ISOKINETIC SPRINT-CYCLING EXERCISE

Indrek Rannama, Kristjan Port

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Abstract

The purpose of present study was to examine the bilateral differences of pedalling kinetics and thigh muscle activity patterns according to leg dominance during the 30 seconds maximal cycling exercise and to analyse the relationships between asymmetries of pedalling kinetics and muscle activity. Methods: The pedalling power (POW), power production smoothness (PS) and EMG of VL, RF and BF of 17 competitive cyclists (19.2±1.6y.; 1.82±0.07m; 74.1±8.2kg) were measured bilaterally during maximal 30s isokinetic (cadence limit 100 rpm) seated cycling exercise. The dynamics of POW, PS and normalized EMG-RMS amplitude and median frequency (MF) of dominant (DO) and non-dominant (ND) side were measured. The directional asymmetry indexes (AI%) between DO and ND side were computed and compared with student t-test for paired samples. Correlation analyse between AI(%) of pedalling kinetics and EMG patterns was made. Results: The DO side POW and PS values were significantly (p<0.05) higher than ND during the all exercise time (except POW between 5-10 sec). No significant bilateral differences were found between normalized EMG amplitude values. The AI(%) of POW and PS were significantly lowered during the exercise. Significant correlations were found between AI (%) of PS and VL EMG MF (r=-0.64) and between AI(%) of POW and VL normalized EMG amplitude (r=0.63). Conclusions: Results of the present study indicate that during 30 seconds maximal intensity cycling does exist leg dominance dependent asymmetries in pedalling power patterns, which decreased during the exercise and was related with bilaterally asymmetry of vastus lateralis muscle firing patterns.

Key words: Surface EMG, Pedalling Power, Leg Dominance
Introduction

Bicycling is a bilateral cyclical movement and for that reason in most of studies, analysing cycling biomechanics, assuming that cyclists are pedalling symmetrically and have mainly focused on measurements of only one body side (Carpes, Mota & Faria, 2010). In same time the numbers of studies have found a notable asymmetry in the bilateral biomechanical patterns of the pedalling and muscle strength values of competitive cyclists (Rannama et al., 2013; Yanci & Arcos, 2014). Earlier studies focused on recreational population and noted between-legs differences in pedalling kinetic variables like a work (Cavanagh et al., 1974) and crank peak torque (Daly & Cavanagh, 1976). Most of latest researches in this field have been focused on pedalling kinetics and have declared bilateral asymmetry in competitive cyclist’s population in crank torque (Carpes et al., 2007; Bini & Hume, 2014) or different pedal force components profile (Sanderson, 1990; Smak, Neptune & Hull, 1999) and pedal power output (Smak, Neptune & Hull, 1999). Also in some studies have found asymmetry in lower limbs joint kinematics and kinetics patterns (Smak, Neptune & Hull, 1999; Rodano, Squadron & Castagna, 1996; Edeline et al., 2004), but there have been made only a few studies about between-legs differences in muscle activation patterns (Carpes et al., 2010; Carpes et al., 2011).

There are noted differences in pedalling kinetics variables according to leg dominance, identified by kicking preference. Daly & Cavanagh (1976) stated the direction of asymmetry was unrelated of limb dominance and varied day to day. Smak, Neptune & Hull (1999) found, that, at the work rate of 250 W and in cadences between 60 to 120 rpm, cyclist’s dominant leg contributed significantly greater average crank power than non-dominant leg, despite the relatively small difference (0.5-2%). Same study (Smak, Neptune & Hull, 1999) also found higher average positive and negative crank powers in non-dominant side, which refers to different bilateral pedalling technique. There are also described higher crank peak torque values of dominant leg in low to submaximal powers of incremental test (Carpes et al., 2008) and in 40km long simulated time trial (Carpes et al., 2007). It seems that higher power output (Carpes et al., 2008; Sanderson et al., 1991) or accumulated fatigue (Carpes et al., 2007), as indicators of increased effort (Carpes, Mota & Faria, 2010), improve the symmetry of pedalling kinetics, but there are also opposing findings (Bini & Hume, 2014). The asymmetry of pedalling kinetics is also influenced by pedalling rate, but those relations are at the moment not fully understood (Carpes, Mota & Faria, 2010). In the cadence range between 60 and 90 rpm cyclists have individual variations in change of bilateral leg contribution (Smak,
Neptune & Hull, 1999), but there is a trend of increasing absolute asymmetry in higher (over 120rpm) and very low cadences (less than 60), especially in non-cyclists population (Liu & Jensen, 2012; Smak, Neptune & Hull, 1999).

The relations between asymmetries of different biomechanical variables, such as pedalling kinetics, movement kinematics and muscles activity, are not frequently discussed. Edeline et al., (2004) demonstrated that even with a symmetrical pedal force production there was existing bilateral difference in the pedalling kinematics and this leads to the asymmetry in joint torques and muscle loads. In same line are findings of Smak, Neptune & Hull (1999) about leg dominance driven differences in knee and hip joint torque profiles. The bilateral leg dominance driven asymmetries have found in normalized EMG amplitude values of squat jump (Ball & Scurr, 2014) which is similar movement to cycling. In contrast Carpes, et al., (2010b) compared dominant and non-dominant legs normalized EMG-s of 3 muscle groups during single leg cycling at submaximal constant load intensity and found no dominance related differences. During the incremental cycling test Carpes et al., (2011) noted lower EMG variability in Biceps femoris, Gastrocnemius and Vastus lateralis muscles of dominant leg in some conditions, but no significant bilateral differences were found in normalized EMG amplitude values. To best of our knowledge no studies about relationships between bilateral asymmetry of pedalling kinetics and muscle activity of leg muscles are presented.

Competitive road cycling requires for success not only good endurance, but also ability to produce high level maximum power during a short period of time (Ebert et al., 2006; Jeukendrup, Craig & Hawley, 2000). Above discussed researches looked asymmetry in submaximal and mainly in aerobic exercise conditions, but there is lack of known about between-legs differences in pedalling biomechanics and muscle activity patterns during short term maximum anaerobic performance. It is known that during submaximal cycling dominating muscles are knee extensors (Broker & Gregor, 1994; Ericson, 1988) but in maximal cycling condition larger portion of power is generated by hip extensors that produced nearly twice the power compared to knee extension (Martin & Brown, 2009). Also relatively less knee extension and more knee flexion power will be produced (Elmer et al., 2011). The relative larger increase (5 – 9 times) of hip flexors and extensors and knee flexors muscle activity have been found with power increase from 150W to maximum, whereas ankle plantar flexors and knee
extensors activity increased only 2-3 times (Dorel, Guilhem, Couturier & Hug, 2012).

During 30 seconds maximal cycling trial the fatigue occurred at different rates – the hip extensors sustain their power longer and at higher rate, while ankle joint power tends to decrease most rapidly compared to other lower limb joints and in knee joint the flexors power decline is lower than in extensors (Martin & Brown, 2009). On sEMG values reported significant decline in median frequency of the power spectrum of ankle plantar flexors and knee extensors (averagely 14-19%), but sEMG amplitude values are significantly reduced only in plantar flexors and not in knee extensors (Greer et al., 2006; Hunter et al., 2003). There is a lack of evidence about role of laterality and existence of bilateral differences in muscle fatiguing during anaerobic single-sprint exercise.

The purpose of present study was to examine the bilateral differences of pedalling kinetics and thigh muscle activity patterns according to leg dominance during the 30 seconds maximal cycling exercise and analyse the relationships between asymmetries of pedalling kinetics and muscle activity.

**Material and methods**

**Participants.** The study participants were 17 competitive U23 class male road cyclists of age ranging from 18 to 22 (21.1±3.5 years, 181.5±5.0 cm, 74.8±7.0 kg). All athletes had at least 6 years focused endurance cycling training and competition experience. 16 cyclists were right leg dominant and one was left leg dominant, identified by kicking preference (Smak et al., 1999).

All participants were informed about the research procedures, requirements, benefits and risks before the testing. All participants were asked not to do a heavy or intensive training at least two days before the testing. The study was performed in November after the end of competitive season and before the start of new preparation period for cyclists.

**Procedures**

**Experimental cycling exercise** were performed using the participants personal racing bike, which was mounted on a research grade cycling ergometer platform Cyclus 2 (Avantronic, Cyclus 2, Leipzig, Germany) that allows lateral incline of the bike that matches real life cycling. Exercise protocol consisted 4 stages: 10 minutes warm-up of steady ride in power level up to 150W, 6 seconds of isokinetic maximal sprint with cadence set in 100rpm for EMG amplitude normalization, 25 – 30 minutes warm up with mixed power up to VO2 max level to and 30 seconds maximal
isokinetic sprint performance with limited cadence set in 100rpm. All experimental cycling tests were conducted in sitting position hands on the drops.

For measurement of pedalling kinetics bicycle of each participant equipped with same pair of Garmin Vector power meter pedals (Garmin Vector™). Vector pedals were installed and calibrated before each testing session according to description of manufacturer guidelines.

Muscle activity data were recorded bilaterally by surface electromyography (sEMG) from three tight muscles: the long head of biceps femoris (BF), the rectus femoris (RF) and the vastus lateralis (VL) muscles. These muscles were chosen because they are dominant muscles from tree different muscle synergy group involved in cycling (Hug, Turpin, Guevel & Dorel, 2010). Due to technical problems with one sEMG probe during the experimental time only 9 persons sEMG of BF were included to future analysis.

The skin of participants was shaved and cleaned with alcohol to improve the skin impedance. A pair of Ag/AgCl electrodes with inter-electrodes distance of 30 mm was applied on each muscle symmetrically for dominant (DO) and non-dominant (ND) limb, following the SENIAM recommendations (Hermens et al., 2000). Always the same person attached all the electrodes. A wireless electromyography BTS FreeEMG 300 measurement system (BTS, Inc., Milan, Italy) was used to collect sEMG data from six bipolar wireless probes (8.5g). The system features an A/D converter within an EMG sensor for eliminating external noises. Six sEMG channels and one pedal position and start triggering switch channel sampled at 1000 Hz frequency.

The sEMG signal was synchronized with pedalling cycle kinematics by magnetic switch positioned in bottom dead centre of left crank and with cycle ergometer and power pedals by start switch.

Measures. The kinetics of pedalling are described by pedalling power (POW) and pedalling smoothness (PS=pedalling cycle Average power/Maximum power*100(%) ) collected from Garmin Vector pedals with 1 seconds interval separately from DO and ND side from start to end of experimental exercise. The muscle activity patterns were normalized RMS EMG (%) and EMG median frequency (MFr). For all patterns average values of 30 seconds and six (from 0 to 5; 5 to 10; 10 to 15; 15 to 20; 20 to 25 and 25 to 30 seconds) consecutives 5 seconds long time periods were taken to future analyse. Measurements and initial analysis of values were expressed as a mean of dominant and nondominant leg.
The directional asymmetry index \( \text{AI}(\%) = 100 \times \frac{(\text{DO-ND})}{0.5 \times (\text{DO+ND})} \) was calculated (Robinson, Herzog & Nigg, 1987) for pedalling kinetic and sEMG variables.

**Analysis**

The stored sEMG data were analysed with BTS SEMGAnalyzer (BTS, Inc., Milan, Italy) with custom made analyse protocols. Raw EMG signals of 6 seconds normalization and 30 seconds experimental trail were high-pass filtered (10Hz, Butterworth filter) to eliminate possible external noises. To compare the bilateral muscle firing rate patterns and fatigue accumulation during the exercise the median frequency (MFr) values of sEMG power spectrums of whole test and six consecutive 5 seconds time periods were computed. Filtered sEMG signals of normalization and experimental trial were root mean squared (RMS) with 0.025 seconds moving time window to make linear envelope of sEMG amplitude. The sEMG amplitude normalization was made by peak amplitude method according to the directions of Ball and Scurr (2013). Highest 0.025 second RMS value of 6 seconds normalization sprint for each muscle for DO and ND side were taken for normalization of RMS values of experimental trail. Average normalized sEMG RMS amplitude values of whole exercise and every 5 seconds time period were computed and incorporated to the future analyse.

Data analyses were performed using the IBM SPSS Statistics version 21.0 for Windows. Descriptive data were computed for all variables and all time period and expressed as mean ± standard deviation (SD). All the data was tested for their normal distribution (Kolmogorov-Smirnov test). A Student’s t-test for paired data was applied to compare values of DO and ND leg and changes between time periods. The correlation analyze between AI(%) of pedaling kinetic and sEMG values were made. Significance level was set at p<0.05 for all analyses.

**Results**

The average absolute power of 30 seconds cycling sprint test was 846±115 W (ranged from 592 to 1124 W) and relative power was 11.4±1.0 W/kg (from 9.6 to 13.3 W/kg). The descriptive statistics of pedalling kinetics, EMG amplitude and frequency results and between DO and ND side asymmetry values are presented in Table 1. The dynamics of named variables during the test within 5 seconds time stages are presented in figures 1-4.
### Table 1

The descriptive statistics of pedalling kinetics, EMG amplitude and frequency values of DO and ND leg, AI (%) and paired t-test results between bilateral values of 30 seconds maximal cycling exercise

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean</th>
<th>Std. Dev</th>
<th>AI (%)</th>
<th>Paired t-test Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean</td>
<td>Std. Dev</td>
<td>Mean</td>
<td>Std. Dev</td>
</tr>
<tr>
<td>PS</td>
<td>DO</td>
<td>17</td>
<td>34.5</td>
<td>2.9</td>
<td>8.74</td>
</tr>
<tr>
<td></td>
<td>ND</td>
<td>17</td>
<td>31.6</td>
<td>2.7</td>
<td>0.00*</td>
</tr>
<tr>
<td>POW</td>
<td>DO</td>
<td>17</td>
<td>430.8</td>
<td>60.7</td>
<td>3.43</td>
</tr>
<tr>
<td></td>
<td>ND</td>
<td>17</td>
<td>415.5</td>
<td>56.0</td>
<td>0.00*</td>
</tr>
<tr>
<td>RF RMS</td>
<td>DO</td>
<td>17</td>
<td>18.3</td>
<td>4.9</td>
<td>-8.92</td>
</tr>
<tr>
<td></td>
<td>ND</td>
<td>17</td>
<td>20.0</td>
<td>5.1</td>
<td>0.17</td>
</tr>
<tr>
<td>VL RMS</td>
<td>DO</td>
<td>17</td>
<td>22.2</td>
<td>4.7</td>
<td>10.04</td>
</tr>
<tr>
<td></td>
<td>ND</td>
<td>17</td>
<td>20.1</td>
<td>4.1</td>
<td>0.17</td>
</tr>
<tr>
<td>BF RMS</td>
<td>DO</td>
<td>9</td>
<td>22.1</td>
<td>3.9</td>
<td>9.08</td>
</tr>
<tr>
<td></td>
<td>ND</td>
<td>9</td>
<td>20.1</td>
<td>3.1</td>
<td>0.22</td>
</tr>
<tr>
<td>RF MFr</td>
<td>DO</td>
<td>17</td>
<td>79.0</td>
<td>7.8</td>
<td>3.60</td>
</tr>
<tr>
<td></td>
<td>ND</td>
<td>17</td>
<td>76.0</td>
<td>6.3</td>
<td>0.09</td>
</tr>
<tr>
<td>VL MFr</td>
<td>DO</td>
<td>17</td>
<td>65.0</td>
<td>7.2</td>
<td>-1.99</td>
</tr>
<tr>
<td></td>
<td>ND</td>
<td>17</td>
<td>66.4</td>
<td>6.6</td>
<td>0.55</td>
</tr>
<tr>
<td>BF MFr</td>
<td>DO</td>
<td>9</td>
<td>68.5</td>
<td>10.5</td>
<td>-5.52</td>
</tr>
<tr>
<td></td>
<td>ND</td>
<td>9</td>
<td>73.6</td>
<td>9.1</td>
<td>0.01*</td>
</tr>
</tbody>
</table>

- significant difference between DO and ND side (p<0.05)

The comparison of 30 seconds DO and ND leg average values (Tab.1) refers to significantly (p<0.05) higher PS and POW of DO side and higher MFr values of BF muscle. This trend is also shown in dynamics of named variables during the exercise (figures 1 and 2), where PS and POW bilateral differences are maintained from start to end part, but BF MFr differences are disappearing during the last 10 seconds of the exercise.

**Figure 1.** Dynamics of average (+/-SD) DO and ND side pedalling power (POW) (Figure 1A) and pedalling smoothness (PS)(Figure 1B) values observed within the 5 seconds time periods of exercise (n=17)  
(#{- significant difference between DO and ND side p<0.05)
There does exist also some significant differences between DO and ND leg for RF MFr in middle – and for VL MFr in end part of the exercise. No significant bilateral differences were found between normalized EMG amplitude values of any muscle at any stage of exercise.

The AI(%) value of POW was higher (7.7 ±8.4%) at initial part of exercise and after 5 seconds lowered significantly (to the level between 1.9±4.1 and  3.2± 6.3%), PS AI(%) had also significantly higher values in first 10 than in last 10 seconds of effort (Figure 4A). The EMG AI(%)
variables (Figure 4 B and C) have opposite directions in firing rate and amplitude patterns and amount of AI(%) of RF and BF do have the trend to decrease, but VL AI(%) has the trend to increase in the final stage of exercise.

The comparison between initial 5 and last 5 seconds values shows that pedalling kinetics (POW, PS) and EMG frequency decrease significantly during the test. For EMG amplitude there was only significant difference between DO BF start and end part values. But there does exist significant differences between second stage (5-10 sec) and final stage DO and ND BF normalized RMS EMG and between third stage (10-15 sec) and final stage DO and ND VL normalized RMS EMG values.

Figure 4. Dynamics of average AI(%) of pedalling kinetic (Figure 4A), normalized sEMG RMS amplitude (Figure 4B) and sEMG MFr (Figure 4C) values observed within the 5 seconds time periods of exercise (n=17)

(1-significanly different from 1-st time period; 2 - from 2-nd period; 3 - from 3-nd period; 4 - from 4-th period; 5 - from 5-th period, p<0.05)

Table 2

<table>
<thead>
<tr>
<th>AI (%) of kinetics</th>
<th>PS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pow</td>
<td>.533*</td>
</tr>
<tr>
<td>RF</td>
<td>.07</td>
</tr>
<tr>
<td>VL</td>
<td>.38</td>
</tr>
<tr>
<td>BF</td>
<td>.24</td>
</tr>
<tr>
<td>AI (%) of EMG RMS</td>
<td></td>
</tr>
<tr>
<td>RF</td>
<td>-.08</td>
</tr>
<tr>
<td>VL</td>
<td>-.639**</td>
</tr>
<tr>
<td>BF</td>
<td>.09</td>
</tr>
</tbody>
</table>

* Correlation is significant at the p<0.05 level (2-tailed).
** Correlation is significant at the p<0.01 level (2-tailed)
Correlations between computed 30 seconds average AI (%) values of pedalling kinetics and muscle activity variables

Table 3

<table>
<thead>
<tr>
<th>AI (%) of Pedalling Smoothness</th>
<th>AI(%) of Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-5s</td>
<td>5-10s</td>
</tr>
<tr>
<td>AI (%) of Power</td>
<td>.374</td>
</tr>
<tr>
<td>AI (%) of EMG RMS RF</td>
<td>-.194</td>
</tr>
<tr>
<td>VL</td>
<td>.412</td>
</tr>
<tr>
<td>BF</td>
<td>.305</td>
</tr>
<tr>
<td>AI (%) of EMG MFr RF</td>
<td>-.025</td>
</tr>
<tr>
<td>VL</td>
<td>-.459</td>
</tr>
<tr>
<td>BF</td>
<td>.112</td>
</tr>
</tbody>
</table>

* Correlation is significant at the p<0.05 level (2-tailed).
** Correlation is significant at the p<0.01 level (2-tailed)

The correlation analyse results are presented in Tables 2 and 3. Significant correlations were found between AI (%) of PS and VL EMG MFr and between AI (%) of POW and VL normalized EMG amplitude. If to look correlations according to time periods, than stronger relations were found during the middle part of exercise and no significant correlations were found between initial stage values. Also the PS AI (%) and POW AI (%) values are significantly correlated only in between 10 to 25 seconds of exercise.

Discussion

The one purpose of present study was to examine the bilateral differences of pedalling kinetics and thigh muscle activity patterns according to leg dominance during the 30 seconds maximal cycling exercise. With accordance of previous studies, done mainly in aerobic exercise conditions (Smak, Neptune & Hull, 1999; Carpes et al., 2007; Carpes et al., 2008), our results suggest that exist also leg dominance driven asymmetry in pedalling kinetic patterns during the maximal short term cycling. During the maximal cycling DO limb produces higher power with more equally over the pedalling cycle, which is in line with findings of Smak, Neptune & Hull (1999), that dominant leg generate higher average pedalling power with lower average positive and negative power production than ND limb.

Higher between legs bilateral differences were found during initial 5 seconds power and first 10 seconds pedalling smoothness values. After that power asymmetry dropped significantly and stayed almost in same level till the end of exercise. PS asymmetry and also pedal smoothness of DO and
ND side lowered gradually and significantly and had lowest values in final 5 seconds. It seems that asymmetry of pedalling power production during short duration maximal exercise is more sensitive to fatigue like long time trial performance (Carpes et al., 2007), but not to the high power because asymmetry of power production was larger in acceleration part at start of exercise, when the power was higher.

Previous studies about comparison of DO and ND legs normalized sEMG amplitude values did not found any dominance related differences in incremental or single leg constant load intensity cycling (Carpes et al., 2010; Carpes et al., 2011). The results of present experiment showed that there were no significant dominance related differences between DO and ND side normalized EMG RMS values of RF, VL, BF muscles at any time period of exercise.

To the best of our knowledge no previous studies have done to compare sEMG firing rate patterns between DO and ND thigh muscles during cycling exercise. Our data indicated that there exist some significant bilateral leg dominance driven differences in BF MFr values during the initial 20 seconds of exercise and those differences expiring in the end part of exercise. Also were found bilateral differences in some time stages of VL and RF MFr values. It is known that motor units firing frequency modulation become predominant over motor units recruitment mechanism when moderate or high force level is required (Moritani & Yoshitake 1998) and that sEMG firing rate is more sensitive to fatigue than firing amplitude during short term anaerobic exertion (Greer et al., 2006; Hunter et al., 2003). From that view the future investigation of asymmetrical EMG frequency patterns may have important role for understanding neurological mechanisms of pedalling asymmetry.

The pedalling kinetics asymmetry was significantly correlated with asymmetry of VL EMG patterns. Larger DO side PS were associated with higher VL MFr values in ND side and higher DO side asymmetry in POW values was related with same direction asymmetry in VL normalized RMS amplitude. The relationship of VL muscle activity regarding to cycling intensity is well known (Moritani & Yoshitake 1998; Berice et al., 2009) and our findings suggest that between-legs differences in VL EMG amplitude and firing rate may play significant role in directional asymmetry of pedalling kinetics. For better understanding of mechanisms behind cycling asymmetry in future research in the analysis should be incorporated also pedalling kinematic and cyclist’s musculoskeletal state values.
Conclusions

Results of the present study indicate that during 30 seconds maximal intensity cycling do exist leg dominance dependent asymmetries in pedalling power patterns, which decreased during the exercise and were related to bilaterally asymmetry of *vastus lateralis* muscle firing patterns.

References


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ORIGINAL RESEARCH PAPER

EFFECT OF VITAMINS, MINERAL SUBSTANCES AND MANUAL MANIPULATIONS OF VERTEBRAL SEGMENTS C0-C3 AND C6-TH3 ON FUNCTIONAL STATE OF CERVICAL AND CERVICO THOROCAAL PARTS OF BODY

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Abstract

According to literature sources it is known that the functional state of the cervical and cervico thorocal parts significantly affect the functioning of many systems of the body. To normalize the functional state of the neck, the pectoral muscles of the neck and joints, there are different therapy methods from pharmaceutical to even neuroreflectorly applied. In this research we evaluated one pharmaceutical therapy (the therapy of mineral substances and vitamins) and one neuroreflectorly therapy (the manipulation of joints) and their effect on the functional state of the cervical and cervico thorocal parts.

Key words: Functionally weak muscle, neural regulation, mineral and vitamin disturbances, manual manipulations, functional state of the neck muscle.

Introduction

In the practice of physiotherapy we often come across the situations when athletes performing movements do not do it in optimal routine. Assisting muscles are involved in the realisation of the movement, not forming an optimal stereotype of the movement. It is known from the literature that in such situations it is mostly found out that the muscles agonists in the realisation process of the movement operate only in the routine of phasic contraction. In the practice of applied kinesiology (AK) it has been empirically stated that, having neural regulation disturbance, as well as mineral or vitamin insufficiency the muscle cannot use the routine of
tonic contraction. Such muscle neural regulation state in AK is called as a functionally weak muscle.

It is known from the literature that the reasons for muscle functional weakness can be as follows: in muscles themselves, in the segmental, CNS subcortical and cortical levels (Васильева, 1998). In AK practice it has been stated, if the source of the problem is irritated for a short time, muscle neural regulation is normalized for a while, letting it contract in tonic routine.

One of the reasons of formation of functionally weak muscles can be functional changes in the segmental level. The neck level significantly affects the functioning of many systems of the body (Kaprelia, Vourazanisa, Strimpakosa, 2008). We provoked these functional changes in the segmental level in the cervico thoracal part.

Another reason of functionally weak muscles is insufficiency of mineral substances and vitamins. Insufficiency can make muscle neural regulation disturbance which in turn may cause decreased muscle tone (Frost R., 2002).

The aim of the research was to find out changes of the cervical and cervico thoracal parts under the influence of vitamins, mineral substances and manual manipulations of the spinal segments C0-C3 and C6-Th3.

Material and methods

40 participants aged 20 – 25 with problems on the cervical and cervico thoracal parts such as neck flexion, head retroflexion, shoulder protraction participated in this research. Participants are divided into two groups (20 in each). For Group A applied joint manipulation, but for Group B applied pharmaceutical therapy.

The following methods were used in the research:

1. Applied kinesiology (AK) tests. We used AK tests for testing the neck flexor muscles, m.scalenus, m.sternocleidomastoideus and the upper part of m. trapezius for their functional weakness (Ramšak, Gerz, 2001; Frost, 2002).

   Description of AK tests: The neck flexor sitting test: the patient maximally flexes the head and fixes this position (chin to chest). The stabilising hand is behind with the forearm resting over the thoracic spine and the flat hand behind the head. Light contact is made over the forehead. Test vector is in an arc in the direction of extension. The patient pushes further into flexion.

   M. Scaleni test: these muscles can be tested while sitting in flexion and at about 10 degree rotation away from the testing side. Ideally the examiner applies pressure with the ulnar edge of the hand on the middle of the patient’s forehead in the direction of extension.
**M. Sternocleidomastoideus** sitting test: the patient holds the head forward and maximally rotates it. The stabilising hand supports the head with a flat contact and the forearm rests over the thoracic spine. The testing hand makes contact on the side of the head above the temporo-mandibular joint. Test vector is in an arc dorsally, in the direction of extension. The patient pushes anteriorly, further into flexion.

**M. Trapezius** – upper division sitting test: the patient lifts the shoulder and drops the head towards the shoulder, with a small degree rotation to the opposite side. From this position the patient is asked to bring the head and shoulder further together, while the examiner tries to pull the head and shoulder away from each other.

2. **Determination of mineral substance and vitamin deficiencies with AK tests.**

If during testing with AK tests (Galeja, Paeglitis, 2013) of the deep neck flexor muscles, *m. scalenii*, *m.sternocleidomastodeus* and *m.trapezius* (the upper part) we stated neural regulation disturbance, then the subject repeated this test with specific vitamin or mineral substance contact with the body. If during the test with some vitamin or mineral substance contact with the body we could not find any disturbances of neural regulation, we marked this substance as vital to the body (Walther, 2000; Ramšak, Gerz, 2001; Frost, 2002).

The following mineral substances Zn, Se, Cu, Fe, Cr, Mg, Mn and the vitamins A, B₃, B₆, C, D, E, Q₁₀ were used in this research. Participants taking only those substances which normalized the neural regulation.

The subjects used the mineral substances and vitamins necessary for the organism in accordance with the producer recommendations - three weeks daily intake dose.

3. **Goniomethry.** It was used to evaluate the range of motions (ROM). The involved pectoral muscles can influence the range of motions in the segment C0-C1 which ensures the head antiflexion and retroflexion and in the segment C1-Th3 which ensures head-to-neck flexion, extension, rotation and lateroflexion. (Левит, Захсе, Яндла, 1993).

In measuring we used fixed standardised initial state of the head and neck – in the frontal plane the line which connects the *procesus mastoideus* (mounds behind the ear) forms angle of 90 degrees regarding to the central axis of the body, but in the sagittal plane on the vertical axis of the body there is the ear aperture, shoulder centre line and trochanter (Васильева, 1995; Васильева, 1998; Kendall, McCreary, Provance, Rodgers, Romani, 2005).
Description of the standardized tests:

**Antiflexion of the head**

The subject is lying on his or her back and the head is over the edge of the couch (the level of the spine vertebra Th1 is on the edge of the couch). In the rest state the head leans on the examiner’s hand. The head and neck are in standartized initial state. The examiner makes the subject’s head antiflexion in movement until feeling the end state (fig. 1).

**Figure 1.** The standardized tests: Antiflexion of the head

**Retroflexion of the head**

The subject is lying on his/her back and the head is over the edge of the couch (the level of the spine vertebra Th1 is on the edge of the couch). In the rest state the head leans on the examiner’s hand, the head and neck are in standartized initial state. The examiner makes the subject’s head retroflexion in movement until feeling the end state (fig. 2).

**Figure 2.** The standardized tests: Retroflexion of the head
Head-to-neck flexion

The subject is sitting with his back straight. In the rest state the head and neck are in standardized initial state. The examiner makes the subject’s head-to-neck flexion in movement until feeling the end state (fig. 3).

Figure 3. The standardized tests: Head-to-neck flexion

Head-to-neck extension

The subject is sitting with his back straight. In the rest state the head and neck are in standardized initial state. The examiner makes the subject’s head-to-neck extension in movement until feeling the end state (fig. 4).

Figure 4. The standardized tests: Head-to-neck extension
Head-to-neck rotation

The subject is sitting with his back straight. In the rest state the head and neck are in standartized initial state. The examiner makes the subject’s head-to-neck rotation (to the right and to the left) in movement until feeling the end state (fig. 5).

Figure 5. The standardized tests: Head-to-neck rotation

Head-to-neck lateroflexion

The subject is sitting with his back straight. In the rest state the head and neck are in standartized initial state. The examiner makes the subject’s head-to-neck lateroflexion (to the right and to the left) in movement until feeling the end state (fig. 6).

Figure 6. The standardized tests: Head-to-neck lateroflexion
In all cervical and cervico thorocals movement tests: The goniometer plumb axis is placed perpendicularly to the horizontal plane and the goniometer indicator is adjusted on $0^\circ$ mark. In the end of the measurement the value of ROM (range of motions) in degrees showed by the goniometer is read.

4. The methods of mathematical statistics. In order to detect changes we applied mathematical statistical program SPSS. To compare the results of each group before and after therapy we applied paired samples $t$-test. To compare therapies in the research we applied independent samples $t$-test.

Results

Assessing the cervical and cervico thorocals frequency of the neural regulation disturbances (NRD) after the procession of the obtained results of AK tests by the methods of mathematical statistics, we stated that NRD are in the neck deep flexor muscles, *m.scaleni*, *m.sternocleidomastoides* and *m.trapezius* (the upper part).

![Figure 7](image)

**Figure 7.** Neural regulation disturbances (%) of the cervical and cervico thorocals muscles

In the diagram (fig. 7.) we can see that during the tests of the neck extensor muscles NRD were not stated.

NRD in the cervical deep flexor muscles in group A were stated for 100% of the participants of this group and in group B for 50% of the participants (fig. 1).
Assessing *m.scalenii* in group A, NRD were stated for 50% of the participants in the right muscle and 45% of the participants in the left muscle. In group B NRD were stated for 75% of the participants in the right muscle and 55% of participants in the left muscle (fig. 7).

In *m.sternocleidomastoideus* measurement results, we stated NRD in the right side muscle of the body for 70% of the participants and in the left side muscle for 60% of the participants in group A. In group B NRD were stated for 45% of the participants in right side muscle of the body and 35% of the participants in the left side muscle (fig. 7).

Analysing *m.trapezius* (the upper part) measurement results we stated that NRD for 5% of the participants in right side muscle of the body and for 10% of the participants in the left side in group A. In group B NRD were established for 5% of the participants in the right side muscle and for 25% of the participants in the left side muscle (fig. 7).

Using goniometry we assessed ROM in the head antiflexion, head retroflexion, head-to-neck flexion, head-to-neck extension, head-to-neck rotation and lateroflexion, we measured ROM while the neck and neck part of the chest were in the neutral state – after standartized conditions of the model.

![Figure 8](image)

**Figure 8.** Cervical and cervico thorocal range of motions (ROM)

We can see in the diagram (fig. 8) that in the test of the head antiflexion the average value is 13±1° for group A and the average value 11±0.8° for group B. In the head retroflexion the average value is 19±1.2° for group A and the average value 15±0.9° for group B.
Analysing the results of the head-to-neck flexion ROM we stated that the average value of the movement dimension to the right was $50\pm2^0$ for group A and the average value $50\pm1.9^0$ for group B (fig. 8).

The average value of the head-to-neck extension ROM was $70\pm2.3^0$ for group A and the average value $68\pm2.7^0$ for group B (fig. 8).

Processing the data obtained in the head-to-neck rotation measurement we stated that the average value of the dimension of ROM to the right was $81\pm1.4^0$ and $80\pm2^0$ to the left for group A. In group B the average value to the right was $75\pm1.6^0$ and $78\pm1.5^0$ to the left (fig. 8).

In the head-to-neck lateroflexion after the obtained results we stated that the average value of the head-to-neck ROM lateroflexion was $44\pm1.3^0$ to the right and $48\pm0.7^0$ to the left for group A. The average value of the same indicator was $43\pm0.9^0$ to the right and $45\pm1.1^0$ to the left for group B (fig. 8).

Analysing the obtained results of the cervical and cervico-thoracic neural regulation disturbances after the spine C0-C1 and C7-Th3 vertebrae manipulations and use of vitamins or mineral substances we stated that in both groups (A and B) there were changes of the neural regulation disturbances in the neck and neck part of the chest after the application of therapies, except the neck extensor muscles.

Figure 9. Neural regulation disturbances for the neck muscles (%) before and after the spinal segment C0-C3 and C6-Th3 manipulations and use of vitamins and mineral substances

Processing the data obtained in the extensor muscle tests we stated (fig. 9.) that in group A after the spinal segment C0-C1 and C7-Th3
manipulations and in group B after the use of vitamins and mineral substances, there were not any changes, because NRD was not stated.

NRD for group A in the neck deep flexor muscles after the spinal segment C0-C3 and C6-Th3 manipulations were stated for 10% of the participants. NRD for group B in the neck deep flexor muscles after the use of vitamins and mineral substances were detected for 10% of the participants (fig. 9).

After the spinal segment C0-C3 and C6-Th3 manipulations m. scalenii NRD in group A were stated for 10% of the participants on the right and left sides of the body. But in group B after the use of vitamins and mineral substances in m. scalenii on the right side of the body we stated NRD for 30% of the participants and on the left side of the body for 25% of the participants (fig. 9).

Processing results of m. sternocleidomastoideus in group A after the spinal segment C0-C3 and C6-Th3 manipulations NRD were stated for 30% of the participants in the right side of the body muscle and 15% of the participants in the left side of the body muscle. In group B after the use of vitamins and mineral substances in m. sternocleidomastoideus on the right side of the body NRD were stated for 20% of the participants and 15% on the left side of the body (fig. 9).

We evaluated the credibility of result changes with McNemar test and stated that the obtained result changes before and after the spinal segment C0-C3 and C6-Th3 manipulations were statistically significant (a≤0,05).

Processing the results of m. trapezius (the upper part) after the spinal segment C0-C3 and C6-Th3 manipulations, we stated NRD in 5% of the participants on the left side of the body muscle, but we did not stated it on the the right side of the body. We evaluated the credibility of result changes with McNemar test and stated that the obtained result changes before and after the spinal segment C0-C3 and C6-Th3 manipulations were not statistically significant (a≥0,05).

However, in group B after the use of vitamins and mineral substances in m. trapezius (the upper part) NRD were not stated.

We evaluated the credibility of result changes with McNemar test and stated that the obtained result changes before and after the spine C0-C3 and C6-Th3 manipulations were statistically significant (a≤0,05).

In the assessment of ROM of the cervical and cervico thorocal parts after the spinal segment C0-C3 and C6-Th3 manipulations, use of vitamins and mineral substances, we repeated the tests of the head antiflexion,
retroflexion, head-to-neck flexion, extension, head-to-neck rotation and lateroflexion.

Figure 10. ROM of the cervical and cervico thoracal part of the chest before and after the spinal segment C0-C3 and C6-Th3 manipulations and use of vitamins and mineral substances

In the diagram (fig. 10) we can see that during the ROM test we stated that the average value was 17±0.9° for group A and the average value 14±0.8° for group B. In the ROM test for the head retroflexion we stated that the average value was 22±0.9° for group A and 19±0.8° for group B (fig. 10).

In the test of movement dimension for the head-to-neck flexion we stated that the average value was 58±1.4° for group A 55±1.8° for group B. In the test of movement dimension for the head-to-neck extension we stated that the average value was 75±2.3° for group A and 72±2.5° for group B (fig. 10).

In the test of movement dimension for the head-to-neck rotation we stated that the average value to the right was 84±13° but to the left 85±1.2° for group A. In group B the average value was 80±1.4° to the right and 82±1.3° to the left (fig. 10).

Analysing the changes of movement dimension in the head-to-neck lateroflexion after obtained results we stated that in group A the average value of the head-to-neck lateroflexion to the right was 51±1.2° and to the left it was 51±0.8°. The average value of group B to the right was 47±1° and to the left 49±0.8° (fig. 10).
We evaluated the credibility of the results changes with Student`s T-criterion test and groups of model thereby we stated that the obtained result changes before and after the spine C0-C3 and C6-Th3 vertebrae manipulations and use of vitamins and mineral substances were statistically significant (a≤0.05).

**Figure 11.** ROM of the cervico and cervico thoracal scaled values (%) after the spinal segment C0-C3 and C6-Th3 manipulations and use of vitamins and mineral substances

In the test of the head antiflexion ROM in group A has increased by 4\(^{0}\). Assessing the percentage scaled value of the changes it is 23.5% from the average value. In group B it has increased by 3\(^{0}\). Assessing the percentage scaled value of these changes it makes 18.2% from the average value. Comparing these percentage scaled values we can see that the changes caused by manipulations are by 5.3% more than after the use of vitamins and mineral substances (fig. 11).

In the test of the head retroflexion ROM in group A has increased by 3\(^{0}\). Assessing the percentage scaled value of these changes it makes 13.6% from the average value. In group B it has increased by 3\(^{0}\). Assessing the percentage scaled value of these changes it makes 17.6% from the average value. Comparing these percentage scaled values we can see that changes caused by the use of vitamins and mineral substances are by 4% more than after manipulations (fig. 11).

In the test of ROM of the head-to-neck flexion in group A has increased by 8\(^{0}\). Assessing the percentage scaled value of these changes it makes 13.7% from the average value. In group B it has increased by 6\(^{0}\).
Assessing the percentage scaled value of these changes it makes 10.1% from the average value. Comparing these percentage scaled values we can see that the changes caused by manipulations are by 3.6% more than after the use of vitamins and mineral substances (fig. 11).

ROM of the head-to-neck extension movement in group A has increased by $5^0$. Assessing the percentage scaled value of these changes it makes 6.6% from the average value. In group B it has increased by $4^0$. Assessing the percentage scaled value of these changes it makes 5.9% from the average value. Comparing these percentage scaled values we can see that the changes caused by manipulations are by 0.7% more than after the use of vitamins and mineral substances (fig. 11).

ROM of the head-to-neck rotation movement to the right in group A has increased by $3^0$. Assessing the percentage scaled value of these changes it makes 3.6% from the average value. In group B it has increased by $6^0$. Assessing the percentage scaled value of these changes it makes 2.4% from the average value. Comparing these percentage scaled values we can see that the changes caused by the use of vitamins and mineral substances are by 0.7% more than after manipulations (fig. 11).

ROM of the head-to-neck rotation movement to the left in group A has increased by $5^0$. Assessing the percentage scaled value of these changes it makes 5.8% from the average value. In group B it has increased by $4^0$. Assessing the percentage scaled value of these changes it makes 4.9% from the average value. Comparing these percentage scaled values we can see that the changes caused by the use of vitamins and mineral substances are by 0.9% more than after manipulations (fig. 11).

ROM of the head-to-neck lateroflexion movement to the right in group A has increased by $7^0$. Assessing the percentage scaled value of these changes it makes 13.7% from the average value. In group B it has increased by $4^0$. Assessing the percentage scaled value of these changes it makes 8.5% from the average value. Comparing these percentage scaled values we can see that the changes caused by manipulations are by 5.2% more than after the use of vitamins and mineral substances (fig. 11).

ROM of the head-to-neck lateroflexion movement to the left in group A has increased by $3^0$. Assessing the percentage scaled value of these changes it makes 5.8% from the average value. In group B it has increased by $3^0$. Assessing the percentage scaled value of these changes it makes 6.1% from the average value. Comparing these percentage scaled values we can see that the changes caused by the use of vitamins and mineral substances are by 0.3% more than after manipulations (fig. 11).
Discussion

Analysing the obtained results and assessing the functional state of the segments after AK tests we can see that in both groups we could state NRD for the researched muscles. Assessing the causes of these NRD with vitamins and mineral substances used in this study, we stated that the muscle functional weakness is connected to the disbalance of vitamins and mineral substances in the organism. In literature NRD caused by deficite of minerals and vitamins in different muscles are described by Walther D.S (Walther, 2000). At the same time testing the cervical and cervico thoracal part segment mobility we can see that practically in all ROM lack of movement was observed. To restore movement in the segments and decrease NRD we used manipulations on C0-C3 and C6-Th3 spinal segments as described by Levit K. (Левит, et al., 1993) in group A and 3 week long therapy of using vitamins and mineral substances in group B. After the application of these therapies we can see that in both groups A and B the cervical segment mobility has increased statistically significantly (a ≤0,05). NRD in the muscles of group B have similarly decreased statistically significantly. We should point out that that in group A due to manipulations there is statistically significant decrease of NRD in the neck deep flexor muscles, m.scalenii, m.sternocleidomastoideus, but in m.trapezius (the upper part) NRD practically did not change which we can explained by the fact that in these muscles initially NRD were for only two people.

To evaluate the effect of two different therapies on the cervical and cervico thoracal part of the chest mobility we assessed relative changes caused by these therapies as percentage scaled values. Comparing these results we can see that despite the fact that both therapies gave statistically significant changes, the effect of manipulations to mobility is greater than the therapy of using vitamins and mineral substances.

Conclusions

1. Results of the research approve information mentioned in the literature sources that both therapies increase joint mobility and decrease NRD. Results of the research demonstrate statistically significant (a ≤0.05).

2. Comparing therapies used in the research we got that manual therapy method provides a more significant impact on the neck segment mobility as using vitamins and mineral substances.
References


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INVESTING IN YOUR FUTURE

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FINANCING MODEL FOR THE DEVELOPMENT OF LATVIAN ATHLETES

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Abstract

The organization of Latvian sports has come a long way since its foundation in the period of independence between the first and second World Wars. The following situation has developed in the organisational structure in sport in Latvia, individual sports and training expenses for individuals in these disciplines are financed by the state, whereas, team sports depend on funding provided by local governments, private sponsors and contributors. Subsidies to enable the participation of national teams in international games are allocated from the state budget, but there is no support system for the best representatives of team sports in order to develop their individual skill, as with individual disciplines. A support system for team athletes can facilitate success of a particular kind of sport at an international level. The youth sports system is mainly based on sports schools, which are maintained by local governments and are developing the most talented future athletes. The necessity for the establishment of specialized boardingschools, to bring together the best representatives in each kind of sport, in each age group nationwide, as well as the best professional coaches, is being frequently accentuated. Deficiencies in the public system can be remedied by attracting private capital investors. Organizations operating under the aegis of the Ministry of Education and Science have developed criteria for the allocation of funding to provide training for athletes. The respective allocated funding is intended just for the improvement of the individual skills of athletes. Due to the current economic situation, it is obvious that funding is insufficient to achieve all goals.
**Key words:** Sport in Latvia. Finance for sport. Sport system. Division of support for athletes. Youth development system. Financing criteria. Financing of individual sports and sports organizations.

**Introduction**

The division of funding allocated for sport directly impacts on the development of sport nationwide. The planning of funding is topical in every state looking after the social welfare and health of residents. Sport organizations activities in Latvia are directly or indirectly the responsibility of the Ministry of Education and Science. Sport in Latvia is regulated by the Sports Law, the purpose of which is to specify the general and legal basis for sport organisation and development, as well as the general organizational structure of sport nationwide and the mutual relationship of sports organisations, State and local government institutions and basic tasks in sports development. Public funds for sport are allocated in accordance with the annual law of the State budget. Within the budget the finance for ‘High Class Achievement in Sport’ is specified to always be no less than in the previous year (Sports Law, 2002). Funds allocated for sport also include the financial resources allocated by local governments, legal entities and individuals, sports organizations and allocations by international sport federations. Without greater finance and the resulting improvement in the training process from the age of 14, it is not possible to develop a skilled sports person in team sports, in the highly competitive world of sport. At the same time, taking into consideration the objective limitations of the State Budget, it is impossible to expect State funding for all youth development programmes of high achievement sports and for the preparation of world level professionals for adult sports.

The problem researched within this article is related to the financing model of Latvian athletes, and the summarization of the deficiencies of this model has been performed therein. The goals of the research are: The summarization of the entire funding allocation system to sport by the State, as well as the way these funds go to the best athletes. Clarification of the necessary criteria for acquiring public funds, as well as displaying the lack of State funding for the development of sport nationwide, paying particular attention to high achievement orientated sports.

Several tasks were set to achieve these goals:
- Research of the structure of the sport sector created by the Ministry of Education and Science.
- Determining the role of the most important sport organizations and mutual cooperation in the development of sport and division of funding.
- Assessment of the state budget of Latvia for the sport sector 2015 and the major organizations providing consultations in the budgeting process.
- Research of the impact of the Sports Law of Latvia on the sport sector nationwide.
- Summarization of the allocated state funding to the best athletes individually, as well as acceptance criteria.
- Detection of the deficiencies of financing from the State budget and factors affected by the insufficiency of financial resources for sport in Latvia.
- Development of the proposals for the minimization of financing deficiencies.

*Procedures for the financing of sports in Latvia*

This article includes a summary of the financing of Latvian sport organizations, as well as the amount of funds for individual athletes and the acquirement opportunities thereof. Quantitative research methods and content analysis of the division of sport financing in Latvia are applied (Krippendorff, 2004).

The Ministry of Education and Science performs functions of public administration in the sport sector and has created a sport section. (SportsLaw, 2002) The above mentioned sectioned structure shows the responsibility and mutual cooperation within the sectioned organizations, as well as the division of funding among organizations. The structure of the sector shows how the Ministry of Education and Science governs the sector and provides coherence between the sectioned organizations and the division of funding. Funding for the organizations of the sport sector is allocated both directly from the State budget, and from the budget of local governments. The structure created by the Ministry of Education and Science includes the widest range of sport organizations, as well as institutions of sport education, various organizations governing the sport sector and sport federations, and the State sport medicine centre (Ministry of Education and Science) (fig. 1).

The National Sports Council of Latvia plays an important role in the organization of sport events nation wide. The National Sports Council is a non-governmental, consultative organization, which participates in the development process of the national sport policy, facilitates the development of sport and cooperation, as well as decision making on matters related to sport (Regulation of the National Sports Council of Latvia). The National Sports Council of Latvia is approved by Cabinet of Ministers.
Figure 1. Structure of sports sector (Ministry of Education and Science)
The National Sports Council of Latvia can be considered the main and most worthwhile organization in the sport sector, which is responsible for the division of funds between the structural units of the sport sector (Sports Law, 2002).

The tasks of the Latvian Olympic Unit include the organization and financial support of the best Latvian athletes with the purpose to improve the quality of training. The Olympic Unit supports athletes to facilitate achievement of high class results in official international competition. This year the Olympic Unit has allocated the funding for the training of 103 representatives of individual summer sports and 47 representatives of individual winter sports. (Latvian Olympic Unit)

One of the most important non-governmental organizations is the society “Latvian Olympic Committee”. The Sports Law dictates that the Latvian Olympic Committee directs and coordinates the Olympic movement within the state. The society “Latvian Olympic Committee” implements several programmes through the cooperation of public and municipal funds, as well as financial resources of its own, including the programme of Olympic education, the youth programme of Olympic movement, the programme for regional education of Olympic movement, the programme for general development of sports, as well as the programme for participation of the State’s best athletes in the Olympic Games, Youth Olympic Games and other international and regional complex competitions (Sports Law, 2002).

Similar to the Latvian Olympic Committee, another non-governmental organization playing an important role in the sport sector nationwide is the society “Sports Federations Council of Latvia”. The “Sports Federations Council of Latvia” is an independent union of 88 sports federations of the sport sector recognized in accordance with the procedures set by the regulatory enactments, which, in accordance with the Sports Law, represents and implements common interests of these federations (Sports Federations Council of Latvia).

30 million and 447 thousand Euro in total was allocated to sport in Latvia from the State budget in 2015, and this amount was divided between all parts of the structure of the sport sector. 5 million and 491 thousand Euro was allocated to high-class achievement sports (State Budget, 2015) (tab.1).

Funds are also divided between structural units of the sector, organizations and sport buildings, which have been given importance on a national sport basis, or financial resources are allocated specifically for the design of sports buildings.
Table 1

Budget of the most important organizations of sports sector in Latvia

<table>
<thead>
<tr>
<th>Organization</th>
<th>Budget (€)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Government funding for sport</td>
<td>30 447 916</td>
</tr>
<tr>
<td>State Sport Medicine Centre</td>
<td>100 600</td>
</tr>
<tr>
<td>Bobsleigh and luge track</td>
<td>320 425</td>
</tr>
<tr>
<td>Culture and sport centre “Daugavas stadium”</td>
<td>240 000</td>
</tr>
<tr>
<td>Sport centre “Mežaparks”</td>
<td>45 352</td>
</tr>
<tr>
<td>Tennis centre “Lielupe”</td>
<td>50 000</td>
</tr>
<tr>
<td>Latvian Olympic unit</td>
<td>1 422 903</td>
</tr>
<tr>
<td>Latvian Academy of Sport Education</td>
<td>2 700 000</td>
</tr>
<tr>
<td>Murjanu Sport gymnasiun</td>
<td>4 417 000</td>
</tr>
<tr>
<td>Sport museum of Latvia</td>
<td>81 245</td>
</tr>
<tr>
<td>Council of Sport federations</td>
<td>2 684 054</td>
</tr>
<tr>
<td>Olympic committee of Latvia</td>
<td>4 958 026</td>
</tr>
<tr>
<td>Latvian Olympic club</td>
<td>10 000</td>
</tr>
<tr>
<td>Latvian Olympic academy</td>
<td>16 000</td>
</tr>
<tr>
<td>Olympic social club</td>
<td>1 750 000</td>
</tr>
<tr>
<td>Latvian Paralympic committee</td>
<td>250 000</td>
</tr>
</tbody>
</table>

Many of the abovementioned organizations have been established in accordance with the national “Sports Law”. The “Sports Law” indicates basic principles and purposes of many organizations, as well as the division of funding within the sector. The law provides the basis and principles of the financing of sport with the involvement in the international sports movement. The Sports Law forms the base of all actions within the sport sector of Latvia, and it also plays an important role for the development of the sport sector. It regulates organizational processes and provides successful cooperation of the organizations within the sport sector aimed at the achievement of goals. The basic principles defined by the Sports Law, to be followed within the sports sector and governing all the sports related organizations, are – the principle of equality, the principle of fair play and the principle of safety (Sports Law, 2002).

Funding of Latvian athletes

Individual sports are not directly financed from the State budget. The funding reaches them via the Latvian Olympic Unit; Latvian Olympic Committee. However, there is an opportunity to receive state grants for the organization of various separate sports events or sports projects.

One of the most important supporters of individual sports operating under the patronage of the state administration is the “Latvian Olympic Committee”. For example, the Olympic Committee has allocated 160
thousand Euro for the programme “TOP 50”. The top 50 sportsmen and women of individual sports in Latvia, who have won prizes in European and World championships. In 2015, the Latvian Olympic Committee allocated funding to the amount of 599 thousand Euros for the federations and unions of individual sports, as well as an additional 554 thousand Euro as the financial reference for federations and unions of individual sports. The amount allocated for individuals sports accounts for more than one fifth of all expenses of the Latvian Olympic Committee. The remaining financial resources are spent for the maintenance and participation in the Olympic Games (Latvian Olympic Committee).

As mentioned before, the Olympic Unit supports 108 athletes representing individual summer sports. 48 athletes acquiring funding from eight thousand to 15 thousand Euro each are included in the principal team of Latvian Olympic Unit, thus, the total expense accounts for 189 750 thousand Euro. The funding of training expenses of the principal team of the Latvian Olympic Unit mostly covers athletes representing track and field events. The largest amount of funds was received by the representatives of wrestling Anastasija Grigorjeva and Laura Skujiņa, 14 200 Euro. A nearly equal amount was received by Māris Štrombergs, the Olympic champion in BMX cycling – 14 050 Euro (Latvian Olympic Unit).

In the Latvian Olympic body, a unit of future core participants has been created – the Youth team. 37 athletes have been included in the Youth team; however, the team is still incomplete, because participants named by several sport federations have yet to be included (Latvian Olympic Unit).

In regards to the Youth team of individual summer sports within Latvian Olympic Unit – the total funding of 82 800 Euro has been allocated for the athletes, an individual’s funding varies from 400 to 2800 Euro. Unlike the principal team, domination in one particular sport is not typical in the Youth team; however, there is a similar factor – the highest amount of funds is allocated to wrestlers (Latvian Olympic Unit).

The Olympic Unit has composed a reserve team consisting of 18 athletes preparing for competition, and the Latvian Olympic Unit finances the training. The reserve team will replace athletes from the principal team, who are unable to participate in a competition due to various reasons. The total funding for the reserve team accounts for 12 600 Euro. The funding relating to summer sports for the principal team, youth team and reserve team accounts for 285 150 Euro in total (Latvian Olympic Unit).

As with the athletes of summer sports, the Latvian Olympic Unit supports also the ones of individual winter sports. The unit has also composed a reserve team, which has to be supported during the preparation
for the competition of winter sports. 37 athletes are included in the principal team, while the reserve team consists of 10 athletes (Latvian Olympic Unit).

The total training expenses of the winter sports principal team accounts for 363 825 Euro. The majority of the funds were allocated to the bobs ledders Oskars Melbārdis and Daumants Dreiškens, to the amount of 16 750 Euro (Latvian Olympic Unit). The smallest amount of funds was allocated to snowboard athletes. It is interesting that total amount of funds of the principal team is higher in comparison with the summer team.

The Latvian Olympic Unit has established the selection criteria in the individual summer and winter sports for the Olympic disciplines, by awarding points for each achievement. In the summer sports, points are awarded for being amongst the sixteen of the best athletes of Olympic Games and World Championships. Whereas, to be awarded with criteria points if participating in the European championships athletes must be amongst the best twelve athletes. In the overall score of the World Cup or World Rank, the athlete must be in the top ten. Points are also awarded for being in the top three of the World Cup or World Youth Championship or European Youth Championship (age up to 23). If the athlete takes 4th to 6th position in the abovementioned championships, this provides opportunities for the athlete to receive points for entering the youth team. Similarly, as with the principal team, points are awarded also to the youth team. Taking the 1st-6th position in the World Championship and the European Youth Championship, as well as the World Youth Olympic Games athletes aged 16 – 18 should be awarded points for inclusion in the youth team. As previously mentioned, federations also assign athletes, to be included in the youth team. (Latvian Olympic Unit)

A similar system is also operated for the selection criteria of individuals in winter sports. The 1st-16th position must be taken in the Olympic Games and the World Championships or the 1st-12th position in the European Championships. The 1st-10th position is required in the overall score of the World Cup. The Pedestal of Honour in the stages of the World Cup complies with the criteria, as well as 1st-3rd position in the overall score of the European Cup. The rules for meeting the criteria within the Youth team to enter the team of Latvian Olympic Unit are the same as for summer sports (Latvian Olympic Unit).

The Latvian Olympic Unit has developed a methodology for the calculation of funds and premiums for the unit’s training, assigning a certain value to each achievement, the value is compared accordingly to the amount of money the athlete receives to provide his/her activitie
The methodology for the calculation of funds and premiums for the training explains precisely the amount of funds allocated to each athlete. Table 2 reflects the achievements, resulting in certain funding for training.

Table 2

<table>
<thead>
<tr>
<th>stuff type</th>
<th>criterion</th>
<th>amount for place</th>
<th>estimated total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Olympic Games</td>
<td>1</td>
<td>€ 13 600</td>
<td>€ 900 € 14 500</td>
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<tr>
<td></td>
<td>2</td>
<td>€ 750</td>
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<td>3</td>
<td>€ 600</td>
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<td>6</td>
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<td>€ 13 750</td>
</tr>
<tr>
<td></td>
<td>7 - 8</td>
<td>-</td>
<td>€ 13 600</td>
</tr>
<tr>
<td>World Championship</td>
<td>1</td>
<td>€ 900</td>
<td>€ 14 500</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>€ 750</td>
<td>€ 14 350</td>
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<td>7-8</td>
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<td>€ 13 600</td>
</tr>
<tr>
<td>European Championship</td>
<td>1</td>
<td>€ 450</td>
<td>€ 14 050</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>€ 11 200</td>
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</tr>
<tr>
<td></td>
<td>3</td>
<td></td>
<td>€ 11 350</td>
</tr>
<tr>
<td>World Cup</td>
<td>1</td>
<td>€ 300</td>
<td>€ 11 500</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>€ 200</td>
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<td>€ 100</td>
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</tr>
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<td></td>
<td>11-12</td>
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<td>€ 8 000</td>
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<tr>
<td>World Championship</td>
<td>9</td>
<td>€ 300</td>
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<td>€ 150</td>
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<td>11-12</td>
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<td>€ 8 000</td>
</tr>
<tr>
<td>European Championship</td>
<td>4</td>
<td>€ 450</td>
<td>€ 8 450</td>
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<tr>
<td></td>
<td>5</td>
<td>€ 300</td>
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<tr>
<td></td>
<td>1</td>
<td>€ -</td>
<td>€ 8 000</td>
</tr>
<tr>
<td>WCh U23</td>
<td>1</td>
<td>€ 150</td>
<td>€ 8 150</td>
</tr>
<tr>
<td>ECh U23</td>
<td>1</td>
<td>€ 150</td>
<td>€ 8 150</td>
</tr>
<tr>
<td>OG</td>
<td>13-16</td>
<td>€ 5 600</td>
<td>€ - € 5 600</td>
</tr>
<tr>
<td>WCh</td>
<td>13-16</td>
<td>€ -</td>
<td>€ 5 600</td>
</tr>
<tr>
<td>Ech</td>
<td>7-8</td>
<td>€ -</td>
<td>€ 5 600</td>
</tr>
<tr>
<td>W Cup</td>
<td>7-10</td>
<td>€ -</td>
<td>€ 5 600</td>
</tr>
<tr>
<td>W Ch U23</td>
<td>2-3</td>
<td>€ -</td>
<td>€ 5 600</td>
</tr>
<tr>
<td>E Ch U23</td>
<td>2-3</td>
<td>€ -</td>
<td>€ 5 600</td>
</tr>
<tr>
<td>E Ch</td>
<td>9-12</td>
<td>€ 3 200</td>
<td>€ - € 5 600</td>
</tr>
</tbody>
</table>
As mentioned before, the highest valued criteria for becoming a member of the teams of the Latvian Olympic Unit include successful participation in the Olympic Games and World Championships. Each success in the abovementioned competitions results in funding of a corresponding amount. For example, fourth position in the Olympic Games means an award of 14 050 Euro.

State support for individual sports is mainly provided by Latvian Olympic Unit. The Latvian Olympic Unit directly finances the training of athletes representing individual sports and helps in their development. 655 975 Euro have been allocated for the support of individual sports athletes included in the team of Latvian Olympic Unit. Whereas, funding of the budget programme Olympic Preparation Programme of Latvian Olympic Committee, reached 1 154 360 Euro, including the funding for the sub-programme of individual sports/federation to the amount of 599 960 Euro and the financial reference for the individual sports federations/unions (28 x 19800 EUR) – 554 400 Euro.

The total amount of funding to athletes representing individual sports from the public funds accounts for 1 million 810 thousand and 335 Euro. Funding is the main state support for the improvement of skills of the athletes and the basis for the opportunity to represent our state internationally (On the State Budget, 2015).

Funds paid by local governments and donations and contributions of separate organizations must be added to the funding of individual sports, for example, the SIA “Arčers” supports the Latvian Bobsleigh and Skeleton Federation with the funds directly reaching individual athletes.

Murjāņu Sports Gymnasium should also be considered a supporter of individual sports: athletes in individual sports are enrolled and a support system for individual sports has been developed there. Murjāņu Sports Gymnasium prepares the best new athletes of individual sports in Latvia, for example, in track and field events and rowing.

Conclusions

Sport in Latvia is widely represented in a variety of sports. The residents of Latvia have been given an opportunity to be involved in sport life to the corresponding levels of championship. One of the main goals of Latvian sports organizations, in high achievement sports, is the provision of conditions as good as possible for the achievement of maximum results in the Olympic disciplines. 88 sports federations in total have been founded in Latvia, and they cooperate both mutually and with state institutions.

- The structure of the sport sector created by the Ministry of Education and Science includes all the public sports organizations. The
Ministry of Education and Science is the main governing institution of the sports sector in Latvia. Sport organizations nationwide are related in their activities with other public sport organizations.

- The National Sports Council of Latvia is the most influential organization in terms of the division of funds. The National Sports Council of Latvia plays an important role in the planning of the State budget regarding the funding intended for sport. For the successful organization of sport life, sport organizations significantly depend on other sport organizations within the state, and they largely mutually cooperate.

- In creating a sport life in the state, the Ministry of Education and Science works within the parameters of the law or ‘Sports Law’. The ‘Sports Law’ controls the sport organizations activities and how funding is divided.

- Organizations in the sport sector have developed criteria for the allocation of funds linked to results in adult and youth championships. Athletes can apply for public funds if they meet the criteria, to provide preparation for competitions.

- Due to deficiencies in the structure of the State budget funding, the following situation has arisen: In Latvia public funds are allocated for the training process of the athletes representing individual sports only if the athlete has met the selection criteria. High-class individual athletes have the opportunity to improve the level of their sport excellence using public funds allocated for the training process. In comparison, for the representatives of team sports, including members of national adult teams, acquirement of public support for individual training to provide individual growth is practically impossible. The matter regarding opportunities of how to improve the level of sport excellence is of particular importance for the athletes, who have achieved good results within national youth teams – for they have not started their own professional careers, therefore the training must be financed from their own funds.

Upon summarization of the collected information on the allocated funding for the athletes in Latvia, one can come to the conclusion that public support has been allocated to individual sports, especially in regard of adult athletes. Due to objective considerations, funding from the State budget cannot be allocated to all athletes, and it would be especially hard to assess and allocate it in the context of representatives of team sports.
Proposals

In securing a high level training process for athletes of team sports, especially the youth, the State sport community would gain strong representatives internationally, which would increase team sport achievement in international competitions.

Following the conclusion that the State opportunities in the financing of athletes are very limited, the lack of public funding can be compensated by attracting private funding. Since the majority of the representatives of team sports receive remuneration from the represented teams, a system for the attraction of private investors aimed at the development of sports must be established nationwide. A private investor, who has invested in the development of sports and athletes, would gain benefit proportionally to the investments and achieved results.

The investment of private funds in athletes is being widely practiced abroad, and the Latvian sports sector can learn from foreign examples (Forbes, 2012).

Compensating the lack of public fundswith private funds could lead to further development of the sports sector in general, both in terms of individual and team sports, because private investors would opt to invest in athletes, who are currently not able to meet the criteria set by public organizations, as well as in the representatives of team sports, thus filling the lack of public funding and enhancing the success of sport nationwide. Private investors must be attracted for the kinds of sports which are important at national level, for the development of sports sector in general.

References

RUNNING ECONOMY AND BLOOD LACTATE ACCUMULATION IN ELITE FOOTBALL PLAYERS WITH HIGH AND LOW MAXIMAL AEROBIC POWER

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Abstract

The purpose was to determine running economy and lactate threshold among a selection of male elite football players with high and low aerobic power. Forty male elite football players from the highest Swedish division (“Allsvenskan”) participated in the study. In a test of running economy (RE) and blood lactate accumulation the participants ran four minutes each at 10, 12, 14, and 16 km·h⁻¹ at horizontal level with one minute rest in between each four minutes interval. After the last sub-maximal speed level the participants got two minutes of rest before test of maximal oxygen uptake (VO₂max). Players that had a maximal oxygen uptake lower than the average for the total population of 57.0 mL O₂·kg⁻¹·minute⁻¹ were assigned to the low aerobic power group (LAP) (n=17). The players that had a VO₂max equal to or higher than 57.0 mL O₂·kg⁻¹·minute⁻¹ were selected for the high aerobic power group (HAP) (n=23). The VO₂max was significantly different between the HAP and LAP group. The average RE, measured as oxygen uptake at 12, 14 and 16 km·h⁻¹ was significantly lower but the blood lactate concentration was significantly higher at 14 and 16 km·h⁻¹ for the LAP group compared with the HAP group.

Key words: football, aerobic power, running economy, lactate accumulation

Introduction

The duration of the football match in combination with the load on the aerobic system of about 75% of maximal oxygen uptake (VO₂max)
Stølen et al. 2005), indicate that the main energy contribution comes from aerobic processes. The size of the mean aerobic power of a team is related to the position in the league (Apor et al., 1988, Wisslöf et al., 1998). Thus, aerobic power, per se, seems to be a performance factor in football. From a theoretical point of view running economy (RE), measured as oxygen uptake per kg body mass at a given speed and lactate threshold (LT), defined as the work intensity at which the lactate no longer can be metabolized at a rate as it is produced, may also be performance factors in football.

In aerobic sports where the speed is kept constant or close to constant for a long period of time the benefits with a good running economy and a high lactate threshold are obvious and have proven to be important for a high performance level (Sjödin & Svedenhag, 1985). However, the football game is also characterized by a constantly occurring variation in work intensity related to what happens on the football field like e.g. standing, walking, jogging, running, high-speed running, and sprinting. High speed running and sprinting will highly tax the anaerobic energy system involved in the energy production causing an oxygen deficit which will be paid for during the periods of low work intensity. This transition between energy systems in combination with different locomotory forms may make assumptions about the specific contribution from a good RE and high LT harder to do (Buchheit et al., 2011). However, it has been argued that football players with a high VO$_{2}\text{max}$ have a lower lactate production at given speeds (MacRae et al., 1992). If this also is the case with RE still lacks scientific support. Although, test data only indirectly indicate the association between RE, LT and VO$_{2}\text{max}$ versus performance during the game it may give some insight into how these parameters are interrelated.

Thus, the purpose with the present investigation was to study maximal oxygen uptake, running economy and blood lactate accumulation at given speeds in elite male football players with high and low maximal aerobic power. The comprehensive set of data will allow that the interrelation between these parameters can be simultaneously evaluated.

**Materials and methods**

In total 40 male elite football players at the highest Swedish division (“Allsvenskan”) took part in the study at the end of the match season. The players were informed about the tests and their right to finish without giving any explanation. The players were divided into two groups, a high aerobic power group (HAP) and a low aerobic power group (LAP) with respect to their VO$_{2}\text{max}$ with the mean value of the whole group of 57.0 mL O$_2$•kg$^{-1}$•minute$^{-1}$ as reference value (Tab. 1).
**Table 1**

Average (±sd) age, height, body mass and VO$_{2\text{max}}$ of players in the high and low aerobic power groups

<table>
<thead>
<tr>
<th></th>
<th>Age (years)</th>
<th>Height (m)</th>
<th>Body mass (kg)</th>
<th>VO$_{2\text{max}}$ (mL O$_2$·kg$^{-1}$·min$^{-1}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High aerobic power</td>
<td>22.5±3.3</td>
<td>1.80±0.05</td>
<td>76.3±5.3</td>
<td>59.7±2.3</td>
</tr>
<tr>
<td>group (N=23)</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Low aerobic power</td>
<td>26.8±4.8</td>
<td>1.81±0.07</td>
<td>82.8±8.5</td>
<td>53.2±2.0</td>
</tr>
<tr>
<td>group (N=17)</td>
<td></td>
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</tr>
</tbody>
</table>

**Apparatus and test setup**

Running economy, blood lactate accumulation and maximum oxygen uptake was determined during running on a motor-driven treadmill (Cybex Stable flex, Cybex International Inc., US). RE was defined as oxygen uptake (mL O$_2$·kg$^{-1}$·minute$^{-1}$) during running at a given speed. Blood lactate accumulation at given speeds was used to define lactate threshold (Heck et al., 1985).

In order to allow comparison of RE and LT in the present study with future studies measures were undertaken to calibrate speed and to define the stiffness characteristics of the treadmill. The treadmill speed was calibrated by recording a reference point on the moving treadmill belt by means of a video camera (film rate: 50Hz). The preset speed and the calculated speed from the video recording were compared when the treadmill was loaded with a subject (71.3kg body mass) running on the treadmill from 10km•h$^{-1}$ to 20km•h$^{-1}$. The deviation from the preset speed was less than 1.5% in all cases. The stiffness of the running surface of the treadmill, defined as surface deflection per kilo load (per N vertical force), was tested. The treadmill belt was cumulatively loaded with weights (50kg) up to 250kg, which corresponds to a vertical force of 2453N. The deflection of the treadmill was measured with a micrometer at the level of the load position. Surface deflection for every added 50 kg weight was registered. The relationship between deflection (Y) per added mass (X) was best expressed by the polynomial equation $Y=0.025876 + 0.04065X + (-1.48756E^{-5}X^2)$.

The oxygen uptake at sub-maximal and maximal workload during running on a treadmill was determined by means of an automatic measuring system for oxygen uptake with a mixing chamber (OxygenPro, Jaeger GmbH, Germany). This system was validated before the test by means of a comparative in series measurements of OxyconPro and Douglas bags that
were analyzed separately. The OxyconPro was also validated by means of a metabolic simulator (oxygen uptake simulator) (Vacu-Med Inc. US). No significant deviation in results was seen when the results from these comparisons were analyzed. The blood lactate concentrations during running on sub-maximal and maximal intensities were determined by blood from a punctured fingertip. The blood sample (20µL) was analyzed with an electro-enzymatic method (Biosen C-line, EKFdiagnostic GmbH, Germany), which was calibrated by means of standard lactate solutions at a concentration of 2.7 and 18 mM•L⁻¹.

**Test procedures**

All participating players were accustomed to treadmill running before the test. In the running economy and lactate threshold test the participants ran four minutes each at 10, 12, 14, and 16km•h⁻¹ on the treadmill at horizontal level. Between the run at each speed level the participants got one minute of rest when a blood sample was collected. After the last sub-maximal speed level the participants got two minutes of rest before the test of VO₂max. This test of VO₂max started with running on the horizontal level at 14km•h⁻¹. After one minute the speed was increased to 15km•h⁻¹ and this speed were kept for one minute. Subsequently the speed was increased with 0.5km•h⁻¹ each minute until the speed 20km•h⁻¹ was reached. Most of the players were physically exhausted and had terminated the test before this speed level. The different test parameters were constantly checked during the test of VO₂max. Criteria for reaching VO₂max were: “leveling off” in oxygen uptake and/or respiratory exchange ratio (RER) > 1.1, perceived exertion according to Borg and co-workers (1985) higher than or equal to “very hard” and rate of increase in pulmonary ventilation. The rated perceived exertion was registered immediately after the termination of the test of maximal oxygen uptake and after three minutes a blood sample was collected for determination of blood lactate concentration.

**Statistics**

For statistical calculations the StatView statistical package for (Windows version 5.0, SAS Institute Inc., USA) was used. All data are reported as mean ± standard deviation (sd). Differences between the LAP and HAP group were assessed by means of a t-test. Statistical significance was set at the alpha level 0.05.

**Results**

Statistical comparisons were performed between the two groups. The players in the HAP group was significantly younger, had a significantly lower body mass than the LAP group (Tab. 1). Significant differences
were found in VO$_{2\text{max}}$, running economy at 12, 14, 16km•h$^{-1}$ (Figure 1), as well as in lactate accumulation at 14 and 16km•h$^{-1}$ (Figure 2).

![Figure 1](image1.png)

**Figure 1.** Mean (±sd) oxygen uptake during running at 12, 14 and 16km•h$^{-1}$ as well as maximal oxygen uptake for the high aerobic power group (HAP) and low aerobic power group (LAP)

The HAP group showed 3.5-4.1% significantly higher oxygen uptake at speed 12, 14, and 16 km•h$^{-1}$ than the LAP group (Figure 1). On the other hand, the blood lactate accumulation was significantly higher for LAP compared to HAP at 14 and 16 km•h$^{-1}$ (Figure 2).

![Figure 2](image2.png)

**Figure 2.** Mean (±sd) blood lactate accumulation during running at 12, 14 and 16km•h$^{-1}$ as well as after test of maximal oxygen uptake for the high aerobic power group (HAP) and low aerobic power group (LAP)
Discussion

Successful performance in endurance events are strongly correlated to VO$_{2\text{max}}$ (Bangsbo, 1994; Ekblom, 1986; Mohr et al., 2003; Withers et al., 1982). Football can be regarded as a complex endurance sport in which it also has been shown that VO$_{2\text{max}}$ can be related to team success (Apor et al., 1988; Wislöff et al., 1998). Fatigue-related decline in technical proficiency for a given intensity is associated with the fitness level of the players (Rampinini et al., 2008). There was a significant difference in VO$_{2\text{max}}$ between the LAP group and the HAP group. In endurance sport athletes with similar VO$_{2\text{max}}$ running economy is a better performance predictor than VO$_{2\text{max}}$ alone (Withers et al., 1982; Knowles & Brooks, 1974). Running economy among endurance runners seems to be related to morphological factors where a high percentage of slow twitch fibers is associated with a superior running economy (MacRae et al., 1992; Heller et al., 1992; Hoff & Helgerud, 2002). It has also been shown that long distance runners have a better running economy than middle-distance runners (Rienzi et al., 2000; Saltin, 1973; Bunc et al., 1987). The demands in football will probably complicate this optimization due to the need for explosive movements and sprints as well as aerobic performance in combination. The running economy was significantly better i.e. less oxygen was used in the LAP group at the higher sub-maximal speeds (12, 14 and 16km•h$^{-1}$). Thus, in our study the HAP group utilized significantly more oxygen than the LAP group at the tested speeds. The lower blood lactate production in the HAP group was in line with the results of MacRae and co-workers (1992). From a performance perspective it is however important to note that the HAP group could run at 14 and 16km•h$^{-1}$ with a significantly lower blood lactate concentration, which may indicate that the players in the HAP group consumed more oxygen at a given speed but with a lower lactate production. In endurance events the ability to maintain a high speed with a low blood lactate concentration is important. Thus, a small blood lactate accumulation at given speeds is a good indicator of endurance performance (Bangsbo et al., 1991). According to Ziogas and co-workers (2011) velocity at anaerobic threshold can be used to better discriminate endurance characteristics of football teams of different level along with maximum oxygen uptake during preseason testing.

Conclusions

The players in the HAP group i.e. players with the highest maximal oxygen uptake showed higher oxygen uptake at higher speeds but lower lactate concentration than the LAP group. Thus, the HAP group may have spent more oxygen to avoid excessive lactate production something that
may be beneficial to avoid fatigue. At the moment the data are only indirect and further studies are needed to understand the role of RE and blood lactate accumulation in football.

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ORIGINAL RESEARCH PAPER

PSYCHOSOMATIC AND SOMATIC PROBLEMS IN FUTURE HEALTH EDUCATORS: CHANGES AND RELATIONS WITH LIFESTYLE FACTORS

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Abstract

The aim of the research is to determine the changes in psychosomatic and somatic problems of future health educators by analyzing the relations of these symptoms with lifestyle factors. The same questionnaire was used in the surveys carried out in 2008 and 2013 in order to evaluate the variables. The respondents were asked how often they had different psychosomatic and somatic complaints over the last 12 months. These complaints were compared with health lifestyle (doing physical activity, frequency of alcohol consumption and smoking) factors. The participants in the first survey (2008) were 168 students (65 male and 103 female), while the participants in the second survey (2013) were 186 students (81 male and 105 female). According to the study results, sleeping disorders were more frequent in the first course male students in 2013 than in 2008. In addition to these disorders, female students complained that they had headache, shoulder and neck pain and backache. It was noticed that in the second survey there were more female respondents who smoked almost every day (17.9% and 8.1% respectively) and less physically active female respondents (52.4% and 21.6% respectively). Thus health educators who are less physically active have a greater probability to have psychosomatic and somatic problems.

Key words: future health educators, psychosomatic and somatic problems, lifestyle.

Introduction

Health educators, as the ones engaged in providing health services to society, taking care of a positive attitude to health on the part of the society,
children in particular, are responsible for realizing the valuable purpose of physical education. This means that future health educators (future – future specialists) should command respect of the society by their way of living and health condition, as their mission in life will be to display to their clients the social purport of physical education and health encouraging them to form and put into practice a program of physical activity corresponding to the functional capacity of the body and directed at developing health and social abilities. Such a purpose of physical education and health promotion can be realized only by a qualified specialist who strives for developing and perfecting his/her competence (Wong, Louie, 2002). Furthermore, such an educator must be firmly determined on his own physical education and personal example. It deserves noting that health educators should distinguish themselves among other providers of health services by their physical fitness (Muszkieta, 2005) and should be an example to be followed to their clients by a healthy mode of living (McKenzie, 2007).

A deeper analysis into professional skills and peculiarities of future health educators has revealed a decrease in attention of future specialists to emotional dimensions of professional activities (Kardeliene, Kardelis, 2006) with negative habits becoming ever more prevalent in the lifestyle of future specialists (Allender et al, 2008).

Speaking about future specialists it is worth remembering the research done at six universities of Kaunas in the years 2000 (Petrauskas, 2004). The research presented the results of estimation of the peculiarities of health and lifestyle of the first – years students, psychosomatic and somatic problems included. A comparison of manifestation of these health disorders within various groups of the subjects with respect to different spheres of studies was made. No distinction between future health educators on the one hand and the rest of the students on the other hand, however, was undertaken.

Taking into account the principal purpose of professional activities of health educators, that of strengthening health of the members of society and forming their positive attitude to a healthy mode of life, there are all grounds to believe that positive habits of physical activity and a healthy lifestyle advocated by representatives of this profession should contribute to decreasing the manifestations of the problems mentioned above. Still the current changes taking place within the society, as well as the developments undertaken by the sociopolicy of the country have effect on all citizens, health and lifestyles of future specialists included.

The present research is based on the presumption that psychosomatic and somatic ailments and induces of negative factors of improper lifestyle
are more typical for entrants to the Lithuanian sports university (LSU) of the year 2013, compared to their counterparts of the year 2008.

The aim of the research was to determine the changes in psychosomatic and somatic problems of future health educators by analyzing these symptoms in relation to lifestyle factors.

Materials and Methods

Participants. The first anonymous survey of first – year students was undertaken in the years 2008 and the second one – in the years 2013. The first survey embraced 168 students, 65 male and 103 female among them, and second one – 186 students, 81 male and 105 female respectively.

Methods. During the two surveys undertaken in the years 2008 and the same questionnaire divided into separate groups was applied (Petrauskas, 2004). For the assessment of psychosomatic and somatic ailments a 10 – point scale was used (Stock, Kramer, 2000). The subjects were asked how often during the last 12 months they had been troubled by various health disorders (Tab. 1). According to the frequency of health disorders the subjects were divided into 2 groups. The persons who were never or very rarely troubled by ailments mentioned above were attributed to group 1, whereas the ones who experienced ailments frequently or very frequently were attributed to group 2. Besides, each of the psychosomatic and somatic ailments was assessed by a sum of points that was calculated by attributing a respective point to each variant of the answers given as follows: from 1 point for the answer “never” to 4 points for the answer “very frequently”, accordingly. The sum of points gained allowed us to form 2 groups of the subjects. The students who were never or very rarely troubled by ailments and whose sum of points equaled or was less than the median were attributed to group 1, and the students who experienced ailments frequently (with the sum of points exceeding the median) were attributed to group 2.

Of lifestyle factors the frequency of smoking, consumption of strong alcoholic drinks (whisky, vodka, etc.) and physical activity during the last 3 months was assessed. The students who alongside with obligatory classes of physical activity at the university exercised or went in for sports in their free – time at least 2 – 3 times for week with intensity causing sweat and faster breathing were considered physically active ones.

Research procedures. The students filled in the questionnaires after listening to the introductory instructions given during practical classes. The purpose of the research was explained and anonymity of the answers given in the questionnaires was emphasized. The students filled in the
questionnaires and returned them to the researcher during the practical classes. This procedure of the research enabled him / her to recover all the questionnaires handed out since they had been filled in by all the students who participated in the given class. The students were informed that their participation in the survey was entirely voluntary one and they were allowed to withdraw without finishing or even without starting to fill in the questionnaire. Most of the students found it welcome that their opinion and problems faced were appreciated.

Statistical analysis. In the assessment of statistical relations of qualitative factors the Chi square criterion was used and for comparing the samples of quantitative factors the Student’s $t$ test was applied. To assess the dependency of psychosomatic and somatic problems on lifestyle factors the logistic regression analysis was applied.

Results

Changes in psychosomatic and somatic ailments were assessed after joining the variants of answers “frequently enough” and “very frequently” given by the respondents into a single answer “frequently and very frequently”. These data are presented in Table 1.

### Table 1

The percentage of students who frequently and very frequently were troubled by psychosomatic and somatic ailments in the years 2008 and 2013 (in percent)

<table>
<thead>
<tr>
<th>Ailments</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2008</td>
<td>2013</td>
</tr>
<tr>
<td>1. Headache</td>
<td>7.4</td>
<td>11.2</td>
</tr>
<tr>
<td>2. Nervousness and uneasiness</td>
<td>28.8</td>
<td>30.4</td>
</tr>
<tr>
<td>3. Depression and low spirits</td>
<td>18.3</td>
<td>20.4</td>
</tr>
<tr>
<td>4. Sleep disorders and sleeplessness</td>
<td>11.6</td>
<td>31.1*</td>
</tr>
<tr>
<td>5. Fast heart rate and dizziness</td>
<td>7.9</td>
<td>7.1</td>
</tr>
<tr>
<td>6. Diarrhoea</td>
<td>0.9</td>
<td>2.4</td>
</tr>
<tr>
<td>7. Constipation</td>
<td>0.8</td>
<td>0.8</td>
</tr>
<tr>
<td>8. Gastric ailments and heartburn</td>
<td>12.9</td>
<td>12.1</td>
</tr>
<tr>
<td>9. Backache</td>
<td>18.7</td>
<td>20.1</td>
</tr>
<tr>
<td>10. Neck and shoulder pains</td>
<td>14.4</td>
<td>20.3</td>
</tr>
</tbody>
</table>

* p<0.01 the data of the years 2008 and 2013 compared

From the data presented in Table 1 one can see that some portion of the students were troubled by various health disorders and they were more characteristic of female students. Most of them were nervous and uneasy frequently or very frequently during the last 12 months. It is worth nothing that the female students complained of headache, sleep disorders and
sleeplessness more frequently in the year 2013 than in the year 2008. It is of interest that these health disorders were characteristic of the male students too but in the more recent research made female students complained of backache and pains in the neck and the shoulder more frequently. The results show that sleep disorders and sleeplessness were more frequent while the number of other complaints remained stable in the group of male students. Thus, female students were more troubled by psychosomatic and somatic ailment since during the period of study they were more frequent in the group of female students, compared to that of male students.

The assessment of the problems mentioned according to the sum of points showed the point average of psychosomatic and somatic ailments of male students to have been 16.86±0.54 points in 2008, compared to 18.68±0.59 points in 2013 respectively (p<0.05). The same changes have been observed in the group of female students, as the point average of the ailments discussed equaled 18.94 ± 0.56 points in 2008, and this figure had increased to 20.81±0.59 points (p<0.05) in the year 2013.

The date regarding physical activity of future specialists indicate that female students did physical exercises more rarely, as show by the research results of the years 2008 and 2013, i.e. 21.6% and 52.4% (p<0.001) respectively. Less negative changes have been registered in the group of male students.

The results of the research done indicate that there are no statistically significant changes in the consumption of strong alcoholic drinks by future specialists. This means that both in the years 2008 and 2013 the frequency of consumption of these drinks remained nearly the same, except for the fact that the percentage of male students who indicated they never consumed strong alcoholic drinks had grown from 2.1% in 2008 to 11.3% in 2013 (p<0.05). No marked changes in the percentage of female students who consumed strong alcoholic drinks have been registered either.

Speaking about the lifestyle of future specialists it is of importance to note that according to comparison data of the years 2008 and 2013 presented in Table 2 there was a statistically significant increase in the number of female students who smoked nearly every day. It is of interest to note that certain positive changes have been registered in the smoking habits of male students, as there was a light increase in the number of non – smokers according to the data of the year 2013, whereas the number of those who smoked nearly every day remained nearly the same.
Table 2

The frequency of smoking during the last 3 months of the years 2008 and 2013 (in percent)

<table>
<thead>
<tr>
<th>The frequency of smoking</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2008</td>
<td>2013</td>
</tr>
<tr>
<td>1. Nearly every day</td>
<td>28.8</td>
<td>27.3</td>
</tr>
<tr>
<td>2. On special occasions</td>
<td>29.3</td>
<td>18.0</td>
</tr>
<tr>
<td>3. Never</td>
<td>39.7</td>
<td>48.4</td>
</tr>
</tbody>
</table>

* p<0.05, the data of the years 2008 and 2013 among female students compared

After the analysis of the relationship between the factors of psychosomatic and somatic ailments on the one hand and lifestyle factors on the other hand it was found in the research done in 2008 that future specialists, who were less troubled by psychosomatic problems, were more active physically (49.1% and 63.4%; p<0.03). This relationship was also evident in the research done in 2013: the students, who were less troubled by psychosomatic problems, were more rarely less active physically (68.3% and 49.2%; p<0.01). Besides, the future specialists, who had less psychosomatic complaints, smoked more rarely nearly every day (20.2% and 29.4%; p<0.05), as well as smoked more seldom daily and consumed strong alcoholic drinks 2 – 3 times per week (9.8% and 19.5%; p<0.05) in the year 2013.

The relationship revealed between the factors of psychosomatic and somatic problems on the one hand and lifestyle factors on the other hand shows that some of lifestyle factors mentioned above have constant connections with separate factors, i.e. their relationship repeats itself, as evident from both surveys done in the years 2008 and 2013. Thus one could speak about the importance of lifestyle factors for the manifestation of psychosomatic and somatic ailments. Regression analysis of psychosomatic and somatic problems according to the data of the survey undertaken in the year 2013 and lifestyle factors shows that future specialists due to small physical activity have a greater probability of being faced with psychosomatic and somatic problems.

Discussion

The results obtained from the research done can be explained in accordance with the level of awareness of professional role in which, according to K. Green (2002), two distinct factors could be singled out: personal habits and the context of behavior, i.e. the level the person is aware of his own importance as well as limitations and restrictions imposed on him. Habits, as a dimension of the role played in life means that a network
of social relations of young people can affect their values, views, inclinations, etc. and can be decisive as regards their priorities. Therefore this process, as indicated in literature on the subject (Green, 2002), is called unconscionable assimilation of assimilation of tastes. Thus, by participating in the network of social relations a person is subject to changes since his habits undergo changes too. Still changes in habits that constitute the second nature of the person that operates as an automatic blindly functioning mechanism of self – control are slower than changes taking place in the person’s social relations. It is said therefore that personal views are associated with yesterday’s experience. Such an attitude to the results of the research enables one to get a bit closer to the explanation of a social conditionality of the behavior of future specialists and allows one to speak about health and lifestyle problems of schoolchildren as future students. It has been found that the lifestyle of teenagers is not conducive to health (Grabauskas et al., 2004) since they regard their learning load as an excessive one (Sketerskiene et al., 2008) and complain of fatigue (Vaitkevicius et al., 2008). Furthermore, according to the data of the survey undertaken in the year 2006 every third schoolboy of the 11th – 12th forms practiced smoking frequently and the consumption of strong drinks is spreading with every year since the consumption of strong alcoholic drinks has doubled during the period from 2000 to 2006 (Baleviciene, Pauriene, 2007). This circumstance partly accounts for the widespread smoking and consumption of strong among future specialists. This context will be further developed in discussing the relation of psychosomatic and somatic problems of future specialists with certain factors of their lifestyle with special reference to the nature of changes, comparing the data of surveys carried out in the years 2008 and 2013.

A deeper analysis into the peculiarities of research data as regards the gender of students has shown that both in the years 2008 and 2013 female students were more frequently faced with psychosomatic and somatic problems than their male counterparts. Such a fact has been registered by other researchers too (Petrauskas, 2004; Unalan et al., 2008). Besides, female students complained that they had headache, shoulder and neck pains and backache more frequently than male students. What is most important is the fact that negative changes had been observed throughout the period of study. This phenomenon could be explained taking into account the following peculiarities of the lifestyle of female students: these problems are characteristic of less physically active students (the number of physically active female students had decreased by nearly 50 percent during the period
of study) and associated with an increase in smoking (practiced nearly every day).

The fact that a greater number of female than male students maintain that they frequently feel unable to deal with the psychosocial problems that trouble them allows us to assert that future female specialists may encounter difficulties in their professional activities. This argument finds support in publications of other authors as regards the scale of values typical for female students and their attitude to health. Thus, for instance, female students more frequently than male students of the LSU characterize themselves as sensitive and honest personalities who consider friendship and welfare of the family of great importance. They are of the opinion that they lack confidence in themselves (Malinauskas, 2008) and admit that they should take a greater care of their health (Griniene, Zachovajevas, 2008). A great number of roles (daughter, friend, educator, provider of health services, wife, etc.) that women are willing to perform frequently adds to stronger distress and greater morbidity as well as hinders their professional career without some social support being provided to them (Harbour et al., 2008). It is thought that headache, neck and shoulder pains and backache can also be caused by a great deal of time given to studies. The research done in both schoolchildren (Baleviciene, Pauriene, 2007) and students of LSU (Kardeliene, Kardelis, 2006) comes to the same conclusions. It is of importance that other authors writing about physical activity of girls and females in general emphasize physical activity as a means of preventing headache, backache, as well as neck and shoulder pains (Allender et al, 2008).

The research done in 2013, likewise the one done in 2008 revealed the same relationship between psychosomatic problems on the one hand and changes in such lifestyle factors, as physical activity and frequency of smoking. This relationship is supported by the data of other researchers (Allender et al, 2008) while negative changes in the frequency of smoking have also been found among, female students by the authors who have made a study of the students of Kaunas university of medicine from the 1st to 6th years (Veryga, Stanikas, 2005).

The course of development of professionalism and professionalization at the university of future specialists, as providers of health services, in the context of our research might also be explained by subconscious awareness of the assimilation of tastes that emphasizes the importance of habits for personal behavior. The research done shows that signs of de – professionalization are typical for students, as a group united by similar lifestyle habits and these signs become ever more apparent during
the course of studies irrespective of the sphere of studies chosen (Jankauskas et al., 2007). Besides, very frequently the profession of health educator is chosen by school leavers who are more interested in obtaining the university graduation diploma than in the specific character of their professional activities since 17.5% of students share an unfavourable attitude to their future profession (Karanauskiene, 2006). Is is worth nothing that during the years of studies the motivation of future specialists for taking care of their physical fitness is getting weaker and weaker, whereas negative changes in their social behavior connected with health become ever more apparent, i.e. the students practice smoking and consumption of alcohol more frequently (Кардялис и др., 2007). Such facts give us grounds to assert that some portion future specialists are not ready for professional activities, as the personal example of education, one of the basic principles of education, particularly emphasized in hodegetics, will hardly be realized. In forming the awareness of values of clients concerning health lifestyle and physical activity throughout one’s life it is frequently that the personal example of health educator has greater effect on clients than all techniques of education taken together. It is doubtful if a future specialist, who is aware of the values of health but do not acknowledge them, will be on example of desirable social behavior to be followed. Such a situation will only make the process of de – professionalization stronger since, according to subconscious awareness of the assimilation of tastes, habit as a dimension of role is a personality construct that changes slowly.

Conclusions

1. A comparative analysis of the results obtained has shown that future health educators, entrants to the 1st year of studies at the LSU, in 2013 faced greater psychosomatic and somatic problems than their counterparts, entrants to the university in the year 2008. Thus, male students were troubled by sleep disorders more frequently, whereas female students alongside with these problems complained of headache, backache, as well as pains in the neck and the shoulder more frequently, compared to male students.

2. During the period of the research the number of less physically active female students and the ones who smoked nearly every day had grown. The changes mentioned above were less apparent among male students though a greater number of them indicated that they did not use any strong alcoholic drinks in 2013.

3. According to the data of a logistic regressive analysis the manifestation of psychosomatic and somatic problems among future specialists can be increased by a small physical activity.
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ORIGINAL RESEARCH PAPER

THE EFFECT OF SPEED TRAINING ON SPRINT AND AGILITY PERFORMANCE IN 15-YEAR-OLD FEMALE SOCCER PLAYERS

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Abstract

The main aim of this study was to investigate the effects of short burst speed and change-of-direction exercises on sprint and agility performance in youth female soccer players 15.5 (±0.7) years. One training group (n=10) followed an eight-week, once per week training program consisting of short-burst sprinting exercises in addition to two normal soccer training sessions, while a control group (n=9) followed three traditional soccer training sessions. Pre- and post-tests assessed significant improvement in 10 m sprint, pre 1.99 s (±0.08), post 1.91 s (±0.09), 20 m sprint pre 3.53 s (±0.15), post 3.42 s (±0.15), and agility performance, pre 8.23 s (±0.31), post 7.80 s (±0.33). Control group (15.1 years (±0.7) did not demonstrate significant change in performance during the intervention period. The results demonstrate that a training program of short burst high speed exercises improve linear sprint and agility performance in youth female soccer players, beyond the gain of traditional soccer training consisting of small-sided games.

Key words: acceleration, sprint training, young female, agility testing, soccer

Introduction

Soccer is one of the most popular sports among children and youth worldwide, with an increasing number of young female players (Vescovi et al., 2012). Among the different physical qualities needed are the ability to perform straight-line sprint and positive and negative acceleration with rapid changes of directions, often referred to as agility (Muijka et al., 2009). Previous studies have shown a difference in running speed between high-
level and the non-elite youth players in those qualities (Mujika et al., 2009; Malina et al., 2007; Gissis et al., 2006), and sprint performance has been reported to be among the most important variables in predicting player selection (Vescovi, 2012; Gil et al., 2007).

It has been an increased focus on the trainability in the youth age, however, there is little empirical evidence regarding the efficacy of sprint training methods in youth females (Vescovi et al., 2011). Most experiments have been conducted on males, with programs combining strength and speed training (Rumpf et al., 2012; Maio Alves et al., 2010; Faigenbaum et al., 2007). Reports of male youth athletes aged 14 to 18 years, have showed an enhanced effect on sprint with high-intensity strength and speed training (Jovanovic et al. (2011; Mujika et al., 2009; Kotzaminidis et al., 2005). Buchheit et al. (2010) found that a 10 week training program, with one hour per week shuttle sprint and explosive strength training, produced significant improvement in 30m sprint, but no significant improvement in 10 meter sprint in adolescent male soccer players. Hughes et al. (2012) reported enhanced sprint performance in males aged 12 and 15 years, but not in 13 or 14 years, combining speed training and plyometric drills. A program consisting of high-speed and plyometric exercises in 13-year-old males, significantly improved both 20 m linear running speed, and agility performances (Mathisen, 2014).

Polman et al. (2007) found positive effects of a speed and quickness program on 25 m linear sprint and agility performance in 21.2 (± 3.1) year-old female soccer players. However, to our knowledge, there is only one study among youth female soccer players, high-speed exercises produced significant improvement in speed and agility in 13-year-old females (Mathisen & Danielsen, 2014). Furthermore, it is unsolved whether traditional soccer training, consisting of small-sided games, can provide enough stimuli to sufficiently increase sprint performance in young players (Jullien et al., 2008). Previous research has proposed high intensity up to maximal effort during exercises as a key factor in these abilities (Pettersen & Mathisen, 2012). Given the limited body of knowledge, the aim of the present study was to examine the effects of short burst speed exercises on straight-line sprint and agility in 15-year-old female soccer players.

**Material and methods**

**Subjects.** An initial sample of 14 regional female soccer players with a mean age of 15.5 (± 0.7) years was selected. However due to injury, and non-attendance at the testing sessions, the sample was reduced to 10 players. In addition to the intervention program, the participants in the training group (TG) undertook two one-hour organized regular soccer-training sessions
consisting of technical drills and small-sided games. Nine female soccer players from the same league, and at similar performance level, mean age 15.1 (± 0.5) years, served as a control group (CG). The CG undertook three organized sessions of soccer training per week, consisting of technical drills and small-sided games. Written informed consent was obtained from both the participants and their superiors. The study was conducted according to the Declaration of Helsinki, and the study was given institutional ethical approval, and meets the ethical standards in sports and exercise science research (Harris & Atkinson, 2011).

Experimental Approach to the Problem. To compare the effects of speed training versus traditional soccer training we tested 10m (meter) and 20m linear-sprint and agility performance, before and after an eight-week conditioning program. The intervention took place in the preseason period, and the training group (TG) replaced one of three ordinary soccer-training sessions consisting of technical drills and small-sided games, with a program of speed training. Pre- and post-tests assessed the 20m linear-sprint with a 10-m split time, while agility performance was tested using an agility course (Pettersen & Mathisen, 2012).

Training program. The exercises were completed with a one-hour training program per week, for a total of eight weeks. The training group (TG) replaced one of the three ordinary soccer-training sessions with the current program, and followed a strict organization with exercises and recovery periods. Each session started with 10 minutes warm-up consisting of jogging and sprint drills, and was followed by 45 minutes short burst high-speed running exercises. The program consisted of eight partner resisted sprints (15m), eight 20m straight sprints, eight change of direction sprints (20m) with 60° and 90° turns, and finished with relay race with 90° turns with eight race by each participant, thus, the session consisted of a total of 32 short sprints. The exercises lasted between three to six seconds, followed by 60 to 90 seconds of recovery with rest, depending on the length of work periods. The participants were instructed to complete the sprints at maximal speed.

Test Procedures. The sprint test consisted of a 20m track, with 10m split time recording. The photocells were placed at height of 20cm in the starting position, and at 100cm height at 10m and 20m in the straight-line test. All tests were completed from a standing start, with the front foot placed 20cm behind the photocells’ start line. The agility test was a 20m standardized course used in previous experiment (Pettersen & Mathisen, 2012). The test started with a 5 m straight-sprint, followed by a 90° turn, a 2.5m sprint followed by a 180° turn, a 5m slightly curved sprint followed by
a 180° turn, a 2.5 m straight sprint followed by a 90° turn, and finished with a 5 m straight-sprint. Three 120 cm-high coaching sticks were used to ensure correct passage in the turns. The tests were executed with the same starting procedure as the straight-line test, and with photocells placed at 100 cm height at the finish line. Each participant performed two trials with minimum three minutes recovery between the tests, times were recorded to the nearest 0.01 second, and the better of the two trials was recorded. Familiarization test for the sprint and agility track were conducted during both the pre- and post-tests, with two sub-maximal trials prior to the start of the test.

Electronic photocells timing gates were used to record split and completion times (Brower Timing System, USA). The exercises and the tests were executed in a gym with a parquet floor, and with a temperature of 20°C. Prior to the testing, the participants followed the same supervised warm-up procedure with 10 minutes jogging and sprint drills. The tests have shown good reliability by calculating the intraclass correlation coefficient (ICC) (Pettersen & Mathisen, 2012).

Statistical Analyses

Data were checked for normality by histogram plot and by using the Shapiro-Wilk’s normality distribution test. Descriptive statistics were then calculated and reported as mean ± standard deviations (SD) of the mean for each group of players on each variable. A two-way analysis of variance between-groups (ANOVA) was conducted regarding the mean difference between the training group and the control-group before and after the intervention. Turkey post hoc analyses were conducted to identify a training effect. The relationship between performances in linear sprints and agility tests was determined by using Pearson’s correlation (r). The same procedure was used to detect any correlation among the linear sprint and agility.

The reliability of each test was assessed by the intraclass correlation coefficient. All calculations were carried out using SPSS v 21.0 (Inc., Chicago, Il., USA).

Results

Table 1 presents the anthropometric characteristics of the subjects. There was no significant difference between TG and CG.
Table 1

Anthropometric characteristic in the study (mean ± SD)

<table>
<thead>
<tr>
<th>Test</th>
<th>TG (n = 10)</th>
<th>Post</th>
<th>CG (n = 9)</th>
<th>Post</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>15.5 (0.7)</td>
<td>15.7 (0.7)</td>
<td>15.1 (0.5)</td>
<td>15.3 (0.5)</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>162.9 (3.8)</td>
<td>163.1 (3.7)</td>
<td>164.6 (2.6)</td>
<td>165.0 (2.4)</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>58.0 (7.0)</td>
<td>58.4 (7.1)</td>
<td>56.0 (4.7)</td>
<td>56.2 (4.6)</td>
</tr>
</tbody>
</table>

No significant difference between groups

Results of pre- and post-test are presented in Table 2.

Table 2

Pre- and post-test results for sprint and agility performances (mean ± SD) in the training group (TG) and the control group (CG) (mean ± SD)

<table>
<thead>
<tr>
<th>Test</th>
<th>TG (n = 10)</th>
<th>Post</th>
<th>CG (n = 9)</th>
<th>Post</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 m sprint</td>
<td>1.99 (0.08)</td>
<td>1.91 (0.09) *</td>
<td>1.95 (0.06)</td>
<td>1.95 (0.07)</td>
</tr>
<tr>
<td>20 m sprint</td>
<td>3.53 (0.15)</td>
<td>3.42 (0.16) *</td>
<td>3.48 (0.10)</td>
<td>3.49 (0.13)</td>
</tr>
<tr>
<td>Agility</td>
<td>8.23 (0.31)</td>
<td>7.80 (0.33) *</td>
<td>8.04 (0.14)</td>
<td>8.01 (0.15)</td>
</tr>
</tbody>
</table>

*Significant change in performance between groups p<0.05

Results showed a significant improvement between TG and CG in 10m straight-line sprint; pre 1.99 (±0.8) to post 1.91 (±0.09), in 20 m straight-line sprint; pre 3.53 (±0.15) to post 3.42 (±0.16), and in agility; pre 8.23 (±0.31) to post 7.80 (±0.33).

Table 3 shows the relationship between straight-line sprint and agility.

Table 3

The relationship between linear sprint and agility performance in TG and CG (n=19)

<table>
<thead>
<tr>
<th>Relationship assessed</th>
<th>Pearson’s r</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 m linear sprint vs agility</td>
<td>0.60 *</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>20 m linear sprint vs agility</td>
<td>0.58 *</td>
<td>&lt;0.05</td>
</tr>
</tbody>
</table>

*Significant correlation between linear sprint and agility

The correlation between the performances in straight-line sprint and agility was $r = 0.60$, and between 20m straight-line sprint and agility performance $r = 0.58$ ($p<0.05$).

The reliability of each test was assessed by intraclass correlation in the control group, and was found to be 0.94 (10 m), 0.98 (20m) and 0.81 (agility). The statistical significance level was set at $p<0.05$.  

Discussion

We tested the hypothesis that eight weeks, one hour per week of short burst high intensity exercises would lead to improvement in straight-line sprint and agility performance in youth female soccer players, aged 15.5 (±0.7) years. The main findings were an improvement in the 10 m straight-line sprint (4.1%), in the 20 m straight-line sprint (3.2%), and in agility performance (5.2%) (Tab. 2). In females, sprint performance up to 15 – 17 years of age is improved by growth and maturation (Vescovi et al., 2011), and maturity status plays a role in mediating the response to speed exercises (Malina et al., 2004), however, no significant change in any parameters was found in the CG. The results of the current study are in line with junior male soccer players following programs consisting of short-sprint training (Muijka et al., 2009; Markovic et al., 2007), and confirm to positive effect in female soccer players of similar age. Improvements have been reported in adult female soccer players following speed and quickness training program (Polman et al., 2007), and in youths with a program consisting of speed exercises in 13-year-old females (Mathisen & Danielsen, 2014).

This study incorporated exercises of straight-line running speed, change of directions runs, acceleration and deceleration, in bouts lasting from three to six seconds executed with maximal effort (Brown et al., 2005). A training-induced increase in the maximal firing frequency and action potential in the muscles appears to occur in young subjects executing maximal exercises as described above (Hughes et al., 2012; Aagaard, 2003). The improvements observed is supposed induced by enhanced coordination, motor unit recruitment, central nervous activation and improved technical skills (Milanovic et al., 2013; Myer et al., 2005; Aagaard, 2003). Furthermore, training programs that include movements that are biomechanically specific to the performance tests, may be likely to induce improvements in performance measures (Faigenbaum et al., 2007), thus, positive responses in speed and agility are supposed to be associated to specificity in the current program (Buttifant et al., 2002). Exercise protocols consisting of sport-specific drills have shown positive effect on sprint performance, while most methods consisting of strength and power training have failed to improve agility performance (Brughelli et al. (2008). Previous experiments resulting in no or small effect, may be due to ineffective training load or lack of specificity (Jovanovic et al. 2011; Muijka et al., 2009; Jullien et al., 2008; Steffen et al., 2007). Recovery periods in the present study was from 60 to 90 seconds, and is in line with previous programs for young soccer players (Ramirez-Campillo et al., 2014),
however, two to five minutes are recommended among adults (Ramírez-Campillo et al., 2014).

Relationship between straight-line speed and change-of-direction speed in the present study is different compared to trained male athletes (Hennesy & Kilty, 2001). It is supposed that the relationship between linear speed and agility is higher during the early stages of athlete development (Jones et al., 2009), explained by common physiological underlying factors (Aagaard, 2003). The correlation between the 10 m and the 20 m linear sprint, and agility in this study was significant, $r = 0.60$ and $r = 0.58$, (Tab. 3). This is in line with previous reports in youth female athletes (Mujika et al., 2009; Vescovi et al., 2008), however, stronger than reported in 19-year-old female soccer players (Shalfawi et al., 2014). Results from adult male athletes, have showed a smaller transfer effect between these abilities, with low to moderate correlation, $r = 0.33$ to $r = 0.42$ (Young et al., 2001).

Limitations of this study are the small number of participants, and no assessment to determine any effects on the outcome to match-play. However, enhanced sprint performance is beneficial in match play (Polman et al., 2007), and both short linear speed, and agility is powerful discriminators between youths (Mujika et al., 2009, Reilly et al., 2000). Sprint bouts during games are mostly reported to be between 10-30 m, and high-speed actions are known to have an impact on match performance, as the faster player will have an advantage in match scenarios (Krstrup et al., 2005).

Conclusions

We indicate that a training program consisting of short-burst high-speed exercises, may be effective beyond the gain of traditional soccer training in youth female players. Results from this study shows that one training session per week (one hour) over eight weeks, is sufficient to enhance straight-line sprint up to 20m and agility performance in female youth soccer players in the preseason period, compared to traditional soccer training consisting of small-sided games and technical drills.

References


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ORIGINAL RESEARCH PAPER

AEROBIC AND ANAEROBIC TEST PERFORMANCE AMONG ELITE MALE FOOTBALL PLAYERS IN DIFFERENT TEAM POSITIONS

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Abstract

The purpose was to determine the magnitude of aerobic and anaerobic performance factors among elite male football players in different team positions. Thirty-nine players from the highest Swedish division classified as defenders (n=18), midfield players (n=12) or attackers (n=9) participated. Their mean (±sd) age, height and body mass (bm) were 24.4 (±4.7) years, 1.80 (±5.9)m and 79 (±7.6)kg, respectively. Running economy (RE) and anaerobic threshold (AT) was determined at 10, 12, 14, and 16km/h followed by tests of maximal oxygen uptake (VO₂max). Maximal strength (1RM) and average power output (AP) was performed in squat lifting. Squat jump (SJ), counter-movement jump with free arm swing (CMJa), 45m maximal sprint and the Wingate test was performed. Average VO₂max for the whole population (WP) was 57.0mL O₂•kg⁻¹min⁻¹. The average AT occurred at about 84% of VO₂max. 1RM per kg bm⁰.⁶⁷ was 11.9±1.3kg. Average squat power in the whole population at 40% 1RM was 70±9.5W per kg bm⁰.⁶⁷. SJ and CMJa were 38.6±3.8cm and 48.9±4.4cm, respectively. The average sprint time (45m) was 5.78±0.16s. The AP in the Wingate test was 10.6±0.9W•kg⁻¹. The average maximal oxygen uptake among players in the highest Swedish division was lower compared to international elite players but the Swedish players were better off concerning the anaerobic threshold and in the anaerobic tests. No significant differences were revealed between defenders, midfielders or attackers concerning the tested parameters presented above.

Key words: football, physical performance, plays position
Introduction

Played at a relatively high mean work intensity interspersed with short periods of very-high-intensity sprint and jump performance, football may be regarded as a sport with both aerobic and anaerobic demands. The average work intensity during a typical football game between male elite teams at senior level is approximately 85% of maximal heart rate ($HR_{\text{max}}$), which corresponds to about 75% of maximal oxygen uptake ($VO_{2\text{max}}$) (Stølen et al., 2005). The match duration in combination with the load on the aerobic system indicates that the main energy contribution comes from aerobic processes. Typical for football is also the continuous variation in work intensity related to action on the football field, involving standing (0 – 0.6km $h^{-1}$), walking (0.7 – 7.1km $h^{-1}$), jogging (7.2 – 14.3km $h^{-1}$), running (14.4 – 19.7km $h^{-1}$), high-speed running (19.8 – 25.1km $h^{-1}$), and sprinting (>25.1km $h^{-1}$). Thus, oxygen uptake constantly fluctuates between levels above and below average. Fast running and sprinting will cause an oxygen debt, which will be paid for during periods of low work intensity. High intensity running and sprint distance have increased of about 30-50% across the last few years in the English Premier League matches (Bush et al., 2015) and a similar increment has been measured over a 44 years period in FIFA World Cup Final Matches (Wallace & Norton, 2014). The relatively high average intensity level and the long work duration during a typical football match indicate that high aerobic power is relevant in a football capacity profile. $VO_{2\text{max}}$, among senior elite male football players, varies between 50 and 75mL$O_2$•kg$^{-1}$•min$^{-1}$ (Stølen et al., 2005), the average being about 61mL$O_2$•kg$^{-1}$•minute$^{-1}$. Fatigue-related decline in technical proficiency for a given intensity has been negatively associated with the fitness level of the players (Rampinini et al., 2008). In line with this, Apor (1988) showed that the winning team in the Hungarian elite league had a higher average maximum oxygen uptake than lower-ranked teams. Also, Wislöff and co-workers (1998) showed that the winning team in the Norwegian elite league had higher mean aerobic power than the team that finished last.

Running economy (RE) is defined as oxygen consumption during running at a given speed. The football player who can keep a given speed at a lower oxygen cost per kg body mass may theoretically have a smaller oxygen debt and will therefore be less susceptible to fatigue. RE may differ by about 20% among elite runners (Sjödin and Svedenhag, 1985). In terms of quantitative optimization of the aerobic processes during a football game, running economy may be a relevant factor.
The anaerobic threshold (AT), also called the lactate threshold (LT), is defined as the work intensities at which the lactate can no longer be metabolized at the rate it is produced. The AT among football players varies between approximately 80 – 90% of HR\textsubscript{max} (Brewer, 1992; Ströyer et al., 2004). Theoretically it may be advantageous if the AT occurs close to VO\textsubscript{2max} i.e. the higher the relative use of VO\textsubscript{2max} can be without crossing the AT, the better. It has been argued that football players with a high VO\textsubscript{2max} have a higher anaerobic threshold i.e. can use a larger fraction of VO\textsubscript{2max} before crossing AT (MacRae et al., 1992). The reason for the latter possible relationship is unknown at present.

Anaerobic power may play an important role during a typical soccer game. Several studies have shown a significant positive correlation between maximal squats leg muscle strength (1RM) and acceleration and speed in running (Buhrle & Schmidtbleicher, 1977; Hoff and Almåsbakk, 1995; Wislöff et al., 2004). An example of short-time explosive strength (anaerobic power) is also jump ability. Mean values between 44 – 60cm have been recorded in male football players in counter-movement jumps (CMJ) (Adhikari and Kumar Das, 1993; Wislöff et al., 1998). The majority of short anaerobic performance events in a football match are sprints 96% shorter than 30m and 49% shorter than 10m (Valquer et al., 1998). In line with this, sprints between about 2 and 5 seconds are frequent in football (Reilly and Thomas, 1976; Rienzi et al., 2000). Although the longest sprints, up to about 6 seconds, can be regarded as an alactacidic work period, the lactacidic anaerobic system is also activated, further the sprints are performed in a work situation where the mean intensity is about 85% of HR\textsubscript{max} (Stølen et al., 2005). This indicates that the lactacidic anaerobic system may also play a role during certain periods in a typical football match. The above indicates that it may be important to study both aerobic and anaerobic performance factors with respect to football players’ capacity profile.

The team positions in football differ by denomination and defined general function. Few studies have investigated the physiological capacity profile representative of each. In most research studies, the players are classified into four groups: forwards/attackers, midfielders, defenders, and goalkeepers (Bush et al. 2015). Sometimes, defenders are divided into two sub-groups (Davis et al., 1992). Players in different team positions have a different workload during a game: midfielders run the longest distances (up to 11 – 11.5km) followed by forwards and defenders (Bansgbo et al., 1991). The highest oxygen consumption values have been found in midfielders, the lowest values in goalkeepers (Stølen et al., 2005). However, it was not clear
whether the midfield players were chosen as midfielders for their higher aerobic endurance capacity, or whether their higher oxygen uptake was related to the midfield play position or any other factor (Bansgbo and Michalsik, 2002). In elite football, forwards are the fastest players and time observations show that they sprint the most during a match (Rienzi et al., 2000).

It is rare that a study like the present one addresses such a comprehensive set of aerobic and anaerobic performance factors simultaneously in relation to team play position among elite football players. In line with this and the information presented above, the purpose was to determine aerobic factors ($\text{VO}_{2\text{max}}$, running economy and lactate threshold) and anaerobic factors (maximal and explosive leg muscle strength, jump and sprint ability, and maximal anaerobic power) for elite male football players in different play positions.

**Materials and Methods**

Thirty-nine elite male football players from the highest Swedish division took part in the study. Their mean (± sd) age, height and body mass were 24.4 (±4.7) years, 1.80 (±0.59) m and 79 (±7.6) kg, respectively (see also Table 1 in the Result section). The players represented three clubs in the middle of the result list at the end of the season. The tests were performed during the end of or directly after the season. The participants were classified by their team coaches as defenders; D (n=18), midfield players; MF (n=12) or attackers; A (n=9). During all tests the players wore light clothing and sport shoes with rubber soles. The experimental procedures were in accordance with the Helsinki Declaration and all participants were informed that they could leave the study without giving any reason for doing so (signed informed consent).

**Apparatus and test setup**

Anaerobic threshold (determined as lactate threshold; LT), running economy (RE) and maximum oxygen uptake ($\text{VO}_{2\text{max}}$) were determined during running on a motor-driven treadmill (Cybex Stable flex, Cybex International Inc., US). RE was defined as oxygen consumption (mL O₂•kg⁻¹•minute⁻¹) during running at given speeds. LT was defined as onset of blood lactate accumulation (OBLA) at 4 mM•L⁻¹ (Heck et al., 1985).

To allow reproduction of the present study design and comparison of RE and anaerobic threshold, which are dependent on treadmill speed fluctuations and running surface stiffness, treadmill speed was calibrated and the stiffness characteristics of the treadmill were determined. Speed was calibrated by video-filming a reference point on the moving treadmill
belt (film rate: 50Hz). The preset speed and the calculated speed from the video recording were compared with a subject (71.3kg body mass) running on the treadmill from 10 to 20 km•h\(^{-1}\). The deviation from the preset speed was less than 1.5 percent in all cases. The stiffness of the running surface, defined as surface deflection per kilo load (per N vertical force), was tested. A 2.5cm thick iron plate (area: 30.5 • 10.3cm) was placed in the middle of the treadmill belt approximately at the touchdown surface during running on the treadmill. The plate was cumulatively loaded with weights (50kg) up to 250kg corresponding to a vertical force of 2453N, i.e. higher than the vertical reaction force at the highest speed used in the present investigation according to Nilsson and Thorstensson (1989). The deflection of the treadmill was measured with a micrometer at the level of the load position. Surface deflection for every added 50kg weight was registered (Figure 1). The relationship between deflection (Y) per added mass (X) was best expressed by a polynomial equation (Y=0.025876 + 0.04065X + (– 1.48756 E\(^{-5}\) X\(^2\)).

**Figure 1.** The relationship between vertical load (kg) and the treadmill surface deflection (mm). The inset figure shows a top and side view of the arrangement on the treadmill with the load weight on top of the iron plate at the location of touchdown in running. Note the site of the micrometer recording.

Oxygen uptake at submaximal and maximal workloads during running on the treadmill was determined using an automatic measuring system for oxygen uptake with a mixing chamber (OxygenPro, Jaeger GmbH, Germany). This system was validated before the test with comparative in-series measurements using OxyconPro and Douglas bags analyzed separately. The OxyconPro was also validated by means of a metabolic
simulator (oxygen uptake simulator) (Vacu-Med Inc. US). No significant deviation in results was seen when the results from these comparisons were analyzed.

The blood lactate concentrations when running at submaximal and maximal intensities were determined from blood from a punctured fingertip. The blood sample (20 µL) was analyzed electro-enzymatically (Biosen C-line, EKFdiagnostic GmbH, Germany). The instrument was calibrated using standard lactate solutions at concentrations of 2, 7 and 18 mM•L⁻¹.

One repetition maximum (1RM) in concentric squat (from a 90-degree knee angle was performed using a Smith machine. Power output was tested with a loaded squat jump. The external load defined was set as a percentage of the 1RM squat value. During the lifts, security locks were used in the deep position. A vertical displacement linear encoder (Muscle Lab., Ergotest Technology AS, Norway) enabled calculation of power output in each lift. A body mass fraction of 90% was included in the power calculation.

A squat-jump (SJ) and counter-movement jump test with arm swing (CMJₐ) was used to determine maximal explosive jump performance. An optoelectronic measuring system (IVAR Measuring Systems, Estonia) was used to measure flight time during SJ and CMJₐ. The jump height was calculated from the flight time. The system uses infrared light beams and these were set at 11mm distance above the jump surface, creating an optoelectronic circuit between an emitter and a reflector. Start and termination of flight time were triggered when the optoelectronic circuit was electrically opened and closed.

Maximal sprint ability 0 – 45m was also measured with an optoelectronic system (IVAR Measuring System, Estonia). Pairs of photocells and reflectors were placed at the start line (0 m) and at 10, 15, 20, 30, 40 and 45m. Each photocell contained two measuring cells which both had to be interrupted to trigger the timing device. The sprints were performed on a 2mm thick, 1.2m wide and 45m long rubber mat placed on a wooden gym floor. In the sprint test, the players chose their own starting posture with the front foot at a line 0.5m from the first photocell pair. The players made standing starts on their own command. They were allowed three attempts and the rest period between each was 5 – 10 minutes.

Maximal anaerobic power was tested in a 30second Wingate test on a bicycle ergometer (Peak Bike, Monark AB, Sweden). After a preparatory procedure, the test was controlled by means of a computer and software (Monark Anaerobic Test Software, version 2.0). The breaking weight was set to 10% of body mass. The test started at zero flywheel speed with the
pedal crank arms at 45 degrees to the horizontal plane. The breaking load was programmed to be released “momentarily” when the pedals started to rotate.

**Test procedures.** The total set of tests was performed during two consecutive days. All participating players were accustomed to treadmill running before testing. In the test of running economy and anaerobic threshold the participants ran four minutes each at 10, 12, 14, and 16 km•h⁻¹ on the horizontal treadmill. Between the run at each speed level the participants got one minute of rest while a blood sample was collected for determination of blood lactate concentration. After the last submaximal speed level the players got two minutes of rest before the test of maximal oxygen uptake (VO₂max). This started with running horizontal at 14 km•h⁻¹. After one minute the speed was increased to 15 km•h⁻¹ and this speed was kept for one minute. Subsequently the speed was increased by 0.5 km•h⁻¹ each minute to 20 km•h⁻¹. Most players were physically exhausted and had terminated the test before this speed level. Physiological parameters were constantly checked during this test. Criteria for reaching VO₂max were: “leveling off” in oxygen uptake and/or respiratory exchange ratio (RER)>1.1, perceived exertion according to the RPE scale (Borg et al., 1985) higher than or equal to “very hard” and rate of increase in pulmonary ventilation. The rated perceived exertion was registered immediately after the maximal oxygen uptake test, and after three minutes a blood sample was collected for determining blood lactate concentration.

The players performed the squat test during two days, the first day being used for familiarization with the test procedure and progressively reaching 1RM. This allowed the second day to be limited to a few serious attempts to reach 1RM.

In the loaded squat jump test, the players lifted external loads equal to 20, 40 and 60% of the squat 1RM value. Three attempts for each load were performed with 1-3 minutes recovery between lifts. The players were instructed to perform an explosive concentric movement from the start position at 90° knee angle. The power output was calculated during the concentric phase and the best of three trials at each power level was selected.

In both the SJ and the CMJ_a tests, the players were allowed preparatory jumps in which they were instructed concerning the test procedure. In the SJ the players started from a stationary squatting position (about 90° knee joint angle) to jump as high as possible, i.e. to reach the highest vertical displacement. In SJ the hands were kept on the hips during the whole jump. The players were not allowed to employ any downward
movement (i.e., a counter-movement). This instruction was given to reduce the effect of the stretch-shortening cycle before the concentric jump phase. In CMJ_a a free arm swing was allowed. No instruction was given on the depth of the downward movement, and so knee angle in the eccentric preparatory jump phase was a matter of choice. In both jumps, the players were instructed to land on the spot of release with extended ankle joints and straight knees. The best of three SJ and CMJ_a attempts was selected.

In the Wingate test, the players were instructed to pedal at maximal intensity for 30 seconds from the start to the end of the test. They were informed when 10 seconds remained and when the 30 seconds had elapsed. They had to remain seated during the whole test.

Statistics

For statistical calculations the StatView statistical package for Windows (version 5.0, SAS Institute Inc., USA) was used. All data are reported as mean ± standard deviation (sd). Differences between team play positions were assessed with repeated measures ANOVA followed by a Scheffé post hoc test. Statistical significance was set at the 0.05 level.

Results

Mean age, height and body mass of the whole population of tested football players were 24.4 years, 1.80m and 79kg, respectively. There was no significant difference between the team play positions concerning age, height or body mass except for a significant difference in body mass between defenders and midfielders (Tab. 1).

Table 1

<table>
<thead>
<tr>
<th>Subjects characteristics</th>
<th>Age (years)</th>
<th>Height (m)</th>
<th>Body mass (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole population</td>
<td>24.4±4.7</td>
<td>1.80±5.9</td>
<td>79±7.6</td>
</tr>
<tr>
<td>Defenders n= 18</td>
<td>25±4.7</td>
<td>1.82±4.2</td>
<td>80.7±7.4</td>
</tr>
<tr>
<td>Midfielders n= 12</td>
<td>23.9±4.8</td>
<td>1.78±5.3</td>
<td>76.3±5.1</td>
</tr>
<tr>
<td>Attackers n= 9</td>
<td>24.4±5.1</td>
<td>1.81±8.7</td>
<td>79±10.1</td>
</tr>
</tbody>
</table>

The average maximal oxygen uptake (VO_{2\text{max}}), all players included (WP), was 57.0mL O_2\cdot kg^{-1}\cdot minute^{-1}. The midfielders showed somewhat higher values but not significantly different from those of defenders and attackers (fig. 2).
Figure 2. Mean (±sd) maximal oxygen uptake (VO$_{2\text{max}}$) for all players in the whole population (WP), defenders (D), mid-fielders (MF) and attackers (A).

There was no significant difference in oxygen consumption at 10, 12, 14 and 16 km•h$^{-1}$ for players in different team positions in the running economy test (fig. 3).

Figure 3. Mean (±sd) oxygen consumption (mL O$_2$•kg$^{-1}$•min$^{-1}$) for players at different team positions (whole population: WP, defenders: D, mid-fielders: MF and attackers: A) at 10, 12, 14 and 16 km•h$^{-1}$ and maximal oxygen consumption.

Blood lactate concentration was approximately 2 mM•L$^{-1}$ at 10 and 12 km/h, increasing to about 2.5 mM•L$^{-1}$ at 14 km/h and approximately 4 mM•L$^{-1}$ at 16 km•h$^{-1}$ but not significantly different between team positions. The average blood lactate accumulation for the WP after VO$_{2\text{max}}$ test was approximately 11 mM•L$^{-1}$ (fig. 4).
Figure 4 Mean (±sd) blood lactate accumulation (mM•L\(^{-1}\)) at 10, 12, 14, 16km•h\(^{-1}\) at horizontal level and after test of maximum oxygen uptake for players at different team positions (whole population; WP, defenders; D, mid-fielders; MF, and attackers; A).

The average mean relative oxygen uptake as a percentage of maximum oxygen uptakes at lactate threshold was 84.5\% for the whole population. There was no significant difference between team positions (fig. 5).

Figure 5. Mean (±sd) relative oxygen consumption in percent of VO\(_{2\text{max}}\) at lactate threshold for players at different team positions (whole population; WP, defenders; D, mid-fielders; MF and attackers; A).
Squat 1RM was about 12 kg per kg bm$^{0.67}$, with no significant difference between the different team play positions.

**Figure 6.** Mean (±sd) 1RM per kg bm$^{0.67}$ squat strength for the whole population (WP), defenders (D), midfielders (MF) and attackers (A).

Loaded squat jump average power output at 40% of 1RM was 70±9.5 W per kg bm$^{0.67}$ for the whole population, 72±8.9 W per kg bm$^{0.67}$ for the defenders, 68±8 W per kg bm$^{0.67}$ for the midfielders and 68±13.1 W per kg bm$^{0.67}$ for the attackers.

The highest average power tended to be obtained at 40% of 1RM, except for attackers who reached it at 20% of 1RM. There was no significant difference between team positions in power output (fig. 7).

**Figure 7.** Average squat power output (±sd) (W per kg bm$^{0.67}$) at 20, 40 and 60% of 1RM for the whole population (WP), defenders (D), midfielders (MF) and attackers (A).
The mean jump height in the SJ was 38.5±4.0, 39.5±3.9, 37.7±4.1 and 37.2±3.9 cm, for the whole population, defenders, midfielders and attackers, respectively. The defenders performed the highest average jump height, but there was no significant difference between the different team positions (fig.8).

![Squat jump test](image)

**Figure 8.** Mean (±sd) jump height in squat jump (SJ) for the whole population (WP), defenders (D), midfielders (MF) and attackers (A).

The mean jump heights in the CMJ were 48.9±4.4, 49.5±3.9, 48.7±5.2, and 48.1±4.1 cm, respectively, for the whole population, defenders, midfielders and attackers. The defenders achieved the highest average jump height, but there was no significant difference between the different team positions (fig.9).

![Counter movement jump with free arms swing test](image)

**Figure 9.** Mean (±sd) jump height in the counter movement jump with arm swing (CMJ) for the whole population (WP), defenders (D), midfielders (MF) and attackers (A).
There were no significant differences in the sprint results between team positions in any of the recorded distances (fig. 10).

![Sprint test graph](image)

**Figure 10.** Mean (±sd) sprint duration at different distances between 0-45 m average for the whole population (WP), defenders (D), mid-fielders (MF) and attackers (A)

The average power in the 30-second Wingate test was about 10W per kg body mass. There was no significant difference between team positions in mean power (fig. 11).

![Wingate test graph](image)

**Figure 11.** Mean (±sd) power output in the Wingate test during the first five seconds and during the whole test. Average value for the whole population; WP, D; defenders, M; midfielders and A; attackers
Discussion

International team comparison. Average team maximum oxygen uptake obtained among male elite football players in the highest Swedish division in this study was 57.0mL O$_2$\textperiodcentered kg$^{-1}$\textperiodcentered minute$^{-1}$. This is lower than reported from tests on elite male teams in an international comparison (teams in the highest division or national teams) which average approximately 61mL O$_2$\textperiodcentered kg$^{-1}$\textperiodcentered minute$^{-1}$ (Stølen et al., 2005).

To our knowledge, no article has appeared concerning running economy in professional football players which also describes speed consistency and treadmill running-surface stiffness. The stiffness of the treadmill construction is one important factor that might influence oxygen uptake and blood lactate concentration at given speeds. In our study, attempts were made to describe the stiffness and speed characteristics of the treadmill used in order to allow comparisons with results of future studies.

The anaerobic threshold investigated in our study occurred at about 84\% of VO$_{2\text{max}}$. This is a somewhat higher value than those obtained by elite teams in an international comparison, which shows an average value of approximately 82\% of the ventilator anaerobic threshold (Vanfraechem and Tomas, 1993; Al-Hazzaa et al., 2001; Casajus, 2001). The relative use of maximum oxygen uptake in an average male elite football match is approximately 75\% of VO$_{2\text{max}}$ (Stølen et al., 2005). This, together with the fact that a football match of 90 minutes should be regarded as a long performance, indicates that aerobic power is relevant for performance in football. Other things being equal, a high VO$_{2\text{max}}$ and lactate threshold and good running economy could be regarded as performance factors in football because they may, at least theoretically, allow a higher mean speed without excessive use of anaerobic energy metabolism. Scientific indications have been reported that support this assumption (Ziogas et al., 2011). It is also reasonable to assume that recovery between high-intensity runs may benefit from high aerobic power (Bishop et al., 2011). Thus, the parameters presented above can be regarded as factors important for average aerobic work intensity in football. However, additional future studies are needed to evaluate how tests with incremental constant load correlate with the variation in load typical for a football match (Buchheit et al., 2011).

In contrast to the results in maximal oxygen uptake, the Swedish elite players were better off concerning anaerobic performance factors. International male elite football players have been tested concerning sprint ability (0 – 40m) (Brewer, 1992; Kollath and Quade, 1993; Cometti et al., 2001; Helgerud et al., 2001; Dupont et al., 2004; Wislöff et al., 2004). Compared to the results of the international elite players the Swedes
averaged about 4% shorter time on the tested sprint distances. The distance from the first photocell pair (0.5 m) and excellent running surface friction may have contributed to the Swedish results.

In the comparison of jumping ability between international elite players (Casajus, 2001; Wislöff et al., 2004) and Swedish players, squat jump height was similar whereas CMJ_a was somewhat higher (4%) among international elite players.

In the test of anaerobic power (the Wingate test) results for international elite football players (Brewer, 1992; Davis et al., 1992; Al-Hazzaa et al., 2001) were considerably lower (18%) than the power obtained by Swedish elite players. This lower value can partly be the effect of the methodology used during the Wingate test. Starting the test with zero speed on the flywheel in our study instead of accelerating it before starting the power calculation and risking excessive use of the phosphate energy store may be an advantage.

Team position comparison. One might expect that players in different play positions may differ in aerobic and anaerobic power due to different work demands related to their position. This is the rationale behind the present comparison of play positions. However, we made no further sub-division into each play position in the comparison below. This was justified after testing for significant differences in all aerobic and anaerobic parameters between central defenders versus right- and left-wing midfielders. The only significant difference occurred between central defenders and right and left wing midfielders in running economy. Football is a complex sport and numerous performance components have to be trained. This may reduce the time available for training physical performance factors such as VO_2max, RE, anaerobic threshold and anaerobic power. The time conflict with other important components of the game such as team tactics might be a problem. The present investigation compares the physical performance of elite football players in different team play positions. The results of this comparison can be used in the ongoing debate about the need for differentiation in physical capacity between team play positions. The comparison of average values concerning VO_2max, running economy, lactate threshold and anaerobic performance factors such as loaded squat jump power output, sprinting speed and jump height showed no significant differences between team positions (defenders, midfielders and attackers). The absence of physical profiles concerning the above parameters among players in the different team positions may have several causes. One may be the absence of a physiological strategy concerning aerobic endurance and anaerobic power when the team is put together.
Another may be related to deficits in resources for individually training and testing different capacities in the team-developing process. Coaches may also believe that aerobic and anaerobic performance factors are of less importance in the total perspective, so that it is not worth the time and resources to emphasize these for the different team positions. Above, a few examples of explanations concerning the situation in Swedish male elite football are presented. Physical equality between players in different positions might be optimal for total team performance. But it can also be argued that well-developed physical capacity for certain play-position-related performance demands is better for team performance. In an international comparison a slightly different picture emerge especially related to aerobic endurance. The typical pattern concerning distance covered during the game according to playing position in numerous studies of elite football players is that midfielders always show the highest mean values in comparison with those in other playing positions (see e.g. Reilly & Thomas, 1976; Bansgbo et al., 1991; Mohr et al., 2003). It was also shown by Reilly and Thomas (1976) that signs of fatigue during the game were most prominent in center-backs and attackers but less apparent in midfield players and full-backs, who also tended to have a higher maximal oxygen uptake. The midfield players covered the greatest distances and managed to maintain high work intensity throughout the game. The tendency of the midfielders and full-backs to have somewhat higher aerobic power than players in other positions is supported by other studies on elite players (Puga et al., 1993; Al-Hazzaa et al., 2001; Bansgbo and Michalsik, 2002). However, brief information on jump ability among outfield players showed no difference (Arnason et al., 2004). On the other hand, Davis and co-workers (1992) found that central defenders showed the highest mean anaerobic power in a Wingate test, followed by attackers, full-backs and midfielders. All team play positions also require movement in other than the forward directions. Defenders show the highest percentage of backwards and sideways locomotion (Reilly, 1996). Thus players in given team play positions need to be able to locomote in certain ways due to the structure of the game, the behavior of the opponent team and so forth. The energy cost to move sideways and backwards is higher than in forward running (Reilly and Bowen 1984). Thus, players in certain team positions, such as defenders, are forced to use more energy. This indicates that the demand profile concerning movement repertoire, and thereby the energy cost, may differ between team play positions in certain parts of the game.
Conclusion

The average maximal oxygen uptake among players in the highest Swedish division was lower compared to international elite players. In contrast the Swedish players were better off concerning the anaerobic threshold and in the anaerobic tests. In the team position comparison it was evident that there were no significant differences between team positions in the compared test parameters. The knowledge about team performance and team position physical performance can alert the need for further differentiation or similarity as well as new training methods that can serve different purposes. Furthermore, future integration of physiological parameters and tactics may allow an allocation of training time that develops physical performance in parallel with tactical improvement.

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ORIGINAL RESEARCH PAPER

THE OCCURRENCE OF OVERLOAD CHANGES AFFECTING PRISONERS PERFORMING STRENGTH TRAINING

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Abstract

Aim: Without taking into consideration the pedagogical justification for doing the strength training by prisoners, the authors of this study discuss the problem of the consequences of allowing prisoners to do the strength training freely. The study was conducted to determine the frequency and the location of the overload changes in the musculoskeletal system of prisoners who do the strength training as well as the presumable reasons for such changes. Methods: The study was conducted with the use of an interview technique among 44 men, repeat offenders serving a sentence of imprisonment in a prison in Inowroclaw, regularly engaged in strength training in their free time. Results: The respondents trained quite often (more than 5 times a week), slightly more than a half of them started the training with the warm up, and 64% did not do any stretching exercises after the training. The overload changes associated with strength training affected 30% of the respondents. Conclusion: The high level of injury among prisoners who do the strength training is due to: too many sessions a week, the lack of warm up and stretching exercises, as well as the insufficient level of knowledge on the prevention from sports injuries.
Key words: prison, prisoners, strength training, warm up, relaxation, overload changes.

Introduction
A compulsory isolation in prison is often associated with sudden and serious changes in biological and psychosocial aspects of a human lifestyle (Goffman, 2011; Machel, 2003). In countries with humanitarian and correction oriented penitentiary systems, imprisonment can be seen as an opportunity to improve particular health indicators of selected social groups (Niewiadomska, 2007; Poklek, 2010).

Unfortunately, prison isolation is the source of many health risks inevitably resulting in a number of adverse changes in all areas of prisoners' health (Fazel, Baillaregon, 2010). The decreased level of physical activity may be a risk factor for the majority of such changes. It seems that hypo-kinetic reasons for health risks are of particular interest to researchers of Polish penitentiary system, which – in contrast to the West European systems – is characterised by a relatively low minimum standard of living space per person and high overpopulation (Machel, 2008; Council of Europe, 2013a, 2013b).

According to the standards introduced by the Council of Europe, the enforcement of custodial sentences requires the opportunity for all prisoners to do physical exercises daily (Council of Europe, 2006). Skillful use of sport in provoking changes interactions can bring many benefits ultimately resulting in a positive change of prisoners’ behavior and their better adaptation to social life (Meek 2014). However, there is lot of controversy in taking up strength training by prisoners (Poklek, 2008; Todd, 1995). The previous studies among Polish penitentiary personnel show i. e. a lot of concern that during the physical and sports training, prisoners acquire skills and abilities which can be used by them in their later criminal activity (Łapiński, 2007).

However, as penitentiary practice shows, in situations of a severe deprivation of prisoners' need for physical activity, and with insufficient range of motor activities offered by prison administration, prisoners – in spite of the bans – surreptitiously do some physical exercises in their cells (Rejzner, 2002). Instead of the training equipment, they frequently use pieces of furniture (such as stools, cupboards or beds) and self-made weights e.g. interconnected plastic bottles filled with water.

Because of ambiguous rules of doing strength training in Polish prisons, particular prisons implement different solutions. In some prisons with gyms, they organise training with an instructor, or provide prisoners with the equipment and space to train without special supervision over the
safety and the selection of exercise loads. In this article, the authors consider the problem of the consequences of allowing prisoners to do independent and unfettered strength training connected only with the area of physical health. However, they do not focus on pedagogical merits of practicing strength training by prisoners. The study was conducted to determine the frequency and the location of overload changes in the musculoskeletal system affecting prisoners taking up strength training and the most probable reasons for such changes.

**Material and Methods**

The study was conducted among male inmates in prison in Inowroclaw. The participation in the survey was offered to all prisoners who regularly practise strength training in their free time. A deliberately chosen group of participants composed of 44 men – recidivists whose average age was 33 years and 2 months. The men did not participate in organised bodybuilding activities conducted by a qualified instructor but were allowed to use the gym every day. The participants have undertaken strength training for 6 years and 6 months at an average frequency of 5.3 workouts per week.

The research was conducted with an interview technique using a questionnaire of the authors’ own design. Both the research technique (which gives the possibility of detailed questions) and thanks to the physiotherapeutic qualifications of the interviewers it was possible to identify (and reflect in the statistics) only those overload changes (including overload injuries and the overuse syndrome) which were associated with the strength training. In the case of the overuse syndrome, particular phases and periods of remission were recognised separately in the statistics.

**Results**

The overload changes connected to strength training were recorded among 13 respondents who constituted 29.5% of the respondents. Selected information regarding training performed by these people and injuries suffered by them are included in Table 1.
Table 1

Data on strength training performed by individuals who have suffered overload changes and other data referring to these changes (statement by number of changes observed)

<table>
<thead>
<tr>
<th>No</th>
<th>Period of training [years]</th>
<th>No of trainings per week</th>
<th>Performing weight training frequency</th>
<th>Performing a warm-up Timing [min.]</th>
<th>Performing stretching exercises frequency timing [min.]</th>
<th>Occurrence of overload changes Number</th>
<th>Body parts</th>
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<tbody>
<tr>
<td>1</td>
<td>20</td>
<td>6</td>
<td>seldom</td>
<td>15</td>
<td>never</td>
<td>0</td>
<td>15</td>
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<tr>
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<td>15</td>
<td>7</td>
<td>never</td>
<td>0</td>
<td>never</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>7</td>
<td>always</td>
<td>30</td>
<td>never</td>
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<td>5</td>
</tr>
<tr>
<td>4</td>
<td>24</td>
<td>5</td>
<td>not always</td>
<td>5</td>
<td>yes</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>7</td>
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<td>5</td>
<td>never</td>
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<td>3</td>
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<tr>
<td>6</td>
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<td>7</td>
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<td>3</td>
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<tr>
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<td>7</td>
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<td>1</td>
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<tr>
<td>13</td>
<td>1</td>
<td>4</td>
<td>always</td>
<td>15</td>
<td>never</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

With reference to the respondents described in Table 1, the overuse syndrome most commonly occurs in the area of a shoulder girdle (25%), an elbow joint (18%), a spine (18%) and a knee joint (14%). 11% of the respondents experienced overload changes in an ankle and 7% of them experienced overload changes in the femoral biceps. The least changes were recorded near fingers (3%) and the arm biceps (3%).

Respondents who suffer from overload changes; have performed strength training significantly more often than the ones with no such changes recorded (Tab. 2).
Table 2

The frequency of training performed by people who have and have not suffered from any overload changes

<table>
<thead>
<tr>
<th>Occurrence of overload changes</th>
<th>No of trainings per week</th>
<th>U</th>
<th>Z</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Participants with overload</td>
<td>6,1539</td>
<td>0,9871</td>
<td>94,000</td>
<td>-2,7653</td>
</tr>
<tr>
<td>changes recorded</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Participants with no</td>
<td>4,6129</td>
<td>1,8381</td>
<td></td>
<td></td>
</tr>
<tr>
<td>overload changes recorded</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The intention of the researchers was to assess the performance of particular phases of training sessions which significantly determine the risk of overload changes, especially a warm up prior to strength training and stretching exercises ending training sessions.

It was reported that only 54.5% of the respondents always perform a warm up and 23% of them often perform it, but not always. 18% of the respondents never perform a warm up and 4.5% of them do it rarely. Among those respondents who always perform a warm-up, 75% have never experienced overload changes and 25% are the respondents who suffered from such changes.

Stretching exercises after strength training are never performed by as many as 64% of the respondents. Such exercises are always performed by 31.5% of the respondents and 4.5% of the respondents often take stretching exercises, but not always. Among those who always perform stretching exercises, 71.5% are people who do not suffer from any overload changes and 28.5% of them are people who suffer from such lesions.

The duration of the warm-up was between 5 and 40 minutes, 16 minutes on the average. The duration of stretching exercises was between 2 and 45 minutes, 13 minutes on the average.

Respondents were also asked to make a self-assessment about the level of knowledge concerning strength training (by admitting certain number of points between 1 and 10, where 1 point meant a complete lack of knowledge and understanding and 10 points meant the maximum knowledge). The average level of knowledge was estimated at 6.11 points.

Further analysis was only performed with data relating to people who had been reported to suffer from overload changes (Tab. 1). As much as 77% of respondents believe that overload changes endured by them can have been avoided. The rest of the respondents suffering from such changes stated that the changes had been rather impossible to be avoided.
While being asked about the likely causes of the overload changes, the respondents most frequently pointed to the wrong exercise technique (62%) and the excessive training loads (54%). Among the reasons for the overload changes the respondents also pointed to: the lack of the warm-up (23%), inappropriate performance of the warm-up (15%) and the lack of assistance while doing exercises (7%). None of the respondents indicated the failure of stretching exercises as the cause of the overload changes.

62% of the respondents, who suffered from the overload changes, applied a self-healing treatment using a warming ointment. Other methods of treatment have not been used. Almost all respondents (except one person) who suffered from the overload changes were forced to break the cycle of training. This break lasted for an average period of 65 days.

Only 15% of the respondents suffering from the overload changes declare that currently they can perform training in the same way as before. Due to some post-traumatic experience, 70% of the respondents are forced to train less frequently or use a reduced load while training.

Discussion

In accordance with legal regulations the first task (which can be interpreted as the most important) of the Polish Prison Service is "conducting penitentiary and rehabilitation to persons sentenced to imprisonment, mainly by organising their work in the way to promote the acquisition of professional qualifications, cultural and educational activities, activities in the field of physical culture and sport, and specialised therapeutic programmes" (The Act of April 9, 2010 on the prison service). Consequently, prison personnel are responsible for preparing inmates for social life complying with the legal and moral standards after regaining freedom. At this point, it should be stressed that health is very important to live in a society. Health as perceived complementarily is an important means of implementing life plans (Kuński, 2000) and one of personal resources, determining a positive rehabilitation of prisoners (Kalinowski et al., 2010). For this reason, imprisonment should be executed in a way to allow inmates to preserve health, especially to minimise the negative impact of prison isolation on health. This postulate applies to various determinants of prisoners’ health, including their participation in physical culture. The standard for daily physical activity of prisoners, delineated by the European Prison Rules should be – according to the authors – applied in pro-health activity to minimise the negative effects of isolation. This means that it is unjustified to leave the prisoners a complete freedom in the choice of exercises and loads, especially in those types of activities which are relatively easy to become anti-health ones. Strength training is such a kind
of activity. It seems that prisoners are a social group particularly vulnerable to negative effects of strength training for two reasons. Firstly, due to a difficult access to reliable knowledge about training in prisons especially taking into consideration places where training do not have organised form. Secondly, due to other than health reasons for which prisoners undertake strength training, i.e. fast muscle growth at all costs increasing the sense of security and giving a higher status in the informal social structures, as „Appearance and physical strength contribute to gaining a specific position by a prisoner in the hierarchy of a group” (Szaszkiewicz, 127). In such circumstances, amateurs frequently use excessive loads intended for professionals. This situation is contrary to international standards, because prisoners’ health potential is lowered, and thereby their ability to adapt to life at large is reduced.

Conclusions

As far as prisoners are concerned, the reasons for overload changes related to strength training include:

- refraining from performing a warm up and stretching exercises
- incompetent dosage of loads including too many training sessions a week
- limited access to reliable knowledge about the safety of strength training

It is necessary to make a multifaceted educational intervention in the form of a health education programme aiming at:

- changing the place of health in prisoners’ axiomatic system by assigning a higher value to health
- raising prisoners’ awareness of the relations between their personal health potential in all areas of health and the opportunities to implement prisoners’ life plans including their full involvement (after imprisonment) in social life without the danger of re-offending and imprisonment
- raising prisoners’ health awareness in the areas of:
  - determining the place of strength training among other types of physical activity in training plans aimed at fostering health;
  - theoretical and methodological foundations of strength training – with special focus on the specific health risks for prisoners.

Such intervention should be supplemented by:

- actions aimed at increasing prisoners’ access to literature on health training for adults through the purchase of appropriate books to a prison libraries;
- appointing a person with instructor’s competences from among pedagogical personnel to supervise the prison gym or gaining such competences by a designated penitentiary tutor.
Additional analysis should be done in the field of health implications of strength training of prisoners who are free to decide on the frequency and the course of such training (choosing training programs, the loads and technique of training applied), and supplement it with a proper medical examination and expand the area of diagnosis (e.g. by selected cardiological indicators). In the case of people who exercise frequently, it is also worth to make a diagnosis on the addiction to physical activity.

In addition, to meet the international standards concerning physical activity of prisoners (regarding the relationship between the high frequency of training and the presence of overload changes), some changes should be introduced in the functioning of prison gyms aimed at promoting the access to them, including less fit and senior prisoners. At the same time, people who start strength training with heavy loads (especially the ones who to not take up any other physical activity) should be encouraged to participate in health-related programs, in which strength training would be a reasonable part of other types of health training.

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Short communication

ORGANISATION OF MANDATORY SPORTS CLASSES AT RIGA TECHNICAL UNIVERSITY

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Abstract

Physical education and sport play a major role in maintaining healthy lifestyle as well as overcoming negative habits. More and more people are getting involved in various types of physical activity. Most of the students also would love to do sport in order to maintain a good health and spend a good time. Lack of funding is an issue the higher education establishments face trying to ensure students with a possibility to do sport properly. Therefore it is necessary to assign state’s supported grants for sport provision at higher educational establishments. A study about mandatory sports classes in the Riga Technical University (RTU) was conducted in order to determine the needs of students. A conclusion was drawn that students are more eager to choose kinds of sport where emotional expressions are involved. Another important agent is proximity of venue of classes to the place of study. 120 – 130 Euro per student is necessary to organize a physical education classes.

Key words: Physical education, higher education, sport classes.

Introduction

RTU has always valued the importance of sport. Since the 1958 when a sport department was established, mandatory sports classes involving various sports have been organized for the Year 1 and Year 2 students two times a week (60min each) and once a week for the Year 4 students. Those classes were mandatory in all higher education establishments and they were funded by the state. A special attention during that time was paid to the youth physical education. During the restoration of the independence mandatory sports classes were liquidated in most higher education establishments due to the limited finances. Only the RTU and...
Latvia University of Agriculture kept mandatory sports classes for the Year 1 and 2 students. In 2008 due to the crisis a question was raised about liquidation of mandatory sports classes in the RTU. Only students’ survey where more than 75% of students expressed a desire to do sport and support offered by the RTU administration helped to maintain physical education classes for the Year 1 students.

Society acknowledges importance of sport in maintaining healthy lifestyle. More and more people are getting involved in various types of physical activity. Most of the students also would love to do sport in order to maintain a good health and spend a good time. Sports play a major role in overcoming negative habits. Therefore it is clear what role sports play in students’ lives and this issue should be tackled at the state’s level. It should be made mandatory in all higher education establishments and the necessary funding should be granted. In order to pursue the objective mentioned above, it is necessary to assess the situation concerning students’ interests and the cost of organizing mandatory sports classes. It is a topical issue and the goal of the paper.

Material and Methods

Results of the Year 1 student application process to the RTU were summarized for the period of time from 2010 till 2014 in order to determine students’ choice of a certain type of sport. More or less popular types of sport among students and the average number of students in one group were determined.

In order to determine the costs of mandatory types of sport over the same period of time, the money per one student in each type of sport spent on wages, expenses incurred by RTU sports bases and leased bases were summarized. Total average expenses were also calculated.

Results

Quantitative indicators of different kinds of sport for the Year 1 students

In the academic year 2010/11 the most students applied for swimming classes. RTU swimming pool offered sports classes for 542 students; average number in one group was 19.4, the numbers for volleyball were, respectively, 266 and 18.6, but for aerobics: 226 and 20.6.

Athletics was less popular: 40 and 13.4; wrestling: 54 and 18; tennis: 57 and 9.5. In the academic year 2011/12 swimming: 533 and 17.8; volleyball: 272 and 25.3; body building: 251 and 17.3.

In the academic year 2012/2013 for swimming: 590 and 18.4; body building: 318 and 24.1; volleyball: 308 and 27.2.
Less popular were: aesthetic gymnastics: 57 and 11.4; wrestling: 70 and 17.5; athletics: 71 and 23.7 (fig. 1).

**Figure 1.** Students’ distribution by types of sport during the 2010 – 15 academic years

In the academic year 2013/14: swimming: 471 and 14.7; body building 294 and 25.7; volleyball 294 and 26.2.

Less popular: wrestling – 52 and 17.3; aesthetic gymnastics – 58 and 14.5; athletics – 65 and 21.7 (fig. 2).

**Figure 2.** Average number of students in a group during the 2010 – 15 academic years
In the 2014.-15 academic year: swimming – 485 and 15.2; body building – 280 and 24; volleyball – 280 and 24. Less popular were: athletics: 43 and 21.5; wrestling: 58 and 19.3; football: 82 and 16.4.

*Sports and work bases costs per one Year 1 student in various types of sports*

During the 2010 – 11 academic years the most money on salaries per one student in our own bases was spent by tennis – 101.2, body building at Skolas street 11 and volleyball at Meža Street 1 – 76.02. Sports bases costs were higher for football – 105.55, wrestling – 89.06 and aesthetic gymnastics - 88. The highest total costs were incurred by football 158.95, wrestling – 142.25 and body building at Skolas street 11 - 133.63. Average costs in our own bases on salaries were 66.82, on sports bases – 42.24 and total – 109.06. The most expensive type of sport in the leased bases was athletics, salary: 112.82, base: 124.5 total: 237.32, on average, respectively, 70.07, 59.78 and 129.85.

Salary per one student in our own bases in total was lower: 66.82 against 70.07 in leased bases and 68.45 on average. RTU sports base costs were also lower: 42.24 against 59.78 in leased bases and total costs 109.06 against 129.85. Total average costs per one student were: 119.46. During the 2011/12 academic year the highest costs per one student in our bases were incurred by tennis: 79.9, therapeutic exercise: 74.46 and boxing: 63.29. Costs of sports basis were the highest for football: 93.13 and wrestling: 89.06. The highest total costs for wrestling: 142.28 and football: 40.26. Average spending on wages: 54.23, on sports bases: 36.37 and total: 90.59 (fig. 3).

![Figure 3. Cost and the average cost of salaries per student in different sports, RTU and rented bases](image-url)
The most expensive type of sports in the leased bases during the same academic year was also athletics. Salary: 76.49, base: 84.41 and total: 160.9, on average, respectively, 54.32, 46.87 and 101.18. Salary per one student in our bases in total appeared to be the lowest: 54.32 against 76.49 in leased bases and on average it was 65.40. Also costs of RTU sports bases were the lowest – 46.87 against 84.41 on the leased ones and total costs: 101.18 against 160.9. Total costs on average per one student were 131.04.

During the 2012/13 academic year the highest spending on salaries per one student in our own bases was on aesthetic gymnastics: 88.57, exercise therapy: 65.41. The highest spending on sports bases was for football 89.61 and aesthetic gymnastics: 70.67. Reviewing the total costs, one can see the highest costs were incurred by aesthetic gymnastics: 159.24, and football: 134.24. Average spending in our own bases on salaries was 55.24, on sports base: 39.39 and total 94.63.

The most expensive type of sports in the leased bases was athletics – salary: 63.56, base: 72.14 and total: 135.7 but on average respectively: 48.6, 45.08 and 93.68. Salaries per one student in our own bases appeared to be the highest: 55.24 against: 48.6 in the leased bases and on average they were 51.92. RTU bases costs were the lowest: 39.39 against 45.08 and on average: 42.24. Interestingly that in that academic year costs of the RTU bases, leased bases and in total were very similar: 94.63, 93.58 and 94.16. (fig. 3).

**Figure 4.** Cost and the average cost of RTU and rented bases per student in different sports
the highest spending on wages per one student in our own bases was for
exercise therapy – 70.33 and body building at Skolas street 11 – 58.63.
Spending on sports bases was higher for swimming – 459.95 and football –
102.14. This can be explained by the fact that by now the swimming pool,
sports halls for exercise therapy and tennis courts were used free of charge;
the sports department was not required to make financial contribution and
students used them free of charge. However, as we can see, costs are rather
high and income from the other clients did not cover all the costs. Therefore
the highest total costs were for swimming – 505.95 and football – 153.82.
Average costs on salaries in our bases were 51.75, on sports bases – 103.29
and total – 155.04.

The most expensive type of sport in the leased bases was athletics –
salary – 69.43, base – 108.25 and total – 177.68, on average respectively –
44.59, 61.59 and 106.18.

Salary per one student in our own bases in total appeared to be
higher – 51.75 against 44.59 in the leased bases, on average they were 48.17.
Costs on RTU bases were also higher – 103.29 against 61.59 and on average
– 82.44. Total costs on average in this academic year in the RTU bases,
leased bases and in total were – 155.04, 106.18 and 130.61.

During the 2014 – 15 academic years the highest expenses on
salaries per one student in our own bases were incurred by aerobics – 63.0
and exercise therapy – 62.11. The highest costs on sports bases were
incurred by swimming – 531.85 and football – 115.84. The highest costs in
total were on swimming – 581.92 and football – 174.38 (fig. 5).

Figure 5. Total cost and average cost per student in diferent sports, RTU and
rented bases
On average costs in our bases on salaries were 53.65, on sports bases: 145.87 and in total: 199.66.

The most expensive type of sport in the leased bases was athletics – salary: 69.77, base: 130.23 and total: 200.0. During this academic year the costs on sports bases also increased and that it had an impact on the total costs. On average respectively – 56.69, 75.87 and 132.56.

Salaries per one student in our own and rented bases as well as on average appeared to be rather similar and were respectively 53.65, 56.69 and 55.17. Expenses of the RTU sports bases were the highest: 145.87 against 75.87, and on average: 110.87. The predicted total costs per one student in this academic year in the RTU sports bases were: 199.52, in the leased bases: 132.56 and on average: 166.04.

Discussion

Results of the study showed that from the 11 types of sport offered the most students chose swimming. Many students also choose volleyball, body building, aerobics and basketball. Fewer students apply for wrestling, aesthetic gymnastics and athletics. There are also students with health problems. They follow the directions given by the doctor and do exercise therapy.

Sports games are also popular because they are characterized by emotional expression. Lady students choose aerobics; the classes are accompanied by music which also creates emotional factor. Body building in gym is getting more and more popular in our society which influences the choice of students as well.

Our practical experience with students allows us to draw a conclusion that our students’ choice of types of sports is often determined by proximity of sport classes to their place of study. Time saving and transport costs are important factors for students. Therefore rather small number of students chooses such popular kinds of sport as football and athletics. Getting to the sports classes by public transport takes not less than 30 minutes. Compliance of the sports bases infrastructure with up-to-date requirements is also important.[3] Body building in the new sports base at Raņķa dambis 24a is more popular than at Skolas 11.

A special role in organization of the sports classes is played by the number of students in one group. In the regulation issued by the ministry of education of the Russian federation it is stipulated that the number of students in one group should be around 12 – 15. Our experience proves that the number of students can be around 15 – 20. In case there are less than 12 students in one group, the classes become unprofitable. If the number of students in one group is higher than 25, it is very challenging to maintain the
quality of classes and the principle of individuality. Unfortunately due to the lack of funding it is very hard to maintain the optimum number of students in one group.

The highest expenses per one student on salary were incurred by the following types of sport – tennis, body building at Skolas 11, aesthetic gymnastics, exercise therapy, boxing and aerobics. Money spent on salaries depends on the number of students in a particular type of sports. If there are fewer students, the higher are expenses on salary per one student. These costs also depend on the qualification the teacher. The higher was the qualification the higher spending on salaries per one student. Still the qualification of a teacher is important to ensure the highest level of the sports classes. Due to the low number of students, tennis and aesthetic gymnastics appeared to be unprofitable and we were forced to give them up.

The most money per one student in our own sports bases was spent by such types of sport as football, wrestling, and aesthetic gymnastics and recently also swimming. The premises of all those types of sport except swimming are old and have high utility and maintenance bills. Still the costs of swimming pool are the highest per one student as maintenance of the swimming pool is very costly.

Athletics was the most expensive type of sport per one student in the leased bases. There should be options how to reduce costs considered or we will have to give up this type of sport.

During the time of the study the average total yearly costs per one student varied from 94.16 in the 2012-13 academic years to 166.04 in the 2014-15 academic years. During the last year the expenses rose due to the costs of the swimming pool. If it was possible to agree with the managers of the swimming pool on fewer expenses, it would be enough with 120-130 euro per one student. The study fee for students is 1500 euro and 8.7% are spent on mandatory sports classes. This is quite a large figure for the RTU. Therefore it is necessary to have this funding granted by the state for at least study programs funded by the budget in all the higher educational establishments in Latvia.

**Conclusion**

It is necessary to assign 120 – 130 euro a year per one student to organize the mandatory sports classes.

In order to organize the mandatory sports classes in the higher education establishments in Latvia, it is necessary to have a state funding comprising 8 – 9% of the total study costs per one student a year.

RTU students choose types of sport where more emotional expression is involved and those which are more popular in society.
Important factors which determine choice of type of sports are proximity of the sports base to the place of study and compliance of the sports base with today’s requirements.

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Short communication

SUMMER SCHOOLS AS AN EXAMPLE OF THE DEVELOPMENT OF INTERNATIONAL COOPERATION BETWEEN THE UNIVERSITIES OF PHYSICAL EDUCATION

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The summer school is a result of cooperation between several physical education universities from a number of countries. The first event of this kind was organised in 2010 as a joint effort between the Latvian Academy of Sport Education (LASE) in Riga and the Faculty of Tourism and Health Sciences in Biała Podlaska. The meeting was centred on the subject of traditional games and recreational activities (outdoor physical activities) in the historical environment in Latvia.

The first three summer schools were organized in Madona, Latvia while the fourth one took place in Biała Podlaska, hosted by the Faculty of Physical Education (Bodasińska et al., 2013). The main idea behind the project is to overcome barriers to teaching between students and teachers. In summer schools both groups learn from each other. The ability to learn is being developed during practical and theoretical classes. A lot of attention is given to working in groups. A number of authors highlight this aspect and recognize its value with regard to functioning in a society. The predominance of the cooperative forms of activity over the competitive ones is becoming widely acknowledged (Sas-Nowosielski, 2003; Piech, 2012; Siwiński, 1999). The participants of summer schools collectively explore the historical culture of the environment in which they are staying. They learn about one another, especially about the culture of the countries they come from. In that respect the summer school product has been a great success. Teachers and students who participated in previous schools came from...
Latvia, Poland, Spain, Italy, Australia, Norway, Sweden, Croatia, Russia and South Korea. In subsequent years, the main theme of the traditional games and recreational activities has developed in the direction of new trends and new ideas emerging in the field of physical outdoor activities. This allowed for a greater diversity of presented subjects, both theoretical and practical ones. This development was intentional. Diversity is considered an aspect of sport that shows the unlimited possibilities of participating in physical activities. Everybody, regardless of their age, fitness, abilities and interests, can find a sport of life for themselves (Piech, 2004). Thanks to diversity, participants of summer schools are being familiarized with a number of interesting sports, physical games and other healthy, recreational activities.

The fifth summer school “Recreation In historical environment In Latvia” was organized in a sports centre Smeceres sils, Madona, in September 4 – 11, 2014. The official opening was attended by the rector of the LASE, Professor Janis Zidens in LASE in Riga. During the meeting was presented a cooperative publication entitled “OSRESS outdoor sports and recreation education summer school” by Inta Bula Biteniece, Kalvis Ciekurs, Juris Grants, Ivars Kravalis, Artur Litwiniuk, Krzysztof Piech, Ingrida Smuka (Biteniece et al., 2014). Theoretical and practical classes organized in Madona were delivered by the following participants: Ingrida Smuka - Latvian Culture Heritage (a lecture), Rudolf Zangerln – parcours (a lecture and practical class), Juris Grants, Inta Bula Biteniece – Landscape education and therapy (a lecture), Ruta Dadeliene – Wellness couching (a lecture), Krzysztof Piech, Małgorzata Lichota, Zbigniew Ossowski, Rasa Paulaskiene, Inta Bula Biteniece, Ilze Spike – Nordic walking and different games (practical class), Artur Litwiniuk – Outdoor sport activity and physical fitness as a factor determining sustainable mental and physical development in youth and adults (a lecture), Kalvis Ciekurs, Ivars Kravalis, Juris Grants – Bicycle tour and meeting local people (practical class), Donatas Grazulis – Horseshoe (practical class). These classes were complemented by dance classes taught by Ingrida Smuka: “Latvian National Dances” and Augustina Gomez Caravaca “Dances from Spain.” During cycling excursions, participants of the summer school had a chance to explore the surrounding area. Their attention was drawn to the environmental, cultural and traditional conditions that contributed to the development of particular forms of physical activities. Interviews conducted by the students with the inhabitants of the area of Madona allowed gathering data on traditional games and recreational activities of the examined region. After researching the subject, students presented the collected data during
classes lead by them. The bicycle tours were a beautiful history lesson for all the participants, a lesson taught by the people who were part of that history.

International cooperation as a result of summer schools, establishing an academic and didactic cooperation between staff of the participant universities is an undeniable achievement of summer schools. The exchange of thoughts, joint research and guest lectures, all contribute to perfecting the didactic process and creating new areas for collaboration. Research undertaken collectively by the professors of the participant universities involves many topics. One of the most important ones concerns physical activities within a family (a child as an initiator of physical activities in a family – Piech K., Bula Biteniece I., Birontiene Z., Grants J., Jansone R.), and elite sport training in secondary higher education - models for sportive success (Carlson R., Grants J., Piech K. et al.). The results have been published in various international journals (Piech et al., 2013). Many academics from LASE, the Faculty in Białe Podlaska and the University of Malaga have delivered lectures and practical classes for students. The publication “OSRESS outdoor sports and recreation education summer school”, which was created as a result of summer schools, is comprised of several chapters written by the authors from different countries. The work includes articles based on studying the data collected during previous summer schools. They are as follows: outdoor recreation activities for learning to learn, games and movement games as a means of recreation in OSRESS, folk games and movement games from Southern Podlasie as an element of cultural heritage, bike tours with the aim to explore cultural environment, physical activity as a factor determining men’s well-being and health, and the outcomes of the workshops (Nilsson, 2014). That last, very important part of the publication constitutes a conclusion of the study of traditional games and recreational activities and is an example of engaging students in academic research.

There was an initiative to organize a conference on sports games in physical education in 2015 in Riga. The conference was organized by LASE in Riga and the Faculty of Tourism and Health Sciences in Białe Podlaska. For the Faculty in Białe Podlaska it was already 10th academic and methodological conference dedicated to teachers of physical education. It is worth noting that the students from participant universities have taken part in LASE scientific conferences in Riga and also in the Erasmus student exchange. Students from Białe Podlaska have multiple times participated in winter camps in Ergli organized by LASE.
Summer schools have been permanently incorporated into the academic life of the participant universities. For the 6th consecutive year Outdoor Sports and Recreation Education Summer School (OSRESS), “Outdoor Activities and Alternative Sports” was held in Torremolinos, Malaga, Spain, in September 14 – 18, 2015. At this time the main organizer of the summer school was the University of Malaga. The aims of the Summer School 2015 were: educational and scientific exchange proposals and establishing common guidelines of work. The participants took part in sports and physical activities in Malaga. The summer school participant student and teacher numerical ratio was similar, learning skills were developed in practical classes in many hiking tours; games/alternative sports were discussed in conferences and workshops.

The 7th Summer School will take place in Biala Podlaska, Poland, September 8 – 14, 2016. Additional information concerning Outdoor Sports and Recreation Education Summer School (OSRESS) in official summer school website: http://osress.weebly.com/.

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CURRENT NEWS

Latvian Academy of Sport Education

LASE International Scientific Conference in Sport Science
March 21 – 23, 2016, Riga, Latvia

LASE 8th PhD and Master Student Scientific Conference
"Theory and Practice in Sport Science"
March 24, 2016, Riga, Latvia

LASE 68th Student Scientific Conference
June 7, 2016, Riga, Latvia

LASE 95th Anniversary International Scientific Conference in Sport Science,
September 5, 2016, Riga, Latvia

The official languages of the Conferences for oral and poster presentations are Latvian and English. The information is placed on the website: www.lspa.lv

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OSRESS 2016

Outdoor Sports and Recreation Education Summer School 2016

September 8 – 14, 2016 Biala Podlaska, Poland

Organizers: Jozef Pilsudski University of Physical Education in Warsaw, Faculty of PE in Biala Podlaska, Poland and Latvian Association of Outdoor Education and Recreation in collaboration with Latvian Academy of Sport Education, State College of Computer Science and Business Administration in Lomza, Poland, Swedish School of Sport and Health Science, Sweden and University of Malaga, Spain.
We congratulate Zinta Galeja, PhD student at the Latvian Academy of Sport Education, who has defended her thesis “CHANGES OF SPORTSMEN NECK AND CHEST SEGMENT FUNCTIONAL CONDITION DUE TO REFLECTOR IRRITATION” (Sport Science) at the Latvian Academy of Sport Education on June 30, 2015. Supervisors: Dr.paed., prof. Alvis Paeglītis.

We congratulate Lilita Voitkeviča, PhD student at the Latvian Academy of Sport Education, who has defended her thesis “BODY HYDRATION IN SPORTS GAME PLAYERS” (Sport Science) at the Latvian Academy of Sport Education on June 30, 2015. Supervisors: Dr.paed., prof. Inese Pontaga.

The Doctoral Thesis has been developed by ESF support within the project “Support for Sport Science” Nr. 2009/0155/1DP/1.1.2.1.2/09/IPIA/VIAA/010 work program „Human resources and employment” 1.1.2.1.2. sub activity ”Support to Implementation of Doctoral Study Programme”

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Claessens (2010) found evidence that attention will be given to multi-compartment models, such as the 3-water, 3-mineral and 4-compartment models, to assess percentage of body fat. However, Raslanas, Petkus and Griškonis (2010) noted that Aerobic physical load of low intensity got 35.1 % of total trainings time. Research on physical loading also focused on
identifying the basis of many years’ research of physical activity (Bytniewski et al. 2010). According to Ezerskis (2010), “… heavy physical loads had the undulating character depending on the dynamics of workloads…” (p. 71) yet girls are more ascertained that the Track & Field training helps to develop courage.

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