Social, Humanitarian and Medical Aspects of Physical Activity
A PROPOSAL FOR THE REDUCTION OF STATIC BALANCE TESTING PROTOCOL IN YOUNG-TO-ELDERLY COMPARATIVE STUDIES

Jernej Rošker¹, Nejc Šarabon¹², Stefan Loefler², and Helmut Kern²
¹ University of Primorska, Science and Research Centre Koper, Institute for Kinesiology Research, Koper, Slovenia
² Ludwig Boltzmann Institute of Electrical Stimulation and Physical Rehabilitation, Wilheminspital, Vienna, Austria

Abstract

The aim of this study was to define the most appropriate static balance measurement protocol for comparisons between young and elderly subjects. A group of young healthy and a group of elderly subjects (n = 2 x 28) volunteered. They performed eight quiet stance tasks in which they were first screened for being able or not to complete a 30 s trial. Additionally, the body sway mechanical parameters were analysed. Results showed that all subjects managed to carry out three tasks, while the proportion of completed trials dropped significantly with the increased task intensity. The observed parameters of the centre-of-pressure showed acceptable levels of sensitivity and repeatability. The outcome of this study enabled us to set the testing protocol for the main study of our project.

Key words: balance, seniors, assessment, fall prevention.

Introduction

Balance assessment is a common part of medical and preventive screening of fragile elderly (DeMyer, 2004). Compromised balance can be the cause of falls during daily activities, that can result in major medical complications (Baczkowicz, Szczegielniak, & Proszkowiec, 2008; Karinkanta, Piirtola, Sievänen, Uusi-Rasi, & Kannus, 2010; Persad, Cook, & Giordani, 2010; Sturnieks, St George, & Lord, 2008). On the other hand, in younger populations, especially athletes, good balance is known to be the ground base for superior sports technique execution (Lamoth, van Lummel, & Beek, 2009), as well as to be an important part of sports injury prophylaxis (Alentorn-Geli et al., 2009; Johansson, Pedersen, & Bergenheim, 2000; Lephart, Pincivero, Giraldo, & Fu, 1997; Taube, Gruber, & Gollhofer, 2008).

Control of equilibrium is a complex task and yet readily mastered by our sensory-motor system (Benvenuti, 2001; Winter, 1995; Winter, Patla, Ishac, & Gage, 2003). Biomechanically speaking the main objective of the sensory-motor system is to maintain the projection of centre of mass (COM) between the borders of the support surface (Benvenuti, 2001; Sarabon, Rosker, Loefler, & Kern, 2010; Winter, 1995). For sensing body sway (BS) or COM movement, various sources of somatosensory information can be used to provide information about the body position and possible balance loss. Most crucial are visual, vestibular, cutaneous, and proprioceptive information derived from eyes, inner ear, skin, muscle and joint proprioceptors respectively (Lackner & DiZio, 2000; Riemann & Lephart, 2002; Schweigart & Mergner, 2008).

As has been shown by various authors, aging can result in loss of muscle proprioceptive function (Goble, Coxon, Wenderoth, Van Impe, & Swinnen, 2009; Ribeiro, Mota, & Oliveira, 2007; Zuckerman, Gallagher, Lehman, Kraushaar, & Choueka, 1999). This is compensated by increased reliance on visual somatosensory cues that slowly prevail to determine body position in space (Jeka, Allison, & Kiemel, 2010). Moreover Lackner and DiZio (2000) argued that some people rely more heavily on visual
information, that is, on referencing their body posture and movement on extrinsically or environmentally
based reference frame. This can cause elderly to become extensively dependent on visual information,
compared to younger counterparts. This modified subconscious processing of various sensory information
influences preparation of appropriate motor responses that enable the maintenance of body equilibrium
(Winter, 1995).

As proposed by some authors (Asseman, Caron, & Crémieux, 2005) the dynamic sensory-motor
control of BS in adult healthy subjects responds differently under vision or no-vision conditions.
Awareness and subconscious perception of body position and movement can be markedly influenced
(Ribeiro et al., 2007; Zuckerman et al., 1999). Vision elimination is therefore commonly used during
balance assessment (DeMyer, 2004). Considering effects of aging and change in use of different
somatosensory information, one can expect BS of elderly to react differently to the vision elimination
than the BS of younger adults. No attempts towards identifying this difference between young adults and
elderly have been done. If there is a difference, it should be considered when preparing prevention
training for elderly as well as in balance assessment in clinical or sports practice.

In striving to compare how differently old and young adults react to vision elimination in various
balance tasks, this pilot study of static balance was conducted. Its main objective was to prepare an
appropriate measurement protocol, which could be used to answer our basic question in the research to
come. The pilot study had two main objectives. First we tried to find balance tasks that could be
performed by both observed age groups. Secondly we wanted to observe, if the balance tasks that can be
performed by both elderly and younger adults, can ensure sufficient sensitivity to change in balance task
intensity in younger adults. Based on the results obtained an appropriate measurement protocol will be
presented, that will enable us to conduct the main experiment.

Methods

The study of static balance consisted of two parts – the screening study and the study of sensitivity of the
body sway related parameters (centre of pressure average velocity - V, amplitude - A and frequency - F).
In both studies neurological, locomotor, vestibular and visual system disorders were used as exclusion
criteria. Prior to participation, each subject was informed about the course of the study and signed an
informed consent form approved by the national committee for medical ethics.

In the screening part two groups, each consisting of twenty-eight subjects were recruited (young
26.3 ± 4.7 years old and elderly 71.2 ± 7.5 years old). The groups were accordingly named as YOUNG
and ELDERLY group, respectively.

Each subject was asked to carry out four quiet stance balance tasks (parallel - PS, semi-tandem -
SET, tandem - TAN, and single leg stance - SL (Figure 1)) with eyes open (EO) and with vision
restriction (VR). When performing the quiet stance tasks with EO, the subjects were instructed to focus
on a reference point marked on the wall in front of them (2-metre distance) and to stand as still as
possible. In the VR variations of the task, a non-transparent band was put over the head to completely
cover their eyes. Throughout the measurement, their hands were placed on their hips, while keeping the
knees in an actively stretched position. An individual made one trial of each of the tasks. The goal was to
try sustaining each stance position for 30 seconds without failing (i.e. making a step, touching the
support, touching the ground with the unsupported leg). Sixty-second breaks were used between the trials.
For each individual subject, each of the eight balance tasks was marked either as a successful or a fail.

Figure 1: the four different foot positions used: (a) PS, (b) SET, (c) TAN and (d) SL. The leg dominance
is marked by D (dominant leg) and ND (non-dominant leg). Note that the m-l dimension in PS (a) equals
that of the hip-width.
The screening study was followed by the sensitivity study of body sway parameters observed by the centre of pressure (COP) movement. Five subjects from each group (young 24.5 ± 2.3 years old and elderly 69.3 ± 3.5 years old) were compared regarding the main COP parameters. Subjects from both groups carried out three 30-second balance tasks (PS with EO and VR as well as a SET stance with EO), each repeated for three times. All the instructions and organization of the measurements were the same as in the screening study.

Ground reaction forces representing the COP sway were acquired by the use of a force plate (AMTI, Watertown, USA) with a sampling frequency of 1000 Hz and signals were stored on a personal computer for further analysis. Signals were 0.1-15 Hz band-pass filtered. The COP curve was quantified with custom-written software (LabView 8.1, NI, Texas, USA) using the following parameters: the velocity of the common COP movement (VΣ), the average amplitude of the COP oscillations (AΣ), and the frequency of the COP oscillations represented by the mean value of the Furrier-transformed signal (FΣ). All the parameters were calculated as an average of a 30-second trial.

For the screening study number of successful subjects was expressed as a percentage of all participating subjects of a group. Ninety percent success for a stance in young and elderly group was used for considering the stance as appropriate for further inclusion in the sensitivity study. In the second study a three-repetition average of each individual parameter was calculated for each of the quiet stance tasks.

### Results

Results from the screening study are presented in Table 1. As can be seen in the YOUNG group, all participants were able to perform all tasks without falling. The exception was SL with VR. In the ELDERLY group the percentage of success fell dramatically with increase in task intensity. In EO conditions PS and SET tasks could be considered as the ones that could be completed by above 90 percent of the subjects in the YOUNG and the ELDERLY group.

#### Table 1: Capability of the subjects to complete the 30-second task (n = 2x 28 subjects).

<table>
<thead>
<tr>
<th>EYES</th>
<th>STANCE</th>
<th>YOUNG</th>
<th>ELDERLY</th>
<th>POSSIBLE IN BOTH</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(n/all) (%)</td>
<td>(n/all) (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EO</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PS</td>
<td>28/28 100</td>
<td>28/28 100</td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>SET</td>
<td>28/28 100</td>
<td>27/28 96</td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>TAN</td>
<td>28/28 100</td>
<td>12/28 43</td>
<td>no</td>
<td></td>
</tr>
<tr>
<td>SL</td>
<td>28/28 100</td>
<td>3/28 11</td>
<td>no</td>
<td></td>
</tr>
<tr>
<td>VR</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PS</td>
<td>28/28 100</td>
<td>28/28 100</td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>SET</td>
<td>28/28 100</td>
<td>16/28 57</td>
<td>no</td>
<td></td>
</tr>
<tr>
<td>TAN</td>
<td>28/28 100</td>
<td>5/28 18</td>
<td>no</td>
<td></td>
</tr>
<tr>
<td>SL</td>
<td>22/28 79</td>
<td>0/28 0</td>
<td>no</td>
<td></td>
</tr>
</tbody>
</table>

Results of the sensitivity study are presented in table 2. The observed parameters show an increase with increase in balance task intensity. The ELDERLY group showed higher absolute values of VΣ and AΣ. Both YOUNG and ALDERLY group showed changes in the observed parameters between three observed tasks that are significant. The smallest changes could be observed in FΣ in both groups. As the YOUNG group shows a trend of stable FΣ the ELDERLY group shows a trend where the FΣ increase with balance task intensity. Relative change form PS-EO to PS-VR proved to be smaller for elderly, as from PS-VR to SET-EO the changed proved to be bigger.

#### Table 2: General COP derived parameters (n = 2 x 5 subjects).

<table>
<thead>
<tr>
<th>AVG ± SD</th>
<th>VΣ</th>
<th>AΣ</th>
<th>FΣ</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Young</td>
<td>elderly</td>
<td>young</td>
</tr>
<tr>
<td>PS-EO</td>
<td>10.2 ± 5.1 mm/s</td>
<td>14.4 ± 4.4 mm/s</td>
<td>2.5 ± 1.0 mm</td>
</tr>
<tr>
<td>PS-VR</td>
<td>13.3 ± 6.3 mm/s</td>
<td>17.2 ± 5.7 mm/s</td>
<td>3.5 ± 1.7 mm</td>
</tr>
<tr>
<td>SET-EO</td>
<td>15.1 ± 4.2 mm/s</td>
<td>27.9 ± 11.8 mm/s</td>
<td>4.5 ± 1.4 mm</td>
</tr>
</tbody>
</table>
Discussion

The first part of this pilot study showed that three out of eight different body balance tasks could be performed by young and elderly subjects. Tasks such as TAN and SL with EO as well as SET, TAN and SL with VR were too demanding for the majority of the elderly subjects. In the second part we showed that the BS parameters observed are able to differentiate between the three balance tasks where all subjects were successful. Based on these results PS-EO, PS-VR and SET-EO can be used for further studies where comparisons between young and elderly adults are in the focus of interest.

As expected elderly subjects were not able to successfully perform all of the balance tasks observed. This is also true when the vision was unrestricted. Based on these results one can conclude that foot positions that are more demanding than SET are not appropriate for successful comparison between elderly and other age groups.

Due to changed sensory reweighting (Goble et al., 2009) the subjects were very susceptible to restrictions of vision as compared to the condition where vision was unrestricted as can be seen in the first study. More in-depth insight into how the restriction of vision influences can be seen from the second part of our pilot study. Here the trends observed clearly suggest that the BS of elderly is affected to a greater extent by vision restriction than in the younger subjects. The $\Sigma$ as well as $\Lambda \Sigma$ are higher for the elderly. But relative change suggests that the change from PS-EO to PS-VR in the elderly is smaller than in younger subjects. But the change from PS to SET both with EO shows a larger decrement in BS of elderly. Although this pilot study does not lend itself to conclude how differently vision effects BS of young and elderly during different foot positions, the trend of difference can be seen.

Conclusion

For the purpose of observing the effect of vision elimination on BS during stances of various intensities, PS-EO, PS-VR as well as SET-EO can be used. These stances enable elderly and younger subjects to successfully complete the balance task, so that the more in-depth study of BS using COP-derived parameters can be performed.

Acknowledgements

The authors would like to acknowledge the support of: (1) the EU Interreg-IVa programme Österreich-Slowakei, no. SK-AT_080612_N0033 and (2) the Austrian national co-financing of the BM BWK.F.

References


ACHILLES TENDON DIAMETER DEVELOPMENT IN 4-YEAR OLD CHILDREN

Boštjan Šimunič 1,2 Nejc Šarabon 1,2 Rado Pišot 1,2

1 University of Primorska, Science and Research Centre of Koper, Institute for Kinesiology Research, Koper, Slovenia
2 University of Primorska, Faculty of Education Koper, Koper, Slovenia

Abstract

Achilles tendon (AT) is an important connective tissue organ that attaches calf muscles to the calcaneus bone. There has been little research in AT developmental potential in children although it seems to be the basis for a child’s motor development, especially of flexibility, strength and speed. The aim of the study was to evaluate multiple linear regression model of AT diameter based on child morphology, calf muscle architecture and ankle/knee maximal voluntary torques. Measurements were conducted on 104 children using standard instruments, diagnostic sonography, adapted isometric dynamometers. We found 23 % explained variance with muscle gastrocnemius medialis diameter (R = 0.258; P = 0.018), pennation angle (R = -0.195; P = 0.047) and muscle soleus diameter (R = -0.322; P = 0.003) as significant factors. Interestingly, we have not found maximal knee and ankle torques as significant factors. In conclusion we could confirm that AT diameter is related to calf muscle geometry and architecture but only with 23% of explained variance. However, in 4-year old children such magnitude of determination factor could be interpreted as very important.

Key words: Child, Skeletal muscle, Ultrasonography, MVC, Gastrocnemius, Soleus

Introduction

Achilles tendon (AT) is an important connective tissue organ that connects calf muscle mass to calcaneus. There has been little research in AT developmental potential in children although it seems to be the basis for a child’s motor development, especially of flexibility, explosive strength and speed. Furthermore, it is well known that at coordinated movement elastic energy recoil of in-series elastic component of the muscle-tendon system (as AT is) increases elastic strength and reduces energy consumption in repetitive movement.

AT geometry is closely related to its mechanical properties and therefore to its function. As far as we know little research is available for AT geometrical development (Bezerra, Campos Júnior, Bezerra, Pires Júnior & Bezerra, 2009; Koivunen-Niemelä & Parkkola, 1995) and no research has been done on identification of possible developmental factors of AT geometry. AT diameter changes with child age from 4.6 mm at 10 years up to 6.3 mm at 18 years. However, one of the metabolic factors that diminish AT diameter in newborns is parental administration of drugs for hypercholesterolemia (Tsouli, Xydis, Argyropoulou, Tselepis, Elisa & Kiortsis, 2009). Furthermore, severe intratendinous abnormalities and an AT diameter over 10 mm suggested a partial rupture in adults (Åström, Gentz, Nilsson, Rausing, Sjöberg & Westlin, 1996). It seems that in adults AT diameter or cross sectional area plasticity could be neglected as it does not change as a result of strength training (Urlando & Hawkins, 2007) nor as a result of 21-days of bed rest (Kubo, Akima, Ushiyama, Tabata, Fukuoka, Kamehisa & Fukunaga, 2004).

Recently, Morse, Tolfrey, Thom, Vassilopoulos, Maganaris & Narici (2008) found about 20% higher gastrocnemius muscle specific force in boys than in men. However, they could not explain it by differences in moment arm length, muscle activation, or architecture, nor with other factors, such as tendinous characteristics and/or changes in moment arm length with contraction. AT physiology (with
inhibitory tendinous Golgy organ developmental aspect) was not included in the above study, but it seems that AT might be the reason for the higher gastrocnemius muscle specific force in boys than in men.

The aim of our study was to investigate some possible factors for AT development in 4-year old children. The null hypothesis was that there is no regression trend between AT diameter (dependent variable) and morphological, gastrocnemius medial and soleus geometrical and architectural characteristics, and leg maximal voluntary torques (independent variables).

## Applied methods

**Participants:** Hundred-nine (52 boys) 4-year old children were included in the study and 88 (40 boys) of them passed all tests. Descriptive children data are presented in Table 1. This experiment was a sub-study of a basic national research project (“Analysis of fundamental motor pattern, skeletal and muscle adaptation on specific sedentary lifestyle factors amongst 4 to 7 years old children” (J5-2397)) conducted by University of Primorska, Institute for kinesiology research. Children’s parents gave their written consent prior to the study initiation. All testing procedures conformed to the 1964 Declaration of Helsinki and were approved by the Committee for Medical Ethics at the Ministry of Health (Slovenia).

**Figure 1.** Achilles tendon diameter measurement with ultrasonography.

**Figure 2.** (A) Measurement of Achilles tendon diameter ($D_{AT}$); (B) gastrocnemius medialis (GM) and soleus (SO) diameter (D), fascicle length (L), and pennation angle ($\alpha$).

**Sonographic measurements:** Achilles tendon diameter ($D_{AT}$), gastrocnemius medialis (GM) and soleus (SO) muscle architecture were measured twice at mid-distance along the mid-sagittal plane in prone position by ultrasound imaging using a digital ultrasonographer (Esaote Mylab 25) fitted with a 7-10 MHz linear probe (Figure 1). As muscle architecture we assessed muscle belly diameter ($D_{GM}$ and $D_{SO}$), muscle fascicle length ($L_{GM}$, $L_{SO}$) and muscle fibre pennation angle ($\alpha_{GM}$, $\alpha_{SO}$) as presented in Figure 2B. An average of both measurements was taken into further analysis.

**Maximum voluntary torque measurements:** Maximum voluntary torque was measured at knee extension and ankle plantar flexion (Figure 3). Knee extension is not directly related to AT function; however it gives approximate reflection of overall leg muscle strength. Children were motivated to exert three unilateral maximal contractions where the amplitude of the contraction with the highest torque taken
in further analysis. The test was carefully explained to children and they were motivated with visual feedback to assure their maximal effort.

Figure 3. Maximum voluntary torque measurement in knee extension (left) and ankle plantar flexion (right).

Statistics: All data were normally distributed and are expressed as means ± standard deviation. Descriptive analysis includes t-test comparison of gender differences. We have tested two null hypotheses: (i) there is no significant correlation between $D_{AT}$ with GM and SO muscle architecture and other morphological parameters with Pearson product-moment correlation coefficient; and (ii) there is no multiple linear regression model that could significantly explain $D_{AT}$, on the basis of GM, SO architecture and/or morphological parameters. Statistical significance was always set at $P < 0.05$.

Results

All descriptive data are presented in Table 1 for boys and girls separately. Statistically significant differences were expected and found just in fat mass ($P = 0.002$) and muscle mass ($P < 0.001$).

Bivariate Pearson correlation analysis revealed significant correlation between $D_{AT}$ with body mass ($R = 0.240; P = 0.017$) and $D_{GM}$ ($R = 0.307; P = 0.001$) while no relation was established with body height ($P = 0.092$). We could reject first null hypothesis and confirm that $D_{AT}$ is significantly related to body mass and $D_{GM}$.

Table 1. Descriptive analysis of observed parameters

<table>
<thead>
<tr>
<th></th>
<th>Boys</th>
<th>Girls</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>40</td>
<td>48</td>
</tr>
<tr>
<td>Body mass (kg)</td>
<td>18.8 ± 2.6</td>
<td>18.5 ± 2.7</td>
</tr>
<tr>
<td>Body height (cm)</td>
<td>108.3 ± 4.4</td>
<td>108.2 ± 4.4</td>
</tr>
<tr>
<td>Tibia length (cm)</td>
<td>21.4 ± 1.4</td>
<td>21.5 ± 1.3</td>
</tr>
<tr>
<td>Fat mass (%)</td>
<td>15.0 ± 2.9</td>
<td>16.4 ± 2.6*</td>
</tr>
<tr>
<td>Muscle mass (kg)</td>
<td>5.9 ± 0.8</td>
<td>5.1 ± 0.7*</td>
</tr>
<tr>
<td>GM diameter (mm)</td>
<td>10.0 ± 1.1</td>
<td>10.3 ± 1.8</td>
</tr>
<tr>
<td>GM fascicle length (mm)</td>
<td>47.9 ± 11.9</td>
<td>46.3 ± 10.3</td>
</tr>
<tr>
<td>GM pennation angle (deg)</td>
<td>14.1 ± 2.8</td>
<td>14.0 ± 3.0</td>
</tr>
<tr>
<td>SO diameter (mm)</td>
<td>10.4 ± 1.6</td>
<td>10.7 ± 2.2</td>
</tr>
<tr>
<td>SO fascicle length (mm)</td>
<td>54.6 ± 18.3</td>
<td>57.8 ± 17.8</td>
</tr>
<tr>
<td>SO pennation angle (deg)</td>
<td>13.2 ± 3.6</td>
<td>13.4 ± 2.7</td>
</tr>
<tr>
<td>AT diameter (mm)</td>
<td>2.1 ± 0.3</td>
<td>2.1 ± 0.4</td>
</tr>
<tr>
<td>Knee MVC torque (Nm)</td>
<td>38.9 ± 12.0</td>
<td>41.1 ± 11.6</td>
</tr>
<tr>
<td>Ankle plantar MVC torque (Nm)</td>
<td>26.9 ± 8.5</td>
<td>28.4 ± 7.0</td>
</tr>
</tbody>
</table>

GM – gastrocnemius medialis; SO – Soleus; AT – Achilles tendon; MVC – Maximum voluntary contraction; * $P < 0.05$. 

345
Furthermore, a multiple linear regression of $D_{AT}$ revealed significant overall prediction model (Table 2) with $R = 0.477$ ($P = 0.006$). The predictors that significantly contribute to overall prediction model were $D_{GM}$ (part $R = 0.235$; $P = 0.018$); $\alpha_{GM}$ (part $R = -0.175$; $P = 0.047$); and $D_{SO}$ (part $R = -0.322$; $P = 0.003$).

### Table 2. Multiple linear regression model of Achilles tendon diameter

<table>
<thead>
<tr>
<th>Predictor list</th>
<th>B</th>
<th>SE B</th>
<th>B</th>
<th>Part R</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>0.178 mm</td>
<td>0.035</td>
<td>0.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Body mass</td>
<td>0.003 mm/kg</td>
<td>0.002</td>
<td>0.259</td>
<td>0.167</td>
<td>0.092</td>
</tr>
<tr>
<td>Fat mass</td>
<td>-0.001 mm/%</td>
<td>0.001</td>
<td>-0.071</td>
<td>-0.061</td>
<td>0.531</td>
</tr>
<tr>
<td>GM diameter</td>
<td>0.065 mm/mm</td>
<td>0.027</td>
<td>0.312</td>
<td>0.235</td>
<td>0.018*</td>
</tr>
<tr>
<td>GM pennation angle</td>
<td>-0.002 mm/deg</td>
<td>0.001</td>
<td>-0.211</td>
<td>-0.175</td>
<td>0.047*</td>
</tr>
<tr>
<td>SO diameter</td>
<td>-0.053 mm/mm</td>
<td>0.017</td>
<td>-0.318</td>
<td>-0.298</td>
<td>0.003*</td>
</tr>
<tr>
<td>SO pennation angle</td>
<td>-0.001 mm/deg</td>
<td>0.001</td>
<td>0.105</td>
<td>0.099</td>
<td>0.316</td>
</tr>
<tr>
<td>Knee MVC torque</td>
<td>0.000 mm/Nm</td>
<td>0.000</td>
<td>-0.029</td>
<td>-0.023</td>
<td>0.817</td>
</tr>
<tr>
<td>Ankle plantar MVC torque</td>
<td>0.000 mm/Nm</td>
<td>0.000</td>
<td>0.008</td>
<td>-0.007</td>
<td>0.945</td>
</tr>
</tbody>
</table>

$B$ – Unstandardized coefficient; $SE$ – Standard error; $\beta$ – Standardized coefficient; $R$ – Correlation coefficient; $P$ – P-value; * $P < 0.05$

We could reject second null hypothesis and confirm that $D_{AT}$ could be predicted using above multiple linear regression model with determination magnitude of 23% of explained variance.

### Discussion

Power of determination of our multiple regression model was significant at 23% of explained common variance. We used 8 predictors, which could be interpreted as a big number but we wanted to demonstrate the effect of all possible factors. We limited variance inflation factor at values below two.

Significant factors that affected $D_{AT}$ were four: positive correlation was found in $D_{GM}$; while negative correlation was found in $D_{SO}$, and $\alpha_{GM}$. However, we could not neglect the body mass positive correlation ($P = 0.092$).

Positive correlation of $D_{GM}$ on $D_{AT}$ was actually expected. GM muscle is directly attached to proximal end of AT and therefore all the exerted GM muscle power is transmitted through AT to calcaneus bone. GM muscle is involved in ankle planter flexion and activates at physical activities where knee joint is (almost) extended.

Surprisingly, we found the same, but negative correlation between $D_{SO}$ and $D_{AT}$. The posterior aponeurosis and median septum of the SO muscle join with the anterior aponeuroses of the gastrocnemius muscles to form the Achilles tendon. SO muscle is a large and powerful muscle and has a higher proportion of slow muscle fibers than GM muscle (Johnson, Polgar, Weightman & Appleton, 1973). Since the sitting ankle MVC torque was insignificant factor of $D_{AT}$, we could conclude that SO strength has no effect on $D_{AT}$. Other mechanisms have to be searched for to explain the negative correlation between $D_{SO}$ and $D_{AT}$. As already mentioned, GM muscle activates just at extended knee joint, SO muscle is theoretically active independently of anatomical position of knee joint, however, power sharing effect takes over at extended knee joint. The GM muscle takes over the larger proportion of torque generation. This is even more evident at rapid movements where more fast twitch fibers of GM muscle activate. We controlled this with partial correlation between $D_{SO}$ and $D_{AT}$ and controlling for $D_{GM}$. There was no change between partial correlation and raw Pearson correlation. The activation patterns of the two main ankle extensor muscles: SO, with a predominance of slow-twitch muscle fibers; and GM, in general consisting of >50% fast-twitch muscle fibers shifts in relative activation magnitude from the slow SO to the fast GM with increasing demands of force and speed (Moritani, Oddsson & Thorstensson, 1991). This finding indicates a task-specific preferential reliance on either of the two functionally specialized muscles within the ankle extensor synergy. In summarizing this part of discussion we could conclude that some children are more “sedentary oriented” or with other words are involved in physical activities where knee joint is flexed and therefore are less involved in rapid standing physical actions. This group of children might have thinner $D_{AT}$. This should be further investigated and experimentally confirmed.
Another significant contribution to overall regression model of $D_{AT}$ was found in $\alpha_{GM}$. $\alpha_{GM}$ is negatively related to $D_{AT}$ and is higher in muscles that exert more muscle force, but is lower in muscles that exert more rapid bursts of muscle force, that is power.

Therefore, we might conclude that $D_{AT}$ is mainly related to GM architecture. Although the regression power of determination is low to medium (23%) we might conclude that selected factors do affect $D_{AT}$, however, other factors have to be considered in following studies. For causative relationship a longitudinal study is already in progress.

Acknowledgements

The authors are thankful to Slovenian Research Agency for financing the research project “Analysis of fundamental motor pattern, skeletal and muscle adaptation on specific sedentary lifestyle factors amongst 4 to 7 years old children”. We are grateful to all children and their parents for permitting us to perform a study of such magnitude. Nevertheless, big thanks also to other researchers and students for their help.

References


CASE STUDIES REPORTS ON CONSERVATIVE TREATMENT OF THE SHOULDER INJURIES IN SPORT

Šarabon Nejc
University of Primorska, Science and Research Centre Koper, and
Institute for Kinesiology Research, Koper, Slovenia

Abstract
The aim of this report is to present three case studies about conservative treatment of the soft tissue shoulder injuries suffered by a swimming, tennis, and hockey athlete. Anamnesis, testing and evaluation data as well as program design and its realization are presented for each case – i.e. lesion of a biceps humeri proximal insertion, sub-acromial impingement and recurrent gleno-humeral luxation. Special attention is given to the mechanisms behind the injury development and criteria for selection of the proper exercises. The latter encompasses the aspect of flexibility, strength and power, and functional joint stability. Evidence based argumentations for the presented approach and the discussion of the gained results are provided.

Key words: upper extremity, shoulder, conservative treatment, kinesiotherapy

Introduction
Anatomical structure of the shoulder is adjusted for good mobility and enables high amplitude movements which are carried out primarily in open-kinetic chain. The shoulder joint (i.e. gleno-humeral joint) has the greatest range of motion of all the joints in the human body (Veeger & van der Helm, 2007). It is a ball-socket joint with all three degrees of freedom. Stability of the gleno-humeral joint, on the other hand, is often insufficient to ensure safe operation during the presence of extreme shear forces. Arthrokinematics of the glenohumeral joint consists mainly of rotation but may also include some translational movements (rolling/gliding).

When considering injury mechanisms, injury prevention and rehabilitation programs, we need to be aware of the complex structure and function as well as the inter-dependence of the entire shoulder girdle complex. The latter encompasses gleno-humeral, sterno-clavicular, acromio-clavicular, and scapulo-thoracic articulations and the active and passive stabilizers and mobilizers which act over these joints (Borsa, Laudner, & Sauers, 2008).

Because the shoulder lacks inherent bony stability, this joint relies on the static and dynamic soft tissue stabilizers. Geometrical stability of the very narrow convex part of the joint, the glenoid fossa, is partly compensated by labrum, a connective tissue anatomical structure on the rim of the socket. Besides articular capsule and ligamentous apparatus, the main active stabilization system is rotator cuff muscles. These muscles function primarily in co-contraction manner and play an important role of the movement control of the entire upper extremity (Bytomski & Black, 2006). To put together, shoulder stability depend on a glenoid of the adequate size, a posterior tilted glenoid fossa, a retroverted humeral head, an intact capsule and an intact glenoid labrum, and an intact functioning rotator cuff.

When speaking about the neuro-muscular control, interplay of the shoulder complex muscles involves combinations of (i) stabilizers and movement generators, (ii) agonists and antagonists and (iii) single-joint and bi-articular muscles. In order to be effective, prehabilitation and rehabilitation programs should respect these functional characteristics and should encompass three main types of exercises –
strength/power, stretching and stabilization (for a thorough review see (Bytomski & Black, 2006; Escamilla, Yamashiro, Paulos, & Andrews, 2009; Kelly, Wrightson, & Meads, 2010; Mölsä, Kujala, Myllynen, Torstila, & Airaksinen, 2003)).

Appearance of shear forces and translational movements represent the source of the majority of the overuse shoulder problems (Braun, Kokmeyer, & Millett, 2009; Lugo et al., 2008; Veeger & van der Helm, 2007). Interestingly, majority of the improper kinematics and dynamics starts at the weak and functionally deficient muscles around the scapula (Bytomski & Black, 2006; Forthomme, Crielaard, & Croisier, 2008). The base for solving majority of the shoulder injury problems is well positioned and actively mobile scapula – i.e. optimal scapulothoracic rhythm during sport specific movements. Among sport-related movement patterns there are some which predominate in stressing the shoulder structures more than the others. Shoulder-related injuries of different kinds are most commonly linked to the so called “overhead” or “overhand” activities (Braun et al., 2009). However, these activities can be very different in the context of volume-to-intensity relationship, which can range from one end (a tennis serve, a baseball pitch, a water polo or a team-handball shot, etc.) to the other (different swimming strokes). Anyhow, shoulder injuries are not limited to these movements. They appear regularly also in many other sport specific situations which involve low-elbow movements of different intensities (rowing, golf strokes, etc.) external forces (martial arts, falls in different sports, etc.) or a combination of all these (ice hockey) (Bayes & Wadsworth, 2009; Deits, Yard, Collins, Fields, & Comstock, 2010; Mölsä et al., 2003; Owens et al., 2007; Romaine, Davis, Casebolt, & Harrison, 2003; Rumball, Lebrun, Di Ciacca, & Orlando, 2005).

The aim of this paper is to present three case reports on shoulder sport injuries – lesion of a biceps tendon proximal insertion in a swimmer, sub-acromial impingement of a tennis player, and recurrent gleno-humeral subluxation in an ice-hockey player. For each case the injury mechanism is explained and the description of the kinesiotherapy intervention used is given. Outcome results of the physiotherapeutic treatment are described.

Case study 1

Fifteen years old elite male swimmer (body height 186 cm, body weight 76 kg) and eleven years of training suffered from shoulder pain at the lateral and anterior compartment on the right side of the body. The pain was progressing during the six-months period before he visited an orthopedic specialist and got his injury diagnosed (clinical examination, MRI) as a 1st degree SLAP lesion with an accompanied tendinosis of m. supraspinatus and the resulting posterosuperior impingement.

Acute unloading of the shoulder (three weeks) and passive physiotherapy procedures for tissue healing were prescribed. The latter encompassed 10x laser and 10x interference electrical current therapy. After the three weeks of the passive procedures, the pain during rest and during moderate-intensity activities disappeared. Therefore a conservative progressive movement therapy was announced indicated by the doctor.

At the first training session functional examination of the shoulder complex was carried out and the following specificities were identified: (i) weak parascapular muscles with the accompanied anteroposition of the scapula, (ii) moderate deficit of internal rotation, (iii) increased tone of upper trapezius, and (iv) positive provocative test for m. biceps and m. supraspinatus using a controlled eccentric contraction task.

Based on these deficits a nine-week training plan was designed. The plan was characterized by: (i) three training sub-periods, each lasting for three weeks, (ii) adjusted basic swimming and physical conditioning training so that the unloading, i.e. progressive loading was assured, (iii) general conditioning of other body parts was regularly involved, (iv) strength, flexibility and stability contents for the shoulder girdle as a whole, and (v) closely guided progressive loading of the tendon of the long head of biceps humeri and the tendon of supraspinatus. This progressive loading was done through the control of the key characteristics of the strength and functional stability exercises (Figure 1) – type of muscle contraction (from concentric over isometric to eccentric), volume (increasing the number of repetitions and sets), and intensity (increasing the load and frequency).

The outcome of this conservative treatment turned out to be positive. After the finish of the therapeutic period, the patient was able to perform daily as well as swimming activities pain free. At that
stage, he was slowly progressing to the full volume training regimen (during the following 4 weeks) and he got a complementary training plan aimed to prevent from injury recurrence.

A SLAP tear or lesion occurs when there is damage to the superior or uppermost area of the labrum. If only the highest frequency of SLAP lesions are known especially in throwing athletes (Dodson & Altchek, 2009; Keener & Brophy, 2009; Manske & Prohaska, 2010), they are far from rare also in other sports, even in swimming (Richardson, Jobe, & Collins, 1980). However, in swimming, the mechanism for this injury is significantly different (repeatedly overstressing the tendon-labrum junction) than in the case of explosive throwing (acute high-intensity overstress during either the early acceleration phase or during the eccentric loading in deceleration phase of the overhead throw). Less than 30% of SLAP lesions are isolated. Rotator cuff tears, acromio-clavicular joint disorders and instability are most common associated diagnoses. In the case of the first degree SLAP lesion a degenerative fraying of the superior portion of the labrum, with the labrum remaining firmly attached to the glenoid rim is present. The possible consequence of chronic superior labrum tear may be formation of a cyst that can compress the suprascapular nerve, evoke pain and affect motor control of the shoulder. However, in our study, no final status check using the imaging techniques has been used to check for the structural healing.

It is therefore very important to include preventive measures (warm-up, technique optimization, stretching of the posterior capsule and long head of biceps and concentric/eccentric strength at high velocities). If not doing so, repeatedly overloading the superior labral region will lead to increasingly more severe SLAP tears which almost inevitably require surgical treatment.

Case study 2

Fifty years old male recreational tennis player (body height 181 cm, body weight 74 kg) was diagnosed (ultrasonography and MRI) to have a combination of acute irritation-inflammation processes and chronic degenerative changes of the joint and joint surrounding structures. These involved an initial stage of arthritic changes in acromio-clavicular and gleno-humeral joints. Cervical lordosis was flattened and the C5-C6 intra-vertebral space was narrowed. The subacromial space was irritated because of the subacute phase of the overloaded the m. supraspinatus. A small tendon tear was diagnosed but accompanied by the active inflammatory process that involved also the subacromial bursa.
The patient was instructed to treat the injury conservatively with unloading, cooling and progressive movement therapy. Clinical examination was carried out and the following deficits were identified: (i) shrinking of the posterior capsule of the gleno-humeral joint and an extreme internal rotation deficit, (ii) weak abductors and adductors of the scapula and the resulting anteroposition of the scapula, (iii) very high tension of upper m. trapezius, (iv) weak external rotators of the shoulder joint. Provocative tests for m. supraspinatus and sub-acromial impingement were positive. No pain was present during the contractions performed in the positions in which the elbow did not exceed 40° flexion/abduction.

Addressing the described deficits we set a three months training plan which was aimed to unload the irritated structures, strengthen the weak muscles, stretch the tightened structures, and also to take care of very slow gradual return back to the tennis activities after the tissues became healed. For this purpose, we introduced a progression training plan that consisted of flexibility, strength and stability exercises. During the first month the focus was on stretching the posterior capsule, scalene muscles and upper trapeze muscles (four exercises, ~10 min per each exercise per day, every day). The strengthening (four exercises, 3-5 sets, submaximal loads, three times per week) and stabilization-enhancing exercises (three exercises, 3 sets, two times per week) were mildly introduced (Figure 2). The focus was put on the rhomboids, middle trapezius, serratus anterior, and rotator cuff; especially external rotators. In this introduction period, only the exercises with low elbow positions, not exceeding 70° abduction/flexion of the shoulder, were applied. This was followed by the progression in volume, intensity in exercises during the second and the third month. In this context the exercises in 90° shoulder flexion/abduction were slowly introduced. As the most important guide for a day-to-day workout was the occurrence of pain. While the kinesiotherapeutic intervention was carried out, the subject was instructed to avoid playing tennis or any other ballistic upper extremity movements. Instead of playing tennis, he participated regularly in other activities of his choice (running, cycling, etc.) in order to sustain/develop aerobic-anaerobic endurance and general physical fitness. After the end of the three months period, a plan for a slow return to the tennis field was set. It was a tree week transition plan. During this time he was playing tennis only twice a week. He was restricted to using the following strokes: first week only forehand and backhand at ~70% intensity, second week the same two strokes at ~90% intensity, and third week adding the overhead strokes (serve and smatch) at submaximal intensity.

Figure 2: Two stretching and two strengthening exercises that were used in the program. Stretching of the posterior capsule of the gleno-humeral joint using internal rotation of the shoulder (A) and passive horizontal flexion (B); strengthening using an elastic tubing for a “full-can” exercise which is an abduction 0-70° in the scapular plane (C) and external rotation with accompanied scapular retraction (D).

The outcome of the four week work with the patient resulted in a pain free tennis participation (3-4 times per week) still half a year after our collaboration was finished, when the last check-up meeting was done.

Shoulder impingement syndromes are one of the most common causes for shoulder pain and dysfunction, especially in overhead athletes, but also among general population (Budoff, Nirschl, Ilahi, &
Traditionally the causes for subacromial impingement are grouped into structural and functional factors. Among the structural, also called primary or extrinsic factors, an abnormal morphology of acromion, acromio-clavicular joint osteophytes and coraco-acromial ligament hypertrophy are the most common ones. Apart from these, internal or dynamic factors, such as an intrinsic tendon injury or degeneration, are much more often. However, we need to understand the mechanics of the shoulder girdle as a whole in order to be effective in our rehabilitation and prevention interventions. It turns out that subacromial irritation can have its roots in scapular dysfunction, glenohumeral instability, muscle imbalance, primary tendon overload and/or repetitive tendon microtrauma (Cools, Declercq, Cagnie, Cambier, & Witvrouw, 2008). Therefore if we aim to have a long lasting effect, we need to first search for the underlying mechanisms and then to take those measures which will address the cause and not the result/symptom.

Case study 3

A national team member in ice hockey (20 years old, body height 177 cm, 75 kg) suffered several right shoulder dislocations during the last 12 months of playing hockey the last one being only 14 days before searching for the medical help to address his problems for the first time. He described the typical injury mechanism when the anterior/inferior luxation had been taking place after falling aside with the hand in the abducted/elevated position. He also recalled three occasions when the superior luxation took place after falling aside on the extended hand positioned in a way to catch the falling body; i.e. high compression and translational forces in cranial direction. After each such event the acute pain he needed to stop with the activity and the pain slowly disappeared during the following five to seven days. For the last two months the frequency of the luxations increased and so did also the resulting functional deficits.

Clinical examination revealed well trained extrinsic muscles of the shoulder girdle. Scapular depressors and rotator cuff were identified as the weak links. All ranges of motion were normal. The pain was still present especially in abduction and elevation. Using the test of passive external rotation in the supine position with the shoulder at 90° abduction the shoulder spontaneously dislocated in anterior-inferior direction after the patient completely relaxed his rotator cuff muscles.

The doctor prescribed conservative treatment using movement therapy. We set a ten-week plan (three times a week) that involved: (i) strengthening of the rotator cuff and scapula depressor muscles and (ii) stability training for the shoulder girdle and specifically for the gleno-humeral joint. The training plan respected a principle of progressive overloading. This was achieved by changing the exercises, addressing all the important functional strength and stability entities (eccentric control, eccentric-concentric coupling, co-contraction and pre-activation, etc.). We also took care of avoiding all those activities which could overload and re-luxate the joint during the period of the therapeutic intervention.

The program was carried out in full extend and there was no pain or injury recurrence during the treatment period. After that a four-week plan for a very safe and slow return on the ice was defined and carried out. But unfortunately, the new luxation happened again already in the third week of being back on the ice. The patient returned to the control of the doctor who took care of the further diagnostic procedures and indicated the need for an arthroscopic surgery.

Among all the joints in human body, the shoulder is most frequently dislocated – predominantly in anterior direction (Owens et al., 2007). Definition of the multidirectional shoulder instability is an excessive involuntary glenohumeral translation in the anterior, posterior and inferior directions, manifesting clinically as symptomatic subluxation of dislocation. An atraumatic multidirectional instability is usually associated with generalized joint laxity, biomechanical alterations and anatomical differences such as glenoid hypoplasia, hypoplastic labrum and redundant capsule (Guerrero, Busconi, Deangelis, & Powers, 2009; Marcellin-Little, Levine, & Canapp, 2007). Opposite to that, repeated excessive overstress, caused by the overhead activities (Dodson & Cordasco, 2008) or body contacts/falls (Mölsä et al., 2003), produces microtrauma which can result in a symptomatic unstable shoulder. The prevalence of recidive shoulder luxation is much higher in those individuals who suffered from the first luxation before the age of sixteen. It is therefore very important to take all possible prevention measures (strength and flexibility balance, functional joint stability and proper technique of movement) which can help at diminishing the possibility for the subluxations/luxations/dislocations to occur.
Conclusion

The structure of the shoulder system is a complex one. The function of the gleno-humeral joint requires a contrasting balance between stability and mobility. However, this is a challenging task for the passive and active stabilizers. Sports which involve overhead activities and/or high environmental forces are at the highest risk of suffering from the shoulder injuries. If we want to be effective in shoulder injury prevention and treatment we need to understand the mechanics of these injuries and the intrinsic causes that play a role. There is no single magic exercise that would make the problems disappear, but rather, there is a need for a holistic and functionally oriented treatment approach. Such a problem oriented movement intervention should address strength balance, flexibility balance, proximal stability for distal mobility, automatic neuro-muscular control mechanisms, technique adjustments, morphological specificities, gender and age differences, etc.

References


EFFECTS OF ADAPTIVE SWIMMING PROGRAM ON MENTAL ADJUSTMENT, INDEPENDENT MOVEMENT AND SWIMMING IN CHILDREN WITH CEREBRAL PALSY

Bojan Jorgić, Marko Aleksandrović, Dejan Madić, and Tomislav Okićić
Faculty of Sport and Physical Education, University of Niš, Serbia

Abstract

The sample of subjects consisted of nine children with cerebral palsy, aged between 5 and 10, who live in Niš. The sample of variables consisted of three variables for the assessment of mental adjustment and independent movement in water, obtained according to the results of the WOTA2 test (Water Orientation Test Alyn 2). The variables were obtained at the initial and final testing, and they were the following: WOTA2U-total adjustment and independence in the water, WOTA2MA-mental adjustment and WOTA2BM-movement and swimming in the water. Experimental treatment lasted for 8 weeks, 45 minutes of exercise two times per week. The exercise program included the implementation of the Halliwick method combined with the exercises used in swimming trainings for people without disabilities. The results of the t-test for dependent samples have shown that there was a statistically significant difference in the results of applied WOTA2 test between the initial and the final testing. In all three variables, the examinees have had significantly higher scores in the final measurement (p = 0.00). The results indicate that the applied eight-week swimming program allows children with cerebral palsy to eliminate fear, to move independently through the water and learn to swim.

Key words: cerebral palsy, adaptive swimming, effects

Introduction

There is a significant number of people with disabilities both in our country and the rest of the world. A disability can be defined as a condition caused by an illness, injury or congenitally, with the consequence of a long-term partial or total diminishing of a person’s ability to lead a normal life. (Durašković & Živković, 2009). People with disabilities belong to a very heterogeneous population, since their deformations are localized on different body senses and body parts. Cerebral palsy is one type of disability. Cerebral palsy is defined as a group non-progressive but often variable motor impairments, caused by the injury of the central nervous system in the early stages of development (Kuban & Leviton, 1994). Swimming, as well as other forms of physical exercise, has its own characteristics and it positively affects motor, morphological, functional and psychological development (Jorgić, 2009). In children with cerebral palsy, adaptive aquatic activities have a significant influence on improving their psychophysical condition. Adaptive aquatic activity has improved from hydrotherapy to appropriate adaptive swimming programs and aquatic exercise. Some of the swimming programs and aquatic exercises used in hydrotherapy are: Halliwick method, Bad Ragaz Ring Method and Al Chi.

Halliwick method of teaching swimming to people with disabilities was designed by James Mc Millan in 1949 in London (Kapus, 2002). The aim of the Halliwick method is to enable people with disabilities to learn to swim and move independently in the water (Brody & Geigle, 2009). This method is suitable for all ages and different forms of disabilities. It is based on the well-known laws of hydrostatics, hydrodynamics and mechanics of body movement in the water.

Hiromi, Takako & Junko (2005), Mackinnon (1997) have confirmed the positive effect of this method on swimming abilities of children with cerebral palsy.

The aim of this study is to determine the effects of an eight-week adaptive swimming program on adjustment, independent movement and swimming in the water among children with cerebral palsy.
Method

The sample consisted of nine children with cerebral palsy, aged between 5 and 10, who live in Niš. The children involved in the sample should not have been mentally retarded or suffering from epilepsy.

The sample of variables consisted of three variables for the assessment of mental adjustment and independent movement in water, obtained according to the results of the WOTA2 test (Water Orientation Test Alyn 2). The variables were measured at the initial and final testing, and they were the following: WOTA2U-total adjustment and independence in the water, WOTA2MA-mental adjustment and WOTA2BM-movement and swimming in the water.

WOTA2 is a test for the assessment of mental adjustment, free movement in the water and learning swimming among the children with disabilities who can understand and carry out simple instructions. This test was made in 1999, in Alyn hospital, which is a pediatric and adolescent rehabilitation center. The test consists of 27 items or tasks used for the evaluation of the adjustment and independence in the water. The assessment of each executed task is rated on a scale from 0 to 3. WOTA2U variable represents the total score of all 27 tasks or items, WOTA2MA variable is the result of the first 13, while WOTA2BM is the result of the last 14 tasks. Tirosh, Katz-Leurer & Getz (2008) have confirmed the test reliability and validity.

Experimental treatment lasted for 8 weeks, 45 minutes of exercise two times per week. The intensity of training was tailored to individual abilities of the examinees.

The exercise program included the implementation of the Halliwick method combined with the exercises used in swimming trainings for people without disabilities. The basic of Halliwick method is a swimming programme consisting of 10 elements (Kapus, 2002). They are the following:

1. Mental Adjustment
2. Disengagement
3. Transversal Rotation Control
4. Sagital Rotation Control
5. Longitudinal Rotation Control
6. Combined Rotation Control
7. Upthrust
8. Balance in Stillness
9. Turbulent Gliding
10. Simple Progression and Basic Swimming Movement

Some authors think that there are certain differences between the elements of this programme (Vute, 1999, Brody & Geigle, 2009). If the elements of this programme are successfully accomplished, the examinees will move around independently and swim in the water applying the technique of back swimming that involves the simultaneous strokes with both hands.

All the results are analyzed in the statistical program Statistica 6.0. Basic descriptive parameters have been calculated for all the variables, and they are the following: Mean-arithmetic mean, R-range, Max-maximum score, Min-minimum score and SD standard deviation. The symmetry of the result distribution has been estimated according to the Skewness values (Skew), while homogeneity of the result distribution has been estimated according to Kurtosis values (Kurt). In order to determine the effects of the applied adaptive swimming program, that is, the difference between the initial and final measurements, the t-test has been used for dependent samples. (Bala, 1990).
Results and discussion

The results of WOTA2 initial and final testing have been presented in Table 1. and Table 2. The total and maximum number of points can be 81. The highest number of points in the initial measurement was 59, while the maximum number of points in the final measurement was 81. The results of the arithmetic mean (Mean) for all three variables showed that test results have been improved after the applied exercise program.

This is indicated by the success of performing the tasks for all three variables expressed in percentage (%). Total adjustment and independence in the water (WOTA2U) has increased from 32.68% to 73.53%. Mental adjustment (WOTA2MA) has increased from 60.61% to 90.91%. Movement and swimming in the water (WOTA2BM) have increased from 6.62% to 57.47%.

In her study, Declerck (2010) has also used WOTA2 test and also found the percent improvement in results after the applied exercise program.

<table>
<thead>
<tr>
<th>Table 1. Initial testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable</td>
</tr>
<tr>
<td>WOTA2U</td>
</tr>
<tr>
<td>WOTA2MA</td>
</tr>
<tr>
<td>WOTA2BM</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 2. Final testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable</td>
</tr>
<tr>
<td>WOTA2U</td>
</tr>
<tr>
<td>WOTA2MA</td>
</tr>
<tr>
<td>WOTA2BM</td>
</tr>
</tbody>
</table>

In order to determine whether the applied eight week exercise program statistically significantly improved adjustment and independence of movement and swimming in the water among the children with cerebral palsy, the t-test for dependent samples has been used. The results of this test are presented in Table 3.

<table>
<thead>
<tr>
<th>Table 3. The results of the t-test for dependent samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Merenje</td>
</tr>
<tr>
<td>Final</td>
</tr>
<tr>
<td>Initial</td>
</tr>
<tr>
<td>Final</td>
</tr>
<tr>
<td>Initial</td>
</tr>
<tr>
<td>Final</td>
</tr>
<tr>
<td>Initial</td>
</tr>
</tbody>
</table>

The results of the t-test have shown that there was a statistically significant difference in the results of applied WOTA2 test between the initial and the final testing. In all three variables, the examinees have had significantly higher scores in the final measurement (p = 0.00). This means that the subjects improved their independence while moving in water, whereas some of the examinees have learned to swim.

These results correspond to the results obtained by (Declerck, 2010; Aleksandrović et al., 2010). Hutzler, Chachman, Bergman, & Szeinberg (1998) have also found a statistically significant increase in orientation abilities in children with cerebral palsy.
Conclusion

The results indicate that the applied eight-week swimming programme allows children with cerebral palsy to eliminate of fear, to move independently through the water and learn to swim. These kinds of swimming programme allow people with disabilities to accept swimming as a regular sport and recreational activity.

References


ENVIRONMENTAL PROTECTION AND FACILITIES OF
PHYSICAL EDUCATION

Dušan Mićić, Dragoslav Jakonić and Goran Vasić
Faculty of Sport and Physical Education, University of Novi Sad, Serbia.

Abstract

According to the essential hypotheses, activities of physical education assume ‘healthy’ way of living and ‘healthy’ environment, which requires a ‘healthy’ living space. However, pollution of environment puts a barrier against these activities. Thus a conclusion can be derived that these two fields – ecology and physical education – are in full accordance with each other. However, certain activities of physical education (especially those taking place in ‘natural environments’, such as activities on snow or in water, may have negative effects in terms of ecology. Conflict between living environment and physical education is mostly expressed in terms of sport facilities. Sport facilities include all areas on which physical activities are being performed. Bringing these areas to conditions for physical education of a mass of people unavoidably endangers natural surroundings, especially plants and animals. As a rule, areas for physical education are located far from the city noise, traffic, and polluted air, which leads to conflict with ecological principles.

Key words: living environment, legal base, protected sites, urban plans.

Introduction

Facilities for physical education provide conditions for realization of teaching, regular psycho-physical development of students and their education in the sphere of physical culture, as well as fulfilling of needs for physical activities of all citizens, in accordance with their affinities. Exercising space is equipped facility or area which should maximize satisfaction of users. In this kind of space, all hygienic and construction norms should be respected, such as: necessary lighting, heating, ventilation, etc. Besides, equipment and teaching means should comply with hygienic, pedagogic and technical conditions.

In order to solve the issue of construction, renovation, reconstruction and furnishing of space for sport-recreational activities and physical education, it is necessary to include all interested parties. Those are Ministry of Education, Ministry of Youth and Sports, Ministry of Finances, local self-government, local community, etc. At allocation of funds it is necessary to respect priorities and/or to establish the list of priority facilities.

According to the Draft of the Law on Sports, sport facilities are furnished and equipped surfaces and buildings designated for practicing of sport activities. Sport facilities, apart from exercising areas, have an extra space (sanitary, wardrobe, storage, audience, etc.) and embedded equipment (construction and sport). Sport facilities must be accessible to people with special needs (children, old, disabled, and invalids).

Estimation of influences on environment implies evaluation of potentially significant influences of the project and/or planned activities, and the ways to improve them, and/or activities which prevent negative influences on the environment and health of people. Estimation of influences on environment is one of unavoidable managing instruments in the policy of protection of environment of modern countries. The subject of proposal of influences are existing sport facilities and their modification, which can have significant influence on the environment.
Method

When observing correlation between the environment and facilities for physical education, we start from the descriptive method which is based on facts and normative-legal situation in our country, and/or Autonomous Provence of Vojvodina.

Discussion

Activities of physical education imply, according to the basic premise, “healthy” way of living, “healthy” environment, they demand “healthy” space. Pollution represents an obstacle for performance of such activities. Thus, we can conclude that these two areas, ecology and physical education stand in complete accordance. However, certain activities of physical education (especially those taking place in “natural” environment, such as snow activities and water activities) can, in a sense of ecology, have negative impacts. That is how the conflict between ecology and physical education occurs, and it becomes most obvious through the problem of facilities for physical education (facilities for physical education imply each area where physical activities take place).

Arranging of the area for mass activities inevitably impairs natural environment, especially flora and fauna. Because such facilities are usually constructed far from the city noise, traffic and polluted air, it results in conflict with principles of ecology, which aspire to preserve unspoilt natural environment.

Base for construction of sport facilities for most diverse purposes is arranged by area and urban plans. Area plans represent documents which plan development of the area for the period of at least twenty years. They should be based upon estimation of needs and possibility of regulation, protection of natural environment and improvement of natural and ambient values and untouched cultural assets, as well as special conditions for regulation of certain areas. Area plan of the area with special purpose is established for the area which, due to its features, has a special purpose which requires special regime of organization, regulation, utilization, protection of environment such as – national park.

In order to protect and improve natural environment in certain areas, Area plan establishes specially significant areas and endangered segments of natural environment, for which measures of protection and rehabilitation are being brought. Special areas which should be included in Area plan are the following:
- Protected natural facilities,
- Forests,
- Immovable cultural assets,
- Historically significant urban and rural whole,
- Lakes, rivers and other watercourses and their banks,

More specified frame of area planning is presented as a detailed Area plan which contains closer conditions for regulation of the area for construction of facilities and performance of other works in general. For example, detailed Area plan is necessarily brought for the areas designated for construction of recreational, health, and similar facilities, areas of special natural features, waterside zones by rivers and other watercourses etc.

Regular investments carried out during the last couple of years have the idea to solve problems of sport infrastructure – network of sport facilities. Empirical research of condition of sport facilities in Serbian schools resulted in the following indicators - 32,70% of primary schools (or 32,00% of secondary schools ) does not have facilities for physical education; 9,90% of primary schools (or 33,60% of secondary schools) does not have playgrounds; 35,53% of schools (primary and secondary) does not have changing rooms or sanitary equipment.

In central Serbia, the situation with infrastructure of facilities for physical education is less favourable than in Vojvodina, especially in North-Banat, North-Backa, and South-Backa county, where material conditions of halls of physical education are much more favourable.
Investing into facilities of physical education should be based on the following starting criteria:

- The condition of the space available,
- Stated needs,
- Established priorities,
- Consent of the interested subjects in a view of providing of the necessary funds,
- Integrity of sports facilities into the existing urban and/or rural environment,
- Evaluation of influences on the current situation of perspectives of the environment.

Realization of generally-social interests and strategic development of almost all areas is impossible without making investments into the physical culture. Development of the modern society, new tendencies of teaching of physical education and sports, imply providing of material conditions for their modernization and construction as well.

In cities and larger municipalities of AP Vojvodina, city/municipality parliament has mainly formed public enterprises for maintenance of sport facilities or working organizations called “Sport centre”. Day-to-day operations require necessary communication with the management of sport and sport association of the city/municipality.

In some areas of AP Vojvodina, due to unplanned, irrational and megalomaniac construction of sport facilities, which are, just to mention, badly located, those sport facilities represent significant burden for city/municipality authorities. In order to allocate higher amount of funds for direct program activities of sport organizations, sport money is spent on expensive and dysfunctional facilities, which have hardly any incomes, but are mainly relying on budget funds. In some cities/municipalities, from 50% to 70% of funds is allocated for regular functioning and maintenance of sport facilities, out of modest funds which are allocated for sports. (Dokmanac, 2009.).

On the level of Serbia, Association of sport centres has been established. We are of the opinion that it is socially justified to consider establishing of the similar association at the territory of the Provence. Especially, we should have on mind privatization in sport, where sport facilities represent material base which attracts interested investors.

Facilities of physical education can impair living environment in many ways. Depending on the type of activity, they differ according to the degree of “danger” which they have on natural environment.

If they are arranged in green zones of suburbia, facilities occupy “green” areas, their noise disturbs the harmony of nature, especially endangering the fauna, heating causes higher air pollution, they demand traffic increase, which again causes pollution, especially air pollution, and than, significant increase of noise. Increased concentration of people leads to significant level of waste, which is often of synthetic origin, and which has extremely negative role in pollution of the environment. Specific arranging of the ground, use of chemical and other compounds in order to increase the quality of base, can cause pollution, not only of the ground where the facility is placed, but also of the surrounding fauna and subterranean waters. This group of facilities, from the ecological point of view, especially point out great-area facilities (golf and football playgrounds).

Surfaces planned for certain activities, out of cities, in “natural” environment (climbing paths, walking paths, etc.), attract users who would like to spend their time in exactly that kind of environment; but, with time, utilization of such areas leads to devastation of ecological balance.

When we talk about facilities on snow, nowadays, their utilization cannot even be conceived without spare facilities, like cable-car or devices for production of artificial snow, whose negative impacts on natural environment should not even be mentioned. Arrangement of skiing lanes, often requires removal of the greenery, which naturally, disturbs ecological balance. Maintenance of skiing lanes, mainly with power engine devices, also endangers ecological balance, and often, careless behaviour of visitors – users of these facilities – contributes to degradation of natural environment.

The situation with facilities of water activities is similar. Utilization of water surfaces or flows for the purpose of practicing various activities of physical education causes their pollution (water-skiing and similar activities have specifically negative effects, due to use of power engine boats), has fatal effects on fauna which uses water surface, and arrangement of facilities on shore, produces all, already mentioned, negative impacts (noise, pollution of soil, air, waste piling).
This problem, which was quite unnoticed until recently, is gradually being considered, in majority of the countries of western civilization. Already mentioned conflict situation is being analyzed thoroughly, and solutions are found in various regulations and laws which regulate this matter. German and Switzerland are far ahead; there are concrete bans on arrangement of facilities for certain types of activities of physical culture (water activities, snow activities, equestrian sport, automoto sport). However, the rest of facilities designated for activities of physical culture need necessary approval issued by the authorities that deal with ecological issues.

Because in these countries great number of people practices activities of physical culture (it is considered that in Germany, for example, one out of three regularly practices some activity of physical culture), the question how to provide the balance between ecology and physical culture represents the topic of many symposiums, congresses, appropriate governmental and social institutions.

The idea to link the aforesaid contents was elaborated, a century ago, by an American landscape architect Federick Law Olmasted, by planning a network of parks and paths over the entire USA. Back in 1905, Olmasted’s sons, designed the system of parks and boulevards in surrounding area of Portland, thus connecting high hills and plains, and that very project is lately being realized. On that base, in the USA, the program called ‘Greenways – ways to future’ has been developed and supported by the authorities.

The term “Green way” originates from merging of two urban-landscape ideas „Green zone“ and „Park path“. Green ways could be treated as pedestrian, bicycle, and riding communications, which encourages people to go to the country, to recreate, because it connects increasing urban population with the nature. But even more than that, “green ways” enable moving of wild animals, at the same time protecting picturesque sceneries. They have an important ecological function.

Conclusion

Investing into development of physical culture is an all-including activity, which implies modernization, construction and reconstruction of facilities of physical culture. Constant investing into improvement of quality of those facilities, provides users with the possibility to realize their needs for activities in facilities which respond to standards and norms proscribed by the law. Providing of material conditions for development of physical culture will offer to great majority of population a modern form of approach to physical activities.

Certain technical solutions can be used to reduce negative effects which arrangement of facilities of physical culture has on natural environment (use of certain materials to decrease the noise, use of technological solutions in order to reduce pollution of air caused by heating, and construction of new facilities in direct vicinity of urbanized and naturally “polluted” zones etc.). It is important to accept the attitude that direct material investing into preserving of the natural environment at construction, arrangement, maintenance and utilization of these facilities, through some period of time, can bring tangible material profit, not counting real necessity to preserve natural environment.

In a sense of urbanity, it is necessary to provide „zoning“ of the space from the ecological point of view, and strictly respect the rules of arrangement and construction of facilities of physical culture in some zones. It is important to encourage and develop research activities, because they represent significant possibility for finding of appropriate solutions. It is necessary to point out the need for cooperation of experts from different spheres, and in order to consolidate numerous aspects of this problem. And finally, among organized forms in the sphere of physical culture and ecology, there must be mutually established cooperation, coordination, understanding of the needs, requests and arguments.

The tendency of development of physical culture and enriching of its material base should go towards the following:

- Consolidation of space capacities on the basis of defined normative of space, equipment and teaching means;
- Construction and adaptation of facilities for realization of physical activities in conformity with the number of people living in settlements and gravitational zone, number of prospective users and needs of teaching and school capacities;
– Providing of the facility which will satisfy hygienic conditions for realization of sport activities and teaching;
– Equipping of the sport halls, as well as other sport facilities in conformity with demands and directions of development of physical culture;
– Full respect of ecological standards depending on real state of living environment.

References

INFLUENCE OF DIFFERENT INTERVAL TRAINING METHODS ON VITAL CAPACITY

Milan Pantović, Maja Batez, and Saša Radosav
Faculty of Sport and Physical Education, University of Novi Sad, Serbia

Abstract

The research on impact of two different interval training methods on indicators of vital capacity was performed on the sample of 33 male, students of the Faculty of Sport and Physical Education in Novi Sad, aged 20 years ± 6 months. The sample was divided into two sub samples: first of 16 subjects and second of 17 subjects. Experimental treatment included two different interval trainings, carried out three times a week in the time period of 5 weeks. First experimental group underwent conventional interval training. Second group of subjects was practicing interval training based on the speed of running at individual runner’s highest rate of oxygen consumption (vVO2max). The impact of treatment on vital capacity was established by measuring the following variables: Forced vital capacity (FVC), Forced expiratory volume in 1 second (FEV1), Peak Expiratory Flow (PEF), FEV1/FVC ratio (FEV1%), Forced Expiratory Flow 25-75% (FEF25-75). The significance of differences in the parameters of vital capacity between the experimental groups after the implementation of the experimental treatments was determined by usage of multivariate analysis of covariance (MANCOVA).

Key words: Speed of running at individual runner’s highest rate of oxygen consumption, vital capacity.

Introduction

Pulmonary function is evolving and increasing during the age. Lung volume and capacity growth continues until reach of physical maturity. Increase of indicators of vital capacity is directly related to the growth of body size. Indicators of cardiovascular system are also very depending on body size [1]. Aerobic training positively affects the development of vital capacity, and anaerobic training on the development of so-called small airways paths or parameters velocity of air through the lungs [6].

Interval training is a well-established strategy that allows high-intensity exercise to be performed for a relatively long period, i.e. repeated periods of maximal or high-intensity exercise alternating with corresponding short intervals of rest. Early studies in healthy subjects has showed that if the aim is to stress adaptive mechanisms then intermittent exercise is more efficient than continuous exercise [4]. Preferable more work can be performed before exhaustion sets in by exercising with intervals than when the same total amount of work is performed continuously.

In recent studies has been reported that interval training consisting of brief high intensity repetitive runs at an average velocity at 100% of the minimal velocity associated with the maximal oxygen consumption (vVO2max) (30 s), alternating with periods of rest (30 s) is efficient in improving maximal oxygen uptake (VO2max) and to be tolerated well even by untrained persons [2]. However, these studies have not investigated the effects on indicators of vital capacity of healthy adults.

The present data of indicators of vital capacity stand on the principles of exercise prescription for chronic obstructive pulmonary disease patients by demonstrating that interval training substantially elicits training effects, which are similar in magnitude to those produced by continuous training at half the exercise intensity but double the exercise time [10].

Some studies suggest that one year endurance training increase markers of inflammation in the airways [3]. However on the other hand, other studies have highlighted that endurance activities put
healthy athletes at risk of asthma, and exercise induced bronchoconstriction has a higher prevalence of physician diagnosed asthma in long distance runners than in speed and power athletes [5]. It is assumed that, colder and/or drier air, and higher ventilatory rate, increase the risk of the small airways becoming dehydrated and damaged. In addition, higher ventilatory rate for longer period of hyperventilation, increase the possibility of deposition of airborne allergens and other irritants particles in lower airways.

The aim of this study was to determine the effects of two endurance training methods on Forced vital capacity (FVC), Forced expiratory volume in 1 second (FEV1), Peak Expiratory Flow (PEF), Tiffeneau index FEV1/FVC ratio (FEV1%), Forced Expiratory Flow 25-75% (FEF25-75) in healthy non-asthmatic students.

Experimental treatment was conducted in the end of April and during May, the period with high concentration of pollen in the air. It was interesting to investigate impact of high pollen concentration in the air on indicators of vital capacity of healthy subjects.

Method

Subjects

Thirty three male, students of the Faculty of Sport and Physical Education in Novi Sad, aged 20 years ± 6 months volunteered to participate in this study. The sample was divided into two sub samples: first of 16 subjects and second of 17 subjects. They were not familiar with severe (intermittent or pyramidal) training and wanted to try these two training procedures.

Treatment procedures

Standard spirometry was carried out before exercise in all subjects using Cosmed Quark PFT1 (Cosmed, Roma, Italy) with a flow volume spirometer. Pulmonary measures included Forced vital capacity (FVC), Forced expiratory volume in 1 second (FEV1), Peak Expiratory Flow (PEF), FEV1/FVC ratio (FEV1%), Forced Expiratory Flow 25-75% (FEF25-75). The highest value of at least three maneuvers was used. The highest value of at least three measurements has been chosen. The test was carried out according to recommendations of ETS/ERS [7].

Experimental (Intermittent) exercise

Participants were assigned to either the intermittent interval training group (Billat) or the pyramidal interval training group (Pyramidal). The participants trained on tartan track 45 min/day, 3 day per week, for 5 weeks period. The intensity of training was defined by incremental exercise test data.

The participants who were assigned to the Billat group received interval training 3 days per week based on training model of Billat et al [2]. After warming up with 15 minutes of easy jogging, they alternated 30-second work intervals at 100% of vVO2max with 30-second recoveries at 50% of vVO2max, sustaining this pattern for as long as possible 1.

Control (Pyramidal) exercise

The participants in the pyramidal training group trained 3 days per week at ahead prepared protocol in which resting heart rate in between sets pause never went below 120 bpm.

Statistical analysis

The results were processed by appropriate statistical methods. For each variable were calculated central and depression parameters. For the purpose of determining the difference between initial and final measurements in Interval training and Pyramidal training group it was used t-test for small dependent samples. In order of determining the effects of experimental treatment it was applied multivariate analysis of Covariance (MANCOVA).

1 For example, a runner who had a vVO2max of 16 km/hr (4.44 meters per second) would run 133.2 metres during the 30-second work intervals and about half that distance (66m) during the 30-second recoveries, thus achieving 50% of vVO2max.
Results

Table 1. Shows the basic statistics at initial measurement of Billat and Pyramidal group.

Table 1. Descriptive Statistics for Billat and Pyramidal group on initial measurement

<table>
<thead>
<tr>
<th>Variable</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Skewness</th>
<th>Kurtosis</th>
<th>KS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Billat</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FVC</td>
<td>5.05</td>
<td>6.68</td>
<td>5.82</td>
<td>.491</td>
<td>.203</td>
<td>.017</td>
<td>.985</td>
</tr>
<tr>
<td>FEV1</td>
<td>4.23</td>
<td>5.03</td>
<td>4.69</td>
<td>.272</td>
<td>-.643</td>
<td>-.614</td>
<td>.923</td>
</tr>
<tr>
<td>PEF</td>
<td>6.69</td>
<td>10.35</td>
<td>9.11</td>
<td>1.300</td>
<td>-1.205</td>
<td>.135</td>
<td>.573</td>
</tr>
<tr>
<td>FEV/FVC</td>
<td>72.90</td>
<td>86.60</td>
<td>80.95</td>
<td>4.324</td>
<td>-.483</td>
<td>.119</td>
<td>.999</td>
</tr>
<tr>
<td>FEF25/75</td>
<td>3.63</td>
<td>5.26</td>
<td>4.61</td>
<td>.582</td>
<td>-.459</td>
<td>-1.096</td>
<td>.801</td>
</tr>
<tr>
<td>Pyramidal</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FVC</td>
<td>5.01</td>
<td>6.43</td>
<td>5.71</td>
<td>.417</td>
<td>.187</td>
<td>.457</td>
<td>.971</td>
</tr>
<tr>
<td>FEV1</td>
<td>4.00</td>
<td>5.51</td>
<td>4.80</td>
<td>.409</td>
<td>-.343</td>
<td>1.836</td>
<td>.919</td>
</tr>
<tr>
<td>PEF</td>
<td>8.31</td>
<td>11.96</td>
<td>9.57</td>
<td>1.285</td>
<td>.837</td>
<td>-.247</td>
<td>.970</td>
</tr>
<tr>
<td>FEV/FVC</td>
<td>73.00</td>
<td>98.20</td>
<td>84.70</td>
<td>6.894</td>
<td>.379</td>
<td>1.787</td>
<td>.776</td>
</tr>
<tr>
<td>FEF25/75</td>
<td>3.13</td>
<td>6.57</td>
<td>5.18</td>
<td>1.106</td>
<td>-.399</td>
<td>.022</td>
<td>.944</td>
</tr>
</tbody>
</table>

From the above showed results it is concluded that there is no deviation from normal distribution in data in any observed variable, nor in the initial or in the final measurement.

Table 2. Shows the basic statistics at final measurement of Billat and Pyramidal group.

Table 2. Descriptive Statistics for Billat and Pyramidal group at final measurement

<table>
<thead>
<tr>
<th>Variable</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Skewness</th>
<th>Kurtosis</th>
<th>KS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Billat</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FVC</td>
<td>5.40</td>
<td>7.23</td>
<td>6.48</td>
<td>.535</td>
<td>-.697</td>
<td>1.461</td>
<td>.920</td>
</tr>
<tr>
<td>FEV1</td>
<td>4.76</td>
<td>5.78</td>
<td>5.40</td>
<td>.324</td>
<td>-.810</td>
<td>.663</td>
<td>.969</td>
</tr>
<tr>
<td>PEF</td>
<td>9.58</td>
<td>11.35</td>
<td>10.65</td>
<td>.583</td>
<td>-.500</td>
<td>-.085</td>
<td>.997</td>
</tr>
<tr>
<td>FEV/FVC</td>
<td>75.20</td>
<td>89.30</td>
<td>83.65</td>
<td>4.790</td>
<td>-.376</td>
<td>-.493</td>
<td>.972</td>
</tr>
<tr>
<td>FEF25/75</td>
<td>4.52</td>
<td>6.80</td>
<td>5.64</td>
<td>.764</td>
<td>.502</td>
<td>-.376</td>
<td>.621</td>
</tr>
<tr>
<td>Pyramidal</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FVC</td>
<td>5.74</td>
<td>7.20</td>
<td>6.36</td>
<td>.503</td>
<td>.446</td>
<td>-.797</td>
<td>.998</td>
</tr>
<tr>
<td>FEV1</td>
<td>4.40</td>
<td>6.13</td>
<td>5.37</td>
<td>.488</td>
<td>-.574</td>
<td>1.358</td>
<td>.863</td>
</tr>
<tr>
<td>PEF</td>
<td>8.74</td>
<td>13.13</td>
<td>10.97</td>
<td>1.513</td>
<td>.239</td>
<td>-.917</td>
<td>.988</td>
</tr>
<tr>
<td>FEV/FVC</td>
<td>74.60</td>
<td>93.50</td>
<td>83.53</td>
<td>6.479</td>
<td>-.046</td>
<td>-1.182</td>
<td>.986</td>
</tr>
<tr>
<td>FEF25/75</td>
<td>3.70</td>
<td>7.65</td>
<td>5.72</td>
<td>1.283</td>
<td>-.308</td>
<td>-.670</td>
<td>.993</td>
</tr>
</tbody>
</table>

Table 3. T test Billat

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>t</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FVC - FVCF</td>
<td>-0.661</td>
<td>.215</td>
<td>-9.191</td>
<td>.000</td>
</tr>
<tr>
<td>FEV1 - FEV1F</td>
<td>-0.706</td>
<td>.357</td>
<td>-5.923</td>
<td>.000</td>
</tr>
<tr>
<td>FEV/FVC – FEV/FVCF</td>
<td>-2.700</td>
<td>4.062</td>
<td>-1.994</td>
<td>.081</td>
</tr>
<tr>
<td>PEF – PEFF</td>
<td>-1.546</td>
<td>1.019</td>
<td>-4.552</td>
<td>.002</td>
</tr>
<tr>
<td>FEF25/75 - FEF25/75F</td>
<td>-1.024</td>
<td>.894</td>
<td>-3.437</td>
<td>.009</td>
</tr>
</tbody>
</table>

T-test for small dependent sample had been used in order to investigate the differences on the indicators of vital capacity of healthy adults between the initial and final measurement of experimental group. Table 3. shows the significant difference between the results in initial and final measurement for the following variables: FVC, FEV1, PEF and FEF25/75. All variables showed increase in values after experimental treatment on level of significance p<0.01, except variable FEV/FVC.
Table 4. T Test Pyramidal

<table>
<thead>
<tr>
<th></th>
<th>Mean Difference</th>
<th>Std. Deviation</th>
<th>t</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FVC - FVCF</td>
<td>-.643</td>
<td>.193</td>
<td>-9.983</td>
<td>.000</td>
</tr>
<tr>
<td>FEV1 - FEV1F</td>
<td>-.570</td>
<td>.205</td>
<td>-8.319</td>
<td>.000</td>
</tr>
<tr>
<td>FEV/FVC – FEV/FVCF</td>
<td>1.166</td>
<td>3.139</td>
<td>1.115</td>
<td>.297</td>
</tr>
<tr>
<td>PEF – PEFF</td>
<td>-1.404</td>
<td>.988</td>
<td>-4.261</td>
<td>.003</td>
</tr>
<tr>
<td>FEF25/75 - FEF25/75F</td>
<td>-.537</td>
<td>.615</td>
<td>-2.620</td>
<td>.031</td>
</tr>
</tbody>
</table>

By closer inspection of table 4, it could be established statistically significant difference between the results at initial and final measurement for the following variables: FVC, FEV1, PEF and FEF25/75. All variables showed increase in values after experimental treatment on level of significance p<0.01, except variable FEF25/75 which showed increase at level of significance of p<0.05, variable FEV/FVC haven’t showed any statistically significant change.

Table 5. Univariate Tests

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>VCF</td>
<td>.002</td>
<td>.002</td>
<td>.061</td>
<td>.810</td>
</tr>
<tr>
<td>FEV1F</td>
<td>.049</td>
<td>.049</td>
<td>.583</td>
<td>.461</td>
</tr>
<tr>
<td>PEFF</td>
<td>.008</td>
<td>.008</td>
<td>.014</td>
<td>.908</td>
</tr>
<tr>
<td>FEV/FVCF</td>
<td>34,379</td>
<td>34,379</td>
<td>2.601</td>
<td>.135</td>
</tr>
<tr>
<td>FEF25/75F</td>
<td>.620</td>
<td>.620</td>
<td>1.013</td>
<td>.336</td>
</tr>
</tbody>
</table>

By inspection of table 5, it could be concluded that there is no statistically significant differences between groups in final measurement. This tells us that both programs were equally successful on developing of indicators of vital capacity of healthy adults.

Table 6. Multivariate analysis of covariance

<table>
<thead>
<tr>
<th>Wilks' lambda Value</th>
<th>F</th>
<th>Hypothesis df</th>
<th>Error df</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>.773</td>
<td>.410(a)</td>
<td>5,000</td>
<td>7,000</td>
<td>.828</td>
</tr>
</tbody>
</table>

From the results of multivariate analysis of covariance (Table 6,) can be concluded on the level of significance P<0.01 that experimental treatment haven’t caused differences between both groups of subjects.

**Discussion**

Implemented experimental program of exercise three times a week for a five weeks period has caused the transformation processes of the indicators of the vital capacity in tested subjects. In both groups (experimental and control) there was a statistically significant increase in the results for following variables FVC, FEV1, PEF and FEF25/75 after experimental treatment, but there was no statistically significant difference between results of two treatments. Both treatments were equally good as methods for increasing values of indicators of vital capacity.

Five weeks of training has demonstrated a statistically significant increase in values of FVC in both groups. This represents increase in volume of 6.5%.

Measurements of FEV1 are the established index of changes in airway calibre and obstruction. If one cannot measure FEV1, measurements of PEF can be used in exercise challenge tests, where a fall of 15% or more from the resting value is indicative of increased bronchial liability [9]. As it was seen in for both groups values of FEV1 as well as PEF has increased showing no signs of airway obstructions, which indicate that programme was beneficial for indicators of vital capacity.
Values of Tiffeneau index (FEV1/FVC x 100) hasn’t been found any statistically significant changes during experimental treatment FEV1/FVC > 70, which is very suggestive that there was no obstructive changes during the treatment.

These results broadly agree with Nourry [8] who demonstrated in children that intermittent running training enhanced resting pulmonary function and led to deeper exercise ventilation reflecting a better effectiveness.

This study also demonstrates that the experimental treatment of exercise 3 times a week for a five weeks period did not provoke a bronchoconstrictor response which can occur with chronic exposure to a higher ventilatory rate, and haven’t increased the risk of the small airways becoming dehydrated and damaged although it was a period of increased concentration of pollen in air [5]. In addition, the higher ventilatory rate, haven’t increased the possibility of deposition of airborne allergens and other irritants particles in the lower airways of subjects.

In conclusion the findings of this study suggest that both treatment, intermittent and common used pyramidal training method, has beneficial effect on enhancing indicators of pulmonary function and led to deeper exercise ventilation reflecting a better effectiveness although it was period of increased pollen concentration in air.

References


LIFESTYLE AND QUALITY OF LIFE OF ENTREPRENEURS AND MANAGERS IN SOUTH-HUNGARY

György Szügyi, Péter Fritz, and Zoltán Szatmári
Euromenedzser Consulting and Education Centre, Szeged, Hungary.

Abstract

There is a big challenge for entrepreneurs and managers because of the tremendous changes and speed up of the rhythm of life, nowadays. The above mentioned reasons are enough them to analyze and evaluate the daily routines of their life-style, namely working-, eating habits, sport, recreation techniques. In cooperation with the target group: 90 pieces of questionnaires have been fulfilled, among which 79 pieces were fully assessed. The research showed: 37% female, 63% male, 23% of the city, 67% of married, higher college 28%, 77% of the declared knowledge of the concept of recreation, 1-30 hours per week of free time 86% of the respondents, 54% of the hobby for sports, 81% “affect the quality of staff by stress”.

Keywords: manager, recreation, stress, health-status, sport, entrepreneurship.

Introduction

In the beginning of 21th Century, many changes has occurred, because of the serious challenge to the permanent market competition, as well for entrepreneurs, executives, managers. They have developed for the typical managerial challenges of life situations, sometimes successfully, sometimes less successful responses.

This is a very compelling argument in daily routines and lifestyles, including work and rest periods, eating habits, sports and recreation in the practice of techniques to access, analyze, their ongoing development.

Basic information:

− The procedure called Workplace Health not only seeks to uncover and eliminate dangers to the workers’ health and thus prevent the deterioration of health, namely the development of disease. Besides it is trying the employees to make themselves as active participants in shaping their state of health. To do so would provide more opportunity, based on the ever-changing needs and professional background (Fritz, 2006).

− Health and energy are together the second elements of success. As the peacefulness is the natural status of the spirit, the health and energy are natural status of the human body (Tracy, 1999).

− The lifestyle is a general and complex sociological category, which is the inseparable unity of material and spiritual half. The lifestyle is a special unity of the usual forms of these actions (Fritz, 2006).

− Various factors are impacting with different power and order to the elements of lifestyle activities. Most common there are multiple groups of factors are facing each other impairing or enhancing each other’s effect (Fritz, 2006).
− For the objective to know human being in working and to see those factors, that in a working situation where the people cross-effect each other’s behavior we have to study those basic principles that are essential of the human nature (Mason, 1964).

− The universal culture involves the culture of health. Health education, primarily through the establishment of health consciousness of people of good governance aimed at lifestyle: how to adapt to the changed environment, how to achieve physical, spiritual and emotional balance, knowing his or her health and hygiene of the

− environment, the modern way of eating, the usefulness of the exercises to the body. Knowing more on the essence of the harmony of the work and rest, the harmful effects of smoking, alcohols, malnutrition, disease prevention, the hygiene of sexual life, the role of active relaxation, the appropriate dressing and all the factors that can help to consolidate and ensure achieve a healthy lifestyle (Szatmari, 2009).

− You often hear people complaining about their jobs, as the source of anxiety or disturbing factor of their spiritual balance. These "mental troubles" may lead to serious physical symptoms. In this process, the executive is taking high risk, and with his behavior he can do the most to the psychological health of others. Moreover he can be blamed for the development of psychosomatic disorders in a workplace (Klein, 2004).

− “The term “human physiology” is used here in its broadest meaning and includes the mind, intellect, and ego-the sense of self” (Nader, 1995, 13. p.).

− “If I am able to create certain types of connection the other side will discover his/her inner capability to develop himself/herself using disconnections: his personality will develop” (Rogers, 2003, 65. p.).

Getting insights about the entrepreneurs, executives and managers health conception. We would like to know the importance of recreation, with the perspective of entrepreneurs, executives and managers.

Method

The students of the University of Szeged (Recreation Organizer) and Euromenedzser Consulting and Education Centre conducted a where they concentrated on stress management, of entrepreneurs and managers and their way of thinking in recreation activities.

We used standardized questionnaire for the survey to discover the stress situations of entrepreneurs and managers by their answers. We got different solutions they are using (eating, leisure-time, sports, smoking and drinking practices) and related to their health protection. In all of this had helped the students of Szeged, the staff of Euromenedzser Consulting and Education Centre, as well as the University of Szeged, Faculty of Science and IT staff as well.

During the research first we wanted to detect the stressful-situations, than the problems that occurs because of them. So, the questionnaire was set up by these intentions and there data were intended to gather. The analyses and the consequences was did by using excel table and software of SPSS and mathematical statistical methods. In the questionnaire we used nominal levels, and Likert scale from 1 to 5. In questionnaire was fulfilled unnamed.
Results

Demographics

The respondents consist of 37% female and 63% male population. The age and sex distribution shows an interesting picture. While the men of 55-60 years olds were the largest share, while the women in this layer is completely left out. Explanation for not finding them, it would be subjected to further analysis of this situation. Residence of the respondents, 23% of the city, 37% of the county-seat, and 23% live in the capital. Overall, 84% of respondents experiencing life in an urban environment, however, the data base searching we discovered further details of a “rural” residents, who lives himself in the agglomeration of Budapest (next to the “village” of housing options). So this is perhaps an even greater proportion as 83% can be treated (Graph 1).

Graph 1. Residence

Graph 2. Marital status

Types of location: the respondents, 59% live in a family house, while family relationship of 67% of married, unmarried couple, living in a largely developed partnership. (Graph 2).
Graph 3. The highest degree

The highest educational level of respondent’s distinguished university (51%) and higher education college (28%) graduates, however, with 79% obtained degrees there. (Graph 3).

The industry of respondents working in the Figure 5 contains elements which do not show significant features, but very important percentage of the respondents regarding the nature of the work. Namely 92%, that is, the decisive majority of intellectual work. Highlighted the importance of this particular respect, namely the stress, physical and recreational needs of the mental state of occupation reflects the characteristics of the investigators.

Graph 4. Know the content of the recreation

The respondents (some preconception was supposed) a big surprise for us 77% of the declared knowledge of the concept of recreation. Of course, we should see behind the content, which will soon happen. (Graph 4)

The date of birth according to gender of respondents did not show any significant breakdown. However, the "yes" respondents were born in the 1970s as increasing numbers of younger and more. Especially those between 1955-1960 responded to the high percentage of, say yes to the 23% of the respondents in this band was. If this is converting the age scale, we find that the 50 years of age became familiar with the concept of priority ratio. Over 50 of the total respondents answered "Yes (yes, 52% of the respondents).

A deeper understanding the personal opinion of recreation, we have found more interesting. There is a “yes” response to the concept of recreation, who says only so "important”. You do not want a long analysis, that this does not reflect the level of conceptualizing the diversity of recreation so that it is indeed not a persuasive in deep knowledge. The overall concepts of recreational activities, however, is very versatile and only the main point of showing aggregated.

Some examples of interpretative answers: "I think a recreational activities:
− important;
− the need to compensate for the constant stress;
− useful leisure time; spending;
− active recreation, relaxed physical activity, which regenerates the brain;
− quality of life doctrine;
Leisure-time, charges, contemplation, healthcare, health give-back "

Turning to the respondents in addition to their work per quantity of leisure-time, we got a very interesting picture. 1 to 10 hours of free time and between 11 to 20 hours a week, are 35% of both. Significant even in the 21 to 30 hours per week between the identified portion (15%), followed by the
next, was made up 2-3% 31-40, 41-50, and additional bands. 1-30 hours per week of free time are the 86% of the respondents.

Although the concept of a common definition of sport is not included in the questionnaire, it is likely that the analyst of questionnaire and the respondents have the same ideas. Yet surprisingly, 75% of respondents declared themselves in pursuit of sporting activities.

Further details on the frequency of sports activity levels and quality connection. 54% of the respondents in the "hobby" for sports, while 32% of the "recreation level" in response to a candidate. Overall, this means that 86% of which performs a hobby, sport or recreation level. First sight, this seems a very high percentage, however, soon reveals what is behind these numbers.

First we look at the sports activities as a function of age of respondents according to their sporting activity is theirs. On the amateur level there was no significant age differences. A hobby for the two age bands showing mode behavior, between 55-60 years and 25-30 years. The recreational level for the 50-55 years between the prominent characteristic appears. All these 10 Details are shown in Figure.

The respondents' responses to the question of whether "their workplace provides any kind of recreational activities during or over the work hours", only 22% replied "yes". One of the most probable cause is that companies, enterprises, institutions in the strong market competition are primarily keeping their focus on defending their state on the market and less on supporting their colleagues’ personal recreational activities.

The respondents to the question whether "affect the quality of staff by stress," 81% answered: "yes". Questionnaire distinguished between positive and negative stress, stress the concept and mechanism of action. The respondents understood very well the positive effects of stress on them and reporting the impact of enhancements:

- "impetus, make creative"
  - "Good acting, because it brings forward, drive towards improved performance."
  - "wording is interesting to stress the positive-negative."
  - "I'd rather have a stress reaction, stress-like situation."
  - "The answer to the question: quicken."
  - "toss up, faster than the brain"
  - "speed"
  - "better, faster work"
  - "motivated"
- "leads me to invest more energy in my work, motivated to achieve my goals"
  - "encourage, motivate, I think in certain situations"

The same is achieved in the negative and performance-killer stress and other negative effects of implementing the features. Here are a few of these features:

- "I'm nervous"
- "It forces me to be flustered"
- "has a positive impact on me"
- "increased efficiency in the short term, long-term fatigue"
- "paralyzing"
- "bad"
- "or blocked - I know, bad decisions that send for me"
- "I'm tired, irritable, less of the performance"
- "discouraged because it consumes my energy."
- "If the negative stress is equal to the negative criticism, it encourages me."
- "lack of concentration"

The respondents to the question "is there some technique to the bad / negative stress to avoid" a very high percentage (72%) answered "yes", but they Naming in most cases only very limited positive impact methods mentioned, such as: avoiding short-term, inner calmness, coolness, quite a number of ways we try, yes, I'll try it too to be so.
"Yes, I try and do keep cool."
"The maximum I give myself up, so I try to avoid negative stress."
"Mind Control"
"concentration"
"Mind Control"
"I smile a lot:)"
"I try to react adequately to the stress situations."
"For example: how do I get the best out of it, what is the solution to a particular situation. How can I best get out of that situation."
"It often comes in the middle, if some external circumstance peeve. In this case, try to calm the external circumstances, eg. I speak in a noisy neighbor to turn down his ... :) I always try to find out the cause of stress and eliminate it."
"optimistic thinking, listening to music."

Conclusion

The survey is the most important lessons can be formulated between the obvious need that we know about the human body's physiological processes, should much more, than we know about it. The important lesson is that people are more prone to blame to their own health (eg, doctor, boss, pharmacist etc) to blame, when in fact it should handle its own responsibility.

Similarly, the psychological and psychosomatic consequences would have to much more conscious handling of harmony. In any case it would be useful to implement. In addition, it also reminds us to keep in our mind that physiological equilibrium of the body, ie, to protect our health, so prevention is much easier and better in every respect as a psychosomatic synthesized physiological abnormality (ie disease) treatment, such as the restoration of normal physiological processes. This is especially true of the cost implications of this process.

References

QUADRICEPS INTER-MUSCULAR COORDINATION DURING VARIOUS STRENGTHENING EXERCISES

Jernej Rošker¹², Nejc Šarabon¹, Nataša Koprivnik², and Roman Šiler ²

¹ University of Primorska, Science and Research Centre Koper, Institute for Kinesiology Research, Koper, Slovenia
² Terme Krka, Ltd., Terme Šmarješke Toplice, Šmarješke Toplice, Slovenia

Abstract

In this pilot study effectiveness of seven common quadriceps femoris strengthening exercises, which are frequently used in the rehabilitation of anterior knee pain, were compared. Activation level measured by EMG of vastus lateralis (VL), vastus medialis longus and obliquus (VMO), and rectus femoris and as well as the VMO:VL ratio. The sample included five adult middle aged subjects. All exercises were tested using 20RM load. Vertical close kinetic chain exercises proved to have the highest quadriceps femoris activation potential, as well as the most beneficial VMO:VL ratio. Based on obtained results, supported by existing literature and knee biomechanics, basic guidelines for their use in the prevention and rehabilitation practice are presented.

Key words: strength, activation level, Quadriceps femoris, anterior knee pain

Introduction

Knee joint extensors are important power generators for body movement in gravity defined environment (Dwek & Chung, 2008). Additional to quadriceps femoris (QF) activity, energy transfer between proximal and distal body segments (Reiman, Bolgla, & Lorenz, 2009) can overstress and cause soft tissue injury at the knee joint. Different injury conditions are known under a common name anterior knee pain (AKP). Although vaguely defined, soft tissue such as patellar tendon, patellar retinaculum system, sub-patellar bursa, patellar cartilage and sometimes even distal part of the ilio-tibial band are considered to be involved in AKP pathology (Collado & Fredericson, 2010). Recreational as well as professional athletes have been reported to suffer from these conditions. As suggested by literature, female athletes are more prone to anterior knee pain development as compared to male counterparts (Arendt, 2006). Different reasons for the overstress of anterior knee structures have been suggested, from increased Q angle (Dye, 2005), exercise overload (Collado & Fredericson, 2010), vastus medialis and vastus lateralis strength imbalances (Smith et al., 2009) as well as intramuscular coordination discrepancies (Chester et al., 2008; Yiu-ming Wong, 2009).

In physical therapy focus is primarily put on QF strengthening contents, especially those exercises that are thought to preferentially strengthen vastus medialis (VM) (Wong & Ng, 2010). When choosing appropriate exercises for strength improvements, different factors should be considered, such as load, volume, intensity and proper hormonal response, which together are necessary to promote muscle growth (Sandri, 2008). Further more, neural adaptations should be considered as well (Carroll, Riek, & Carson, 2001).

Besides considering the above factors, the main goal of kinesiotherapy is to use exercises that selectively strengthen VM but not vastus lateralis (VL). There is a substantial body of literature dealing with VM and VL activity during different QF strengthening exercises (Andersen et al., 2006; Bolgla, Shaffer, & Malone, 2008; Karst & Jewett, 1993; Zakaria, Harburn, & Kramer, 1997). The authors consider two main rationales behind the preferential VM activation. The first one lies on an anatomical mechanism explaining that a specialized part of VM called vastus medialis obliques (VMO) is
structurally connected to adductor magnus (Karst & Jewett, 1993). This suggests that simultaneous hip adduction and knee extension improves VM activation. However, the research using open (OKC) and closed kinetic chain (CKC) exercises, have proven that combining leg adduction with knee extension does not influence VM activity (Hertel, Earl, Tsang, & Miller, 2004; Karst & Jewett, 1993). The second rationale states that during the final 20° of knee extension VL-to-VMO ratio (VL:VMO) is decreased. Instead of the broad use of this concept in practice, it has been extensively criticized and disapproved in the literature (Timothy J Carroll, 2008; de Ruiter, Hoddenbach, Huurnink, & de Haan, 2008; Smith et al., 2009).

Additionally, effects of interventions like simultaneous dorsal flexion during knee extension exercises in OKC (Zakaria et al., 1997) and wider foot placements and heel bolstering in CKC have been studied (Escamilla et al., 2001). These studies have shown no specific effect of such manipulations on VL:VMO.

The goal of our pilot study was to compare activation levels of vasti muscles of the QF in selected OKC and CKC exercises, which are frequently used in rehabilitation and prevention routine. Moreover, in all these exercises as well as two additional isometric exercises, the VL:VMO was analysed. The obtained results are discussed in the context of the current knowledge on stress mechanisms at the knee joint during the OKC and CKC exercises.

**Methods**

Five subjects (4 male and 1 female volunteers) were recruited in the study (age 28 ± 9, weight 77 ± 13 kg, height 178 ± 8 cm). Extensive physical activity three days prior to testing and lower limb injury or other medical conditions were used as exclusion criteria. Subjects were informed about the measurement protocol and signed an informed consent form.

The protocol consisted of testing the 20 RM load for each of the exercises. The same loads, established during this test, were used for the QF activation level analysis.

Testing of 20 RM load began with a standardised warm-up (ten minutes cycling on a stationary bicycle, 70W, 65 RPM). An additional warm-up set was done before the first exercise to be tested. After a three-minute brake, 20 RM load testing began and was usually completed in less than three sets. Slow and smooth two-second concentric and eccentric phases were obligatory. The following OKC exercises were tested; (i) single legged knee extension (SKE) and (ii) single legged knee extension with additional hip external rotation during the last 20º (SKER). Additionally, under static conditions; (iii) isometric knee extension with hip dynamic flexion – “sawing” (IKEH) and (iv) isometric knee extension in 10°, 20°, 60° and 90° angle were performed (IKE). The following OKC exercises were included; (v) single legged squat with olympic barbell (SSQ), (vi) bilateral squat with olympic barbell (SQ) and (vii) single legged leg press (SLP).

Surface EMG electrodes were attached according to the Seniam recommendation to vastus medialis longus (VM), rectus femoris (RF) and vastus lateralis (VL). Electrodes on vastus medialis obliquus (VMO) were attached at a two centimetre distance from medial superior border of patella at approximately 55° angle to reference line of the femur (Holt, Nunn, Allen, Forrester, & Gregori, 2008). Additionally electronic goniometer (Biovision, Wehrheim, Germany) was aligned with knee axis and fixed to the leg.

For each exercise one set of 5 repetitions with 20 RM load was measured. Between exercises, four-minute breaks were used to minimize fatigue. Prior to each set the goniometer was calibrated to 0° and 90 ° knee angle. In IKEH and IKE 10, 20, 60 and 90 the subjects endured five maximal voluntary contractions. Each contraction lasted for 5 seconds and was followed by a five-second break. All dynamic exercises were measured in the range from 0 ° to 90 ° of knee flexion.

Technogym fitness equipment (knee extension R.O.M, Smiths cage and leg press machine) was used to perform all exercises (Technogym, Gambettola, Italy).
All EMG and goniometric data were collected, using Biovision EMG acquisition system (Biovision, Wehrheim, Germany). Specialized software was used for data collection (Wise Coach, Wise technologies, Slovenia). For further data analysis Microsoft Excel was used (Microsoft, USA).

**Data analysis**

EMG data were pre-processed and analysed according to Seniam recommendations. The raw signals were rectified and filtered (running average over 0.5 s). The EMG data were averaged for all five repetitions and maximal muscle activity in ranges from 0° - 30°, 30° - 60°, 60° - 90° of knee flexion were calculated. All EMG activity of individual muscles was normalized to IKE60. Ratio of VL:VMO was calculated to present inter-muscular activation differences.

**Results**

Average activation of individual muscles during various exercises is shown in Table 1. Highest activation levels were present in SSQ. Other exercises were comparable from average muscle activation perspective. The exceptions are SKE, IKEH and IKE with increases in VL activation to 103%, 112% and 163% respectively. Smallest QF muscle activation was observed in IKEH, except for the VL.

**Table 1**: maximal activity of individual muscles in the observed exercises.

<table>
<thead>
<tr>
<th></th>
<th>SKE</th>
<th>SKER</th>
<th>SLP</th>
<th>SSQ</th>
<th>SQ</th>
<th>IKEH</th>
<th>IKE</th>
</tr>
</thead>
<tbody>
<tr>
<td>VMO</td>
<td>69%</td>
<td>61%</td>
<td>59%</td>
<td>92%</td>
<td>67%</td>
<td>52%</td>
<td>96%</td>
</tr>
<tr>
<td>VM</td>
<td>74%</td>
<td>71%</td>
<td>71%</td>
<td>93%</td>
<td>69%</td>
<td>59%</td>
<td>90%</td>
</tr>
<tr>
<td>RF</td>
<td>66%</td>
<td>61%</td>
<td>16%</td>
<td>37%</td>
<td>26%</td>
<td>69%</td>
<td>94%</td>
</tr>
<tr>
<td>VL</td>
<td>103%</td>
<td>78%</td>
<td>72%</td>
<td>98%</td>
<td>80%</td>
<td>112%</td>
<td>163%</td>
</tr>
</tbody>
</table>

In Figure 1 trend of muscle activation through the entire range of motion is presented. Most prominent change in the activation through ROM was observed in CKC exercises, especially SSQ and SQ. An inverse relation in muscle activation increase between CKC and OKC exercises was present. In CKC exercises muscle activation decreased towards knee extension, whereas in the OKC exercises muscle activity increased. The highest increases in activity were observed for the VMO and VL.

![Figure 1](image-url)  

**Figure 1**: muscle activation comparison between different OKC and CKC exercises. Note that individual muscles are compared separately.
Figure 2 presents VL:VMO. Smaller ratios present increase in VMO activity. During SKE, SSQ and SQ the VMO proved to be more activated in 60º-90º range. On the contrary in SLP and SKER VL:VMO was changing to preferred VM activation in 0º-30º range. Smallest VL:VMO was observed in SSQ and SQ in 60º-90º range. Highest VL:VMO was observed for IKEH, IKE and SLP in 60º-90º range.

**Figure 2:** VL:VMO is presented for all exercises. Note that decrease in VL:VMO means more pronounced VMO activity.

Comparison of VL and VMO activity is presented in Figure 3. Highest VMO activity was observed in SSQ and SQ, and highest VL activity in SKE and IKE. The highest difference between VL and VMO activity was observed in SKE, SLP and IKE.

**Figure 3:** Comparison of VL and VMO activation in all exercises observed.
Discussion

Our pilot study showed that OKC and CKC exercises differ in VL:VMO and absolute VMO, VM, RF and VL activation levels. Most preferential exercises for strengthening VMO and VL:VMO were SSQ and SQ. In all other exercises the activation level was lower and of comparable absolute values. Less suitable VL:VMO were observed for IKEH, IKE, SKE in all ranges and for SLP in 30°-60° as well as in 60°-90° range.

According to the literature, CKC exercises have been shown to enable highest absolute VMO activation as compared to OKC exercises (Andersen et al., 2006; Bolgla et al., 2008). Opposite to that, during SKE and SKER, maximal activation of all the observed muscles was present when the knee was at the most extended ranges of motion. This is most probably a consequence of biomechanical properties of OKC and CKC exercises. In CKC exercises highest knee flexion torque is achieved when the knee is in 90° flexion due to longest leaver arm on which body mass and additional load act. In OKC exercises this is just the opposite.

The above described difference should be considered when treating AKP syndromes. Additionally, stress on affected joint structures should be considered. The stress on patello-femoral joint surface increases with knee flexion (Escamilla et al., 2001; Frohm, Halvorsen, & Thorstensson, 2007). Based on these considerations OKC exercises should be used during early rehabilitation. According to our data most appropriate exercise is SKER, where highest VMO activation levels can be achieved in the final knee extension and accompanied with relatively low VL activity. Interestingly IKER shows advantage over IKE from VL:VMO perspective. Although VMO absolute activation level is comparable, VL activation level is significantly increased during final knee extension in IKE. The second exercise that proved to have beneficial VL:VMO for isolated VMO strengthening is SLP in 0°-30° range. Although absolute activation level is relatively low it can become an integral part of strength training in AKP rehabilitation. As the AKP symptoms slowly disappear, closed kinetic chain exercises should be employed, where higher VMO activation levels and more beneficial VL:VMO can be achieved. The same rationale should be followed in prevention training.

The smallest activation level, among all the studied exercises, was observed in SKEH. In these exercises QF is contracted isometrically and relatively low stress on the knee structures is produced. Based on these rationales SKEH is thought to be useful during early rehabilitation. Due to high VL activity and high VL:VMO this exercises should be complemented with other exercises or use of electro-stimulation of VMO.

This study showed that some exercises might have a potential for more isolated VMO strengthening. According to ANP in runners, some authors report that VL and VMO inter-muscular coordination is compromised (Cheung & G Y F Ng, 2009; Yiu-ming Wong, 2009). During amortization phase in running cycle the knee is flexed to 45° knee flexion (Williams, Cavanagh, & Ziff, 1987). From the functional perspective it is questionable if we use OKC exercises in the final range of knee extension or CKC exercises in substantially flexed knee angles is justified for use in prevention. Namely, VL and VMO inter- muscular coordination is functionally not comparable. Based on our preliminary results, CKC exercises might resemble most functionally activation of individual QF muscles. Due to relatively small difference in VL and VMO activation semi-squat might be a proper choice in prevention training in runners.

Although strengthening might improve VMO activity, extent to which strengthening exercises improve intramuscular coordination in AKP remains unanswered. Additional setback of the approach used in our study is that only a small number of healthy subjects was studied. There are no reports on QF activity of subjects with AKP during observed exercises, and possible training outcomes on QF activation. In the future specificity of AKP patients should be considered and evidence of the effects of such training on inter-muscular coordination should be studied in larger number of subjects.
Conclusion

Our pilot study showed that some CKC as well as OKC exercises might have the potential to selectively strengthen VMO. The choice of exercises should consider stress of specific knee joint soft tissue structures. In the future this study should be upgraded with a bigger sample. To sum up, we believe that future research work should focus on finding the evidence and explaining the underlying mechanisms for the selection of the most effective and safe exercises to be used in AKP prevention and rehabilitation.

References


REDUCED LOW BACK PAIN AND IMPROVED PERFORMANCE DURING UPHILL CYCLING WITH ADJUSTED SEAT POSITION: A CASE STUDY REPORT

Borut Fonda¹ and Nejc Šarabon²

¹ S2P, Science to Practice, Ltd., Laboratory for Motor Control and Motor Behaviour, Bled, Slovenia
² University of Primorska, Science and Research Centre Koper, Institute for Kinesiology Research, Koper, Slovenia

Abstract

The aim of this paper is to present the vantages of the adjusted seat position during uphill cycling. One cyclist with chronic low back pain participated in this study. The cyclist did the test in laboratory conditions on a cycling ergometer and on specially designed steel platform for the hill simulation. The subject completed the 20 % climb with normal seat position and the 20 % climb with the adjusted seat position. Muscular activity of the upper limb was monitored with the electromyography, performance was assessed based on the oxygen consumption and comfort was evaluated with the questionnaire. All observed parameters showed that the adjusted seat position improves performance and comfort during uphill cycling.

Key words: low back pain, cycling, bike fit

Introduction

Many physiological and biomechanical studies were dedicated to search for cycling performance and safety improvements (for review see: Coyle et al., 1991; Too, 1990; Wozniak Timmer, 1991). The majority of the literature addresses interaction between certain cycling conditions and biomechanical parameters of cycling (for a review see Fonda & Sarabon, 2010).

A lot of studies were conducted with the aim to find the best position on the bicycle to enhance performance (Faria, Parker, & Faria, 2005; Faria, Dix, & Frazer, 1978), improve the rehabilitation protocols (Ericson, Bratt, Nisell, Németh, & Ekholm, 1986; Ericson, Ekholm, Svensson, & Nisell, 1985; Ericson & Nisell, 1986, 1987; Ericson, Nisell, Arborelius, & Ekholm, 1985), prevent injuries (Burke, 1994; Silberman, Webner, Collina, & Shiple, 2005; de Vey Mestdagh, 1998) and also to improve comfort (Gámez et al., 2008). In their studies they changed the position of the adjustable bicycle components and therefore influenced on the position of the body. In attempt to optimize cyclist’s posture researchers modified saddle position, handlebar position, crank length, etc. (Burke, 1994; Gnehm, Reichenbach, Altpeter, Widmer, & Hoppeler, 1997; Grappe, Candau, Busso, & Rouillon, 1998; Harnish, King, & Swensen, 2007; Jobson, Nevill, George, Jeukendrup, & Passfield, 2008; Nordeen-Snyder, 1977; Silberman et al., 2005; de Vey Mestdagh, 1998)

The above mentioned studies were focused on the level terrain cycling although uphill cycling is also very common in both, racing and leisure cycling. From the racing point of view, uphill cycling represents a decisive part where the winner is determined, whereas in leisure cycling uphill terrains often result in discomfort and consequently many leisure cyclists evade hills.

Low back pain represents common problem in cycling due to the posture the cyclists adopt during cycling (Brier & Nyfield, 1995; Mellion, 1991; Weiss, 1985). The extent to which pelvic and spinal flexion contribute towards the cyclists reaching a handlebar determines whether the cyclists adopts a “round-back” or “flat-back” posture (Burke, 2003). Because the cyclists sit on the seat it increases the
tendency towards kyphotic lumbar spine posture (Salai, Brosh, Blankstein, Oran, & Chechik, 1999) unless there is well-developed flexibility of the hamstrings and hips.

In their fluoroscopic/biomechanical and clinical study (Salai et al., 1999) showed that the saddle tilted forward for 10 to 15° can significantly decrease tensile forces on lumbar vertebrae and therefore reduce the low back pain during cycling. Based on their research we can assume that the low back pain issue can become even worse when cyclists adjust posture due to uphill terrain characteristics. One of the mechanisms to increase the chance of low back problem is a flexion-relaxation phenomenon. This phenomenon is characterized by myoelectrical silence of the m. erector spinae at the end of range of forward flexion which leads to the loading of passive structures and thus placing them at higher risk of overuse injuries.

During uphill cycling the cyclists need to adapt their posture for two main reasons. First, they have to prevent lifting the front wheel and second, they have to ensure a stable position on the saddle so they don’t slide off the saddle. Therefore, during uphill cycling the posture is more flexed as normally during cycling on level terrain. It means that uphill cycling represents higher risk for the occurrence of the flexion-relaxation phenomenon and consequently the risk for low back pain, discomfort and poorer performance.

In this paper, a novel bicycle geometry optimization will be presented with a goal to enhance performance, increase comfort and prevent low back pain during uphill cycling. With adjusted tilt and longitudinal position of the saddle we wanted to bring the posture during uphill cycling close to the posture during cycling on level surface. With a changed posture we wanted to achieve a more comfortable position during uphill cycling.

The aim of our study was to examine the effects of this bicycle geometry optimization by studying muscle activation of the upper limb, oxygen consumption and subjective feeling. Our hypotheses were that with optimized bicycle geometry: (i) the oxygen consumption will decrease, (ii) arm muscles will be less active and (iii) back muscles will be more active. Additionally, we speculate that the subjective feeling of the cyclist in our study will be much better with our bike geometry optimization compared to normal cycling.

Methods

Subjects

One male, trained mountain biker with chronic low back pain volunteered to participate in this study. The interview, during which the details about the study were presented to him, was carried out prior to the start of the experiment. The study was approved by the National Medical Ethics Committee and the subject signed a statement of informed consent at his enrolment.

Protocol

Two test sessions were conducted in the following order: 1) an incremental test until exhaustion in order to standardize the intensity for the main experiment and 2) an experimental test with two different cycling conditions: a) 20 % slope and b) 20 % slope with adjusted seat position. Main experiment was organized three days after the first test to exclude fatigue effects.

During the first visit, the subject performed an incremental test, starting at 100 W with increasing 30 W every 2 minutes. The test was terminated when the subject could no longer maintain the goal power output. The maximal power was noted as the power output which was maintained at least 1 minute.

During the second visit, the subject completed a standardized 10-minutes warm-up at the increasing intensity from 30 to 70 % of the maximal power output. After the warm-up, he was asked to perform two 2-minute trials at 80 % of his maximal power output from the first visit at the constant cadence of 90 rpm. Between both trials there was a 5-minute active break; easy pedaling at 100 W. The subject was instructed to adapt his body posture as he would in real life conditions.
Material

Both tests were performed on the same electro-magnetically braked cycle ergometer (Tacx, Wassenaar, Netherlands, model Flow). Inclination in the second session was simulated with a custom made steel platform for slope simulation. Bicycle geometry optimization was achieved with a specially designed adjustable seat post (ASP; Figure 1). ASP allows changing the position of the saddle by moving the saddle forward and changing the tilt of the seat equivalent to the slope (20%). The subject performed both tests with his own racing bicycle in which the ASP was inserted.

![Image of Adjustable Seat Post](image)

**Figure 1:** Adjustable seat post (ASP) enables the cyclists to adjust the angle and the position of the seat by putting it into three different positions: (i) horizontal position (normal), (ii) 10% angle of the seat and (iii) 20% angle of the seat. For our study we only used the 20% seat position during the uphill cycling. Note that forward move of the seat and optimized seat angle does not alter the seat height. The lever on the handlebar allows safe modifying of the position of the seat.

EMG signals were acquired from m. erctor spinae and m. brachioradialis with wireless EMG device (Noraxon, Scottsdale, USA, model TeleMyo 2400 G2) via bipolar surface electrodes placed according to the SENIAM standards. All the electrodes and wires were fixed on the skin with adhesive tape and elastic sleeve to avoid artifacts. Oxygen consumption was measured with ergo-spirometer (Schiller, Dietikon, Switzerland, model CARDIOVIT CS-200 Ergo-Spiro).

After completing the measurements of the main experiment, the subject was asked to grade his subjective feeling about the comfort and presence of the low back pain when using ASP on a scale from 1 to 3. Grade 1 meant that the subject preferred riding with normal saddle position and would not choose the ASP during the real life conditions, 2 meant that the subject could not choose between normal or adjusted saddle position, and 3 meant that the subject preferred using ASP during uphill cycling and would choose that saddle position also during the real life conditions.
Data analysis

The EMG signals were zero aligned, band-pass filtered (20-750 Hz, Butterworth, 2nd order), full-wave rectified and smoothed. Root mean square (RMS) amplitude on the interval of the last 30 seconds of the test for each of the muscles was compared between the two conditions. For oxygen consumption, the maximal relative value reached during the condition was taken for comparison.

Results

Upper limb muscle activation

The RMS value of the m. brachioradialis was lower (for 34.9 %) during the 20 % with ASP compared to 20 % slope without ASP (28.7 and 44.1, respectively). The opposite was with the erector spinae muscle where it was more active (for 55.8 %) during 20 % slope with ASP compared to 20 % slope without ASP (15 and 34.1, respectively).

Oxygen consumption

Oxygen consumption was lower (for 8.5 %) during 20 % slope with ASP compared to 20 % slope without ASP (45.1 ml/min/kg and 49.3 ml/min/kg, respectively).

Subjective feeling

After completing both tests the subject reported that during 20 % slope with ASP did not felt almost any pain in low back and he was feeling much stronger compared to the condition during 20 % slope without ASP. He graded the condition with ASP with 3 and the condition without ASP with 1.

Discussion

The aim of this study was to examine a novel bike geometry optimization which was achieved with a specially designed adjustable seat post. The main goal of this seat post is to put seat forward and at the same time to change the tilt of the seat. We examined the muscular activity of the m. brachioradialis and m. erector spinae, oxygen consumption and subjective feeling during two uphill cycling conditions. Our hypotheses were based on our previous study (Fonda & Šarabon, 2010a) and were that the muscular activity of the upper limb, oxygen consumption and subjective feeling will all be differ during uphill cycling with our bicycle geometry optimization compared to normal uphill cycling.

Based on the literature (Salai et al., 1999) we additionally wanted to examine the influence of bicycle geometry optimization on the presence of low back pain. Therefore, we did the study on one person who had low back pain and was a trained cyclist at the same time. With this case study we also wanted to see if the ASP will be well accepted and if it needs further research. Although we have found positive effects of the ASP in our previous studies done on well trained cyclists (Fonda, 2010; Fonda & Šarabon, 2010a, 2010b), we wanted additionally tested the ASP on other population with different methods.

Because the posture is adopted during uphill cycling compared to level terrain cycling, muscle activity of the upper limb is modified (Clarys, Alewaeters, & Zinzen, 2001). Clarys et al. (2001) reported that during small inclination (2 -4 %) muscles of the arms are less active compared to level terrain. Probably because arms lose the role of mechanical support on handlebar and more weight is distributed on the seat. However, during steeper climb, arms play a different role with ensuring that the body won’t slide off the seat. In our study we examined the effects of the 20 % slope and therefore arms had to be active for ensuring stable body position. With changed bicycle geometry we achieved that the body was prevented to slide off the seat and consequentially arms were allowed to be less active. This hypothesis was confirmed with EMG measurement of the m. brachioradialis, which was less active during uphill cycling with our bicycle geometry optimization compared to normal uphill cycling.

On the other hand the muscles of the lower back could be less active during uphill cycling compared to level terrain due to the flexion-relaxation phenomenon which is described in the Introduction. With anterior rotation of the pelvis which is a consequence of our bicycle geometry optimization, we ensured more optimal posture for the back muscles activation. That was showed with
EMG measurement of the m. erector spinae which was more active during uphill cycling with bicycle geometry optimization compared to normal uphill cycling.

Lower oxygen consumption measured during uphill cycling with bicycle geometry optimization is a logical consequence of less muscular activity of the upper limb, especially arms. With less need for activating the upper limb to ensure stable position on the seat, less energy is acquired. Although we have measured only one muscle of the arms, it would be necessary to confirm this hypothesis with further research. It is obvious that our bicycle geometry optimization allows more economic movement and thus increases performance. With previous studies on inter-muscular coordination of the lower extremity (Fonda, 2010) was showed that changed seat position influences on the muscle activity patterns of the lower limb in that way, that muscle activity patterns during uphill cycling with ASP become similar to muscle activity patterns during level terrain cycling. That could be another reason for increased performance and thus higher mechanical efficiency of the pedalling cycle (Bertucci, Frederic Grappe, Girard, Betik, & Jean Denis Rouillon, 2005).

Subjective feeling about low back pain and comfort of our subject goes in line with all above mentioned results and other studies (Fonda & Šarabon, 2010a; Salai et al., 1999). With anterior rotation of the pelvis, tensile forces on the lumbar vertebrae are reduced. Our subject reported that there was a big improvement in comfort and presence of low back pain during uphill cycling with our bicycle geometry optimization compared to normal uphill condition.

With this study was showed that our novel approach for bicycle geometry optimization positively influences not only on the performance but also on comfort. Although this study was done on only one subject we can conclude that ASP is a promising piece of equipment and requires further research in the manner of performance and comfort.

References


RELATIONS BETWEEN MORPHOLOGICAL CHARACTERISTICS AND SPEED OF MOVEMENT DIRECTION CHANGES IN PROFESSIONAL SOCCER PLAYERS

Zoran Pajić¹, Jelena Ilić², Marija Macura¹, Saša Jakovljević¹, and Adem Preljević³

¹ Belgrade University, Faculty of Sport and Physical Education, Belgrade, Serbia
² Republic Institute of Sport, Belgrade, Serbia
³ State University of Novi Pazar, Novi Pazar, Serbia

Abstract

Very little research has been conducted with the aim of determining the correlation between the morphological characteristics of the speed of direction change. Contradictory findings were observed in relations between the treated variables. The aim of this study was to determine the influence of the tested morphological variables on realization of the speed of movement direction changes in professional soccer players. This study included 57 professional soccer players aged 22.6±2.16 in which height, weight, body mass index, body fat percentage and the percentage of muscle tissue – independent variables; and speed of direction change (SMDC) – dependent variable were tested. The applied techniques of data processing were descriptive statistics, multiple regression analysis and Pearson’s correlation coefficient. Based on the obtained results of multiple regression analysis none of the variables proved to be statistically significant predictor. Based on the low determination coefficient of determination, it was concluded that the tested morphological variables and speed of movement direction changes are specific motor qualities. None of the morphological variables in professional, adult players can be a predictor based on which one can forecast the test results of direction changes. They are relatively unconnected and cause a limited transfer to each other.

Key words: soccer / anthropometric values / triangle

Introduction

A modern soccer player needs a wide range of individual motor, physiological, morphological and psychological characteristics. Their high level is required throughout the competition so that players would respond to all requests set by soccer game. Elite players are characterized by the relative heterogeneity in the morphological characteristics (Dowson et al., 1999, Reilly et al., 2000). The average values of anthropomorphic parameters are likely to have minimal significance according to great variability. A coach can modify the configuration of his team and adjust the style of play to his players who do not have adequate physical attributes of conventional positions in the team, that are compensated by the superior knowledge, skill and motivation (Ostojic, 2006).

Determining the correlation of morphological features with the speed of movement direction changes is carried out in a very small number of studies. However, it may be interesting to check the relationship of body height, weight, body fat percentage and the percentage of muscle tissue and speed of movement direction changes which is a very important ability of the motor structure of a modern soccer game. Body mass, height, length of individual limbs, the amount of muscle and adipose tissue, fat-free component as well as their relationships may affect the kinematics and dynamics of running. (Pajic, 2006).
It has been shown in several studies that soccer players who have had better results in speed of movement direction changes tests also had a lower body fat percentage (Gabbet, 2002; Meir et al., 2001; Reilly et al., 2000; Rigg & Reilly, 1987). According to Sheppard and Young (2006), while comparing the two athletes of the same weight, more corpulent athletes will have less lean body mass (lean body mass, LBM), which may have an impact on the speed of movement direction change requirements. Thus, literary speaking, a “fatter” athlete has a greater body inertia due to larger amounts of body fat, which requires greater force production per kilogram of lean body mass to perform a certain change in speed or direction of movement. However, this does not confirm the causal relationship. Namely, in these studies a direct correlation between the body fat percentage and the speed of movement direction changes was not conducted. The research involving the direct correlation between the body fat percentage and speed of movement direction change has not found a strong correlation ($r = 0.21$) between these two characteristics (Webb & Lander, 1983).

Based on the results of the abovementioned research, it is possible to assume that the low body fat percentage and the speed of movement direction changes are important characteristics for success in soccer. However, the connection between these two characteristics is still unclear (Sheppard & Young, 2006).

Other characteristics that may impact the speed of movement direction change are the height, relative length of limbs, and thus the height of the center of mass (COM; center of mass).

In one study (Cronin et al., 2003) it was determined that the length of the limbs was associated with successful execution of certain sports tasks, such as lunge, which typically occurs at movement direction changes in tennis. A soccer player with a lower body height has a lower center of mass and may achieve a greater and faster horizontal force than a taller soccer player, because it takes less time to lower the center of mass in preparation for a lateral change of movement direction (Sheppard & Young, 2006). This may mean that the player with a lower center of mass can make faster change of movement direction. It would be interesting to explore this possibility by using quantitative biomechanical measuring techniques (Sheppard & Young, 2006).

Extensive research of correlation between the morphological characteristics and the speed of movement direction changes are to be conducted (Sheppard & Young, 2006).

The objectives of this study were to determine the effect of the tested morphological variables on realization of the speed of movement direction changes of professional soccer players, as well as to determine their interdependence.

### Applied method

**The sample of subjects:** This study included 57 professional soccer players from three different super leagues of the Balkan Peninsula area, aged $22.6 \pm 2.16$.

**The sample of variables:** The variables from the morphological area are: body height (BH), body weight (BW), body mass index (BMI), body fat percentage (% D) and the percentage of muscle tissue (% M) – the independent variable and the speed of movement direction changes (SMDC) – dependent variable. **Body height (BH)** was measured using a laser height gauge (SOEHNLE, professional-5003) with an accuracy of $\pm 0.1\text{cm}$. **Body mass (BM)** was measured using the Body Composition Monitor, Model HBF-511 OMRON with the ability of measuring from 0 to 150 kg and incremental steps of 0.1 kg. **Body mass index (BMI)** was calculated using the appropriate BMI formula. **Body fat percentage (% D)** was measured using the Body Composition Monitor, Model OMRON HBF-511 with the possibility of measuring from 5.0 to 60.0% and the incremental steps of 0.1%. **The percentage of muscle tissue (% M)** was measured using the Body Composition Monitor, Model OMRON HBF-511 with the possibility of measuring from 5.0 to 50.0% and incremental steps of 0.1%. **The speed of movement direction changes (SMDC)** was tested using the "triangle" test, which represents a polygon in a shape of a triangle (Figure 1). This test was chosen because in its realization the respondent has to express the ability of start, acceleration, deceleration, balance, sense of space and good running technique. The respondents were familiar with the test before the measurement, and its relative simplicity was important so that the learning effects would be minimal. The result was measured twice, and the best time was used for the analysis. Between two measurements, the subjects had a break of 5
minutes. The test of speed of movement direction change has been done on indoor synthetic field, and the electronic timing system was used at measuring (Brower Timing System, Salt Lake City, UT).

![Figure 1 The “triangle” test for speed of movement direction change estimation (SMDC)](image)

**Data processing:** The data were processed by basic descriptive statistics. Relationships between variables were calculated using regression analysis, and Pearson’s correlation coefficient was also calculated.

**Results**

The descriptive statistics results are shown in the table 1.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Min</th>
<th>Max</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>BH</td>
<td>163</td>
<td>195</td>
<td>179.79</td>
<td>5.98</td>
</tr>
<tr>
<td>BM</td>
<td>62.4</td>
<td>94.4</td>
<td>78.41</td>
<td>6.23</td>
</tr>
<tr>
<td>BMI</td>
<td>21.3</td>
<td>27.9</td>
<td>24.28</td>
<td>1.57</td>
</tr>
<tr>
<td>%D</td>
<td>10.4</td>
<td>26.0</td>
<td>19.52</td>
<td>3.20</td>
</tr>
<tr>
<td>%M</td>
<td>33.0</td>
<td>55.9</td>
<td>45.45</td>
<td>2.31</td>
</tr>
<tr>
<td>SMDC</td>
<td>17.27</td>
<td>20.47</td>
<td>18.47</td>
<td>0.61</td>
</tr>
</tbody>
</table>

The results obtained in this study differ slightly in some variables; while in other variables they agree with the results obtained in different studies. Thus, Rienzi et al. (1998) in a sample of 95 international players got the average weight 76.4 ± 7.0 and height 1.77 ± 0.06. The average values of body height and body mass obtained by Reilly (1990), measured in nine professional teams were 1.77 ± 0.15m and 74.0 ± 1.6kg respectively. The average values of body height and body mass obtained by Bangsbo (1994) were 1.82 ± 0.05m and 79.06 ± 7.04kg for the Danish elite soccer players. The values of adipose tissue for soccer players are 7 to 19% averagely (Casajus & Aragones, 1997; Rico-Sanz, 1997; Shephard, 1999; Wittich et al., 2001) which is lower than the average results of this study. Similar average values in a sample of 110 elite soccer players were obtained by Rienzi et al. (1989) and they were 10.6 ± 2.6%. Higher values were found with the goalkeeper than with the players in the field, probably due to a lower metabolic load in training and competition (Ostojic, 2006). The method of estimation or muscle tissue measurement should be taken into account when the results are interpreted. Thus, the results of this study have much lower values which amount to 45.45 ± 2.31%, and were measured using the Body
Composition Monitor, than the value of 62.2 ± 2.9% (Rienzi et al., 1998), obtained by the formula application (Martin et al., 1990).

The aim of this study was to determine the impact of the measured variables body height, body mass, body mass index, body fat percentage and the percentage of muscle tissue – independent variables, and the speed of movement direction change – dependent variable. The data were analyzed by multiple regression analysis application (Table 2), while at the results processing the enter method was used (all predictors were observed and entered into the model together). The multiple determination coefficient obtained by this method with all predictors was $R^2 = .208$ (adjusted coefficient value – Adjusted $R$ Square was .131), $F = 2.686$, $df = 5$, $p < .031$.

<table>
<thead>
<tr>
<th>Table 2 Results of multiple regression analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Unstandardized Coefficients</strong></td>
</tr>
<tr>
<td>-----------------------------------------------</td>
</tr>
<tr>
<td>(Constant)</td>
</tr>
<tr>
<td>$BH$</td>
</tr>
<tr>
<td>$BM$</td>
</tr>
<tr>
<td>$BMI$</td>
</tr>
<tr>
<td>$%D$</td>
</tr>
<tr>
<td>$%M$</td>
</tr>
</tbody>
</table>

It can be concluded that the treated morphological variables and the speed of movement direction changes are specific qualities. They are relatively unconnected one to another and cause a limited transfer to each other.

Another aim of this study was to determine the correlation among the treated variables (Table 3) with the objective to explicate their correlation.

<table>
<thead>
<tr>
<th>Table 3 Correlation of variables</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>variables</strong></td>
</tr>
<tr>
<td>---------------------------------</td>
</tr>
<tr>
<td>$BH(cm)$</td>
</tr>
<tr>
<td>$BM(kg)$</td>
</tr>
<tr>
<td>$BMI$</td>
</tr>
<tr>
<td>$%D$</td>
</tr>
<tr>
<td>$%M$</td>
</tr>
<tr>
<td>$SMDC(s)$</td>
</tr>
</tbody>
</table>

The results of multiple regression analysis showed that treated morphological variables cannot be a predictor of speed of movement direction change of soccer players. This is, to some extent, indicated by the results of correlation analysis that shows their interrelations observed individually. It may be noted that the body mass variable, as well as body mass index, the result of which is largely determined by actual body mass, have relatively greatest importance for the speed of movement direction change of the tested soccer players. There is a statistically significant correlation between the high intensity and the positive direction between $BH$ and $BM$ – ($r = 0.637$, $p < .000$). This means that a higher score of body height entails a higher score of body mass. A statistically significant correlation of a medium intensity and a positive direction was obtained between $BMI$ and $BM$ – ($r = 0.596$, $p < .000$), because higher score of body mass entails a higher score of $BMI$. There was a statistically significant correlation of a moderate intensity and a positive direction between $SMDC$ and $BM$ – ($r = 0.396$, $p < .002$). This correlation indicates a connection which should be viewed from the aspect of body mass structure, namely muscle-fat ratio, which was not applied in this study. This would probably confirm that the larger proportion of muscle tissue in the body mass structure favors the body mass influence on the speed of movement direction changes of the tested soccer players. The correlation result between $%D$ and $%M$ – ($r = -0.858$, $p < .000$) indicating that there is a statistically important correlation of a very high intensity and negative direction is logical, given that the ratio of these two variables in the body structure is inversely proportional. Their correlation obtained in this study point to that. Thus, there is a statistically significant correlation of high
intensity and positive direction between BMI and % D – (r = 0.621, p < .000) and statistically significant correlation of medium intensity and negative direction between BMI and % M – (r = - 0.537, p < .000).

Discussion

Thomas and Nelson (2001) suggest that when r < 0.71, the shared variance between two variables is less than 50%, indicating that they are specific or somewhat independent by nature. Based on the low coefficient of multiple determinations, it can be concluded that, based on the knowledge of morphological predictors, only 20.8% of variance of the dependent variable speed of direction change can be explained. It was concluded that the treated morphological variables and speed of direction change are the specific qualities. None of the morphological variables in professional adult players can be a predictor on the basis of which the results of speed of direction change test can be predicted. They are relatively connected to one another and cause a corresponding transfer to one another accordingly.

Since morphometric characteristics that primarily figure body mass were treated in this study, the evaluation of the relationship of body mass and motor manifestations of the speed of movement direction changes is valid. From the abovementioned explication of their correlation it is obvious that there is a statistically significant correlation of moderate intensity and the positive direction between SMDC and BM – (r = 0.396, p < .002), but it cannot explain the quality of body mass variable influence on the speed of movement direction change of the tested soccer players.

The efficiency of a player’s locomotion is more complex if moving is faster. It is inversely proportional to the volume and mass of his body, if it is in large part determined by adipose tissue. The negative influence of inertia and resistance forces provided by a body depending on the quantity of inactive mass is well known. If it is approximately over 20% of body mass, then its impact on the inertial skills is more intensively pronounced.

Extremely corpulent players, whose mass is determined by the increased amount of adipose tissue, achieve worse results in motor activities of maximum running speed, as well as in the speed of movement direction changes. Subcutaneous fat acts as a ballast weight, because it reduces the relative strength, i.e. the relationship between developed force and body mass, which is essential for the successful execution of speed of movement direction change. Therefore, there is a deficit in the speed (reactive) power, which is greatly needed in performing speed of movement direction change in the changed conditions of the gravitational forces, ground reaction forces and limb inertia overcoming. Thus, the negative impact of adipose tissue in all body regions on the locomotion efficiency is undeniable. In contrast, in highly representative sample of soccer players with the compliant muscle-fat ratio, whose body weight is in optimal relation with structural motor demands of soccer, body mass has significantly less impact on motor manifestation of speed of movement direction changes.

In such analysis the limited use of body mass index showing the body weight and height ratio should be emphasized. However, it does not take into account the physical structure and cannot illustrate the body fat percentage in relation to muscle and bone mass. Some players with higher body mass and high BMI who have a large proportion of muscle and bone mass in relation to height, cannot be treated as corpulent. It can be concluded that body mass index is not a reliable indicator, since its results cannot determine what the share of useless adipose tissue in the total body mass component is. Therefore, the percentage of adipose tissue variable is necessary for such conclusions.

Determining the relationship of morphological features with the speed of movement direction change is carried out in a very small number of studies and extensive research on the aforementioned relationship has yet to be implemented. Based on the results of the aforementioned research, as well as on the results of this study, it can be assumed that body mass, body height, length of certain limbs, the amount of muscle and adipose tissue, fat-free component and their relationships can affect the kinematics and dynamics of running to a certain extent. The results of morphological variables measurement obtained in this study differ slightly in certain tested variables, while in other variables they agree with the results obtained in different studies (Rienzi et al., 1998; Reilly, 1990; Bangsbo, 1994; Wittich et al., 2001). The results of multiple regression analysis showed that treated morphological variables cannot be a predictor of the speed of movement direction change of soccer players, which is, to some extent, indicated by the results of correlation analysis that shows their interrelations observed individually.
References

RELATIONSHIP BETWEEN THE SOCIAL ECOLOGY AND SPORT

Dušan Mićić, Dragoslav Jakonić, and Goran Vasić
Faculty of Sport and Physical Education, University of Novi Sad, Serbia

Abstract
Research results in social ecology are expected to contribute to establishment and development of the human scientific approach to the environment, with an aim to harmonize human adaption of nature with objective ecological possibilities. This scientific discipline studies the relationship between society and nature as a global phenomenon, which takes place in contemporary society as a consequence of technical aggression over nature. Physical culture as a part of general culture represents a complex and dynamic system of numerous and diversified activities, organizational forms and activities in physical education, sports recreation and sport, all directed towards fulfilling different needs and interests. Numerous research works indicate that the physical fitness is a complex biological and social phenomenon, which is significant as an element of health and work abilities of a citizen. It maintains the man’s overall working abilities. It also maintains the man’s total physical, intellectual, and emotional abilities.

Keywords: Law on sport, urban aspects of sport, green paths

Introduction
Mutual relation of Social Ecology and sport can be considered from many aspects, depending on the objective of the research. This time, we will keep on theoretical and normative plan, by analysing certain legal regulations, which define protective living environment and the status of sport in our society.

Object distinctness of Social Ecology gives it a special place in the system of sciences. Social Ecology, from its side, studies very significant ecological issues, offering certain cognition to other sciences and, at the same time using other scientific disciplines, makes the synthesis of studying. Ecological issues have been, during the last couple of decades, the subject of studying of great number of scientific disciplines, due to complexity of relations between man and nature, and nature and society, in whole.

What influenced the phenomenon and forming of the Social Ecology also influenced the cognition that disturbing and violation of the ecological balance, does not only appear as a conflict of individuals or groups with its natural environment, but also as a consequence of complex relations of three groups of the system: natural, technical and social. The relation between these three systems could not have been perceived by natural sciences only. Sociological approach to research of these relations was provided by methods of Social Ecology, which lead to its occurrence and development as a science. From that reason, Social Ecology should contribute to solving of conflicts which appeared together with ecological crisis between society and nature.

Understood in a sense of European Sport Charter, 1994, sport includes all forms of physical activities of population, and which contribute to health and fitness, social relations and success in competitions of all levels. Such sport is one of the ingredients of development (especially in preserving of health, fitness and national prestige) although, at the same time, it is linked to contradictories and challenges. Confronted with such challenges, now there is a question of sustainable development put before sports in European countries.
At the same time, we are confronted with phenomena of persistent intercession, to justify the evident abuse of natural environment. We call such phenomena sustainable lack of sustain, which, as a consequence, has a devastated reality of living environment.

**Discussion**

Protection and improvement of the environment is connected to all processes in human society, and consequently, with hot issues which it confronts. Problems of the environment cannot be reduced to problems of pollution, exploitation, devastation of outer environment, like defenders of futurology and scientific-technical revolution as ideology think, but they also represent problems of social relations, conditions of human work, living, physical culture in sports, education, medication, upbringing, relation between individual and group and individual and himself, and position of individual in the society.

Socially-economic and other aspects have been noticed and taken into consideration at making attempts to define human environment and to define what falls within its definition. Practical and theoretical contribution to these efforts was given on many international conferences.

In all that, special merits should be attributed to International Law Association, where our experts for international law have had an important role for decades now.

It is important that Social Ecology is related to practice, that it contains theoretical dependence, and research activities as well. Social Ecology can be approached from different points, so certain problems can be classified differently: some are naturally-scientific, others are socially-scientific. However, for development of Social Ecology, three viewpoints have an importance: first of all, ecology as a classical biological discipline tendentiously deepened and expanded the subject of scientific research in the context of the same tendency in natural sciences. Other tendency is related to research which has been gradually directed towards human being as a social group, and problems of living in the environment. Namely, from the research of man as one of organisms and a natural being, research activities move towards the social aspects – man as a cultural being. And the third tendency is constant deterioration of the conditions of the environment: natural and artificial environment – from exhaustion and consumption of natural resources to increased pollution which, by means of modern technologies, expanded to global level.

Sport is inevitably an integral part of social life, and it manifests attitude towards sports, but also sports towards the society, sports can have very strong influence on development and manifest of patriotic feelings, as well as moral and social system of values as a whole; sport engages huge energy, not only the energy of sportsmen and those that directly participate in organization of sport activities, but far wider circle of people. That is exact significance and social power of sport, which in the modern world records the tendency of growth, and put sport in constant focus of interest of political authorities in each society. In efforts to execute stronger influence to the flow and contents of sport life, to its actors and international relations, authorities adopt laws and/or establish legal base for organizing and functioning of sport as special social activity.

Sport represents on of the oldest forms of social life. Through the entire history, it has had more significant and wider role than entertainment and confirmation of competitive abilities and results of individuals and their teams that participated in various sport competitions. Sport finally developed out of conflict between man and nature, and needs and efforts to conquer the nature and adapt it to the needs of the mankind. So today, each sport competition, although it is not always well seen on phenomenal level, contains the elements of specific confrontation of man and nature.

Modern sport achieves sustainable development if it satisfies the needs of modern generations, without scarifying the ability to satisfy the needs of future generations that will inevitably be changed. Sustainable development of sport in Serbia cannot but to foresee these needs changed with future. The state of sport in Serbia today can be compared with characteristics of the edge of chaos: the state of equally afar to completely ordered and “crystallized” system, as well as from the complete disorder and inconsistence of its elements. That is the state which enables the management of changes. Although public attention is focused on clubs of the supreme competitive sports (expecting their privatization), majority of organizations of mass and recreational sport find the modus of their existence, orienting towards real market and with the support on commercial partnership with (mainly local) sponsors. (Raič, Maksimović, 2007).
Law regulations in the sphere of sport is incomplete, which, as a consequence, has numerous dilemmas on relation between local self-government and state authorities, sport organization (club) and amateur and/or professional sportsman. Engagement of the Ministry of Youth and Sport, which has lasted for years, resulted in consideration of numerous working versions of the Draft on the Law on Sports. Objectively speaking, as a participant in this legislative process, the basic dilemma is the way of privatization of clubs considering the value of the property (terrains, halls, swimming pools, etc.), and which arose the from engagement of the budget funds, self-contribution of citizens, funds of local self-government, donations, presents, etc.

Engagement in sport must be humane, liberate, and voluntary, healthy and safe, in conformity with natural environment and social environment, fair, tolerant, ethically accepted, responsible, independent from any abuse and goals which oppose sport spirit, and available to all citizens under the same conditions, regardless their age, level of physical ability, the degree of possible disability, sex and other personal feature. (Draft of the Law, 2009.).

Special provisions foresee that Autonomous Provence and units of local self-government can establish categorization of sports, sportsmen, sport experts and sport facilities for their territory, and it necessarily starts from the established national categories. Business and Urban plan of units of local self-government include the type, number and rearrangement of sport facilities which serve children, youths, and citizens.

Interpretation of proposed solutions, which refer to wide spectre of sport facilities, is based on due application of ecological standards which oblige both, investors and users. Ecological standards mark technical rules which are applied in domain of protection of human environment. While earlier, when protection of human environment was considered, apart from extraordinary cases, an internal issue of some countries, the solutions were brought by national technical services, lately they are more often established on international level, usually by international organizations and other bodies.

No matter whether they are adopted in form of annexes to international contracts, or in form of decisions of international organizations, they have an extreme significance because it is, through them, possible to execute more specific provisions than introduced into the basic text of some international contract or ending act of some international conference.

Application of ecological standards in physical education is especially significant in urban areas, which are burdened with problems of organization of public transport, phenomena of smog etc. The quality of living in modern cities is also measured by degree of satisfaction of citizens and visitors, and/or the way and intensity of recreational use of city space. Areas of urban recreation are gradually becoming more significant integral part of all happenings which cities offer, and which enable new ways of functional and area connection and mutual penetration of all urban functions in a complex city tissue. Urban recreation is one of the basic city functions which today characterize more expressed needs for different forms of, first of all, quality realization in cities. That is conditioned with characteristics of modern way of living in urban areas. Necessary assumption of satisfying this way of activity is a space which fulfils health as well as hygienic-technical norms. Evaluation of the influence of the environment on health is performed on wide scale of information and procedures from the most diverse disciplines. In presentation of the influence of living environment on health, implied is the process of estimation of risks upon health and which includes phases of identification, description and evaluation.

Young people recognize sport as value and activity; it improves the quality of living, it keeps people fit and in a state of good physical and mental health, it prevents illnesses, especially addiction, as well as social exclusion. It develops the sense of cooperation and competitive spirit as well. (National strategy, 2008.).

European Union contributes to development of sport in all member countries, strictly taking care of diversity of public and private structures as well as competition of its countries and autonomy of sport organizations in relation to sport and its rules.

Activities (procedures) of the Union encourage cooperation among organizations in charge of sport, in member countries, and in the following domains:

- Promoting of exchange of European citizens by means of integration of quality of sport. Such exchange should contribute to better understanding and acceptance of social and cultural differences among the member countries.
Encouraging people to take sports, as a way of promotion of health of European citizens.

Support to sport activities as a way of achieving social objectives regarding fight against unemployment and discrimination, racism and violence, by promotion of equality between sexes.

The Union and its members promote for cooperation with countries out of the Union, and with international organizations in charge of sport issues, especially with European council.

Sport talks about human primary, natural and technologically obtained needs and abilities. Main issues on this level can be formed by analysing of the technological progress and interfering of technology and pharmacology in body degeneration and its very construction. We are searching for adaptable characteristics of the human body and social subsystem. That is the idea, to have the ideology of technological process to manage the world of sport as well. Interesting phenomenon of sport offers many possibilities to express the achievements of non-sport institutions which would like to use sport in service of consumer-oriented society, spectacles and risks (Hosta, 2007.)

European “model” of sport came out of traditional culture of amateurism, whereas in the USA, the “model” represents professionalism. That is why in Europe, sport is not practiced as quite economic activity, as it is the case in the USA. However, tradition is rapidly changing. That created numerous problems, and the answer should be offered by sport laws and European Union.

Conclusion

Social climate, as “state of psycho-physical relations” is certainly one of conditions which socio-ecological structure depends on. Thus current experience and science indicate on certain social climate which is passive and tense, which has conflicts as a consequence of deep economic and political crisis. There is no doubt that certain behaviours and decisions, and which have unfavourable ecological consequences, are partly caused by ignorance, lack of understanding, and failure to take subscribed measures and activities.

Application of ecological standards provides precise insight into the quality of living environment and/or to which extent it is disturbed by human activities or unfavourable natural processes. In ideal situation, it would consist of long list of scientifically established standards, and other criteria by means of which we could precisely establish the way in which one precise part of human destiny is impaired and what is the point in time when such endanger should be considered unbearable.

The protection of human environment represents civilization problem of modern global society. In order to realize it, it is not enough only to adapt legal norms. It is necessary to develop certain “new” ecological components and human moral and/or stressed civil responsibility.

Social role and sport functions, specific features of their contents and organizational forms, establish both, character and components of legal regulation of sport in one society. First of all, diversity of contents and forms, theoretical diversity, prevalence of sport in all parts and levels of society, conditions width and universality of legal norms, in the sphere of sport. The need to regulate sport with legal norms in all crucial manifestations is unquestionable. All forms of normative-legal regulation of sport as a specific activity make one functional whole. Legal norms and autonomous regulations are necessary elements of normative-legal frame of sport life. It is obvious that not everything can be regulated by law, and that some basic relations in sport, according to their nature and contents can only be solved by autonomous regulative.

The future of sport in Serbia attracts attention due to difficulties which it is passing through, because of deregulation and obstacles which occur on the way of its transition towards the state which enables implementation of institutions of European model of sport. Attempts to foresee the needs of sport organizations and units of local self-government represent permanent dialogue on relation the Ministry of Youth and Sport and competent national/city sport associations.
References


THE DIFFERENCE OF MOTOR EFFICIENCY IN RELATION TO THE FOOT STATUS IN SCHOOL CHILDREN

Duro Popović¹, Branka Protić-Gava², Tijana Šćepanović², Goran Dimitrić² & Mirela Dan³

¹Primary school "Sveti Sava", Mladenovac, Serbia
²Faculty of Sport and Physical Education, University of Novi Sad, Serbia
³Faculty of Sport and Physical Education, Vest University „Vasile Goldiș”of Arad, Romania

Abstract

The aim of this cross-sectional study was to establish the difference in the foot status of the elementary school children. Also, the aim was to determine the difference of the motor efficiency with respect to gender and foot status. The sample included 507 examinees of both sexes, 243 male and 264 female from two elementary schools: „Sveti Sava” and „Momčilo Živoinović” from Mladenovac. Respondents were selected according to the principle of group sample. The foot status was determined by Čižin method. In order to determine explosive power of lower limbs, agility and balance, the battery of eight tests was used. The significance of the differences between boys and girls in terms of foot status was analyzed using a chi-square at the level of significance of p <0.05. The significance of the differences between boys and girls in terms of the manifestation of motor efficiency was analyzed using a multivariate analysis of variance (MANOVA) at the level of significance of p=0.00. The significance of the differences between the manifestation of motor performance of boys and girls with respect to gender and foot status was analyzed using a univariate analysis of variance (ANOVA) at the level of significance of p <0.01. Boys with normal status of the feet scored significantly better results in all tests of explosive leg strength and agility. The boys with flat feet scored significantly better results in two tests of agility (shuttle run test and zig-zag test) and in all tests of explosive leg strength.

Key words: Foot; Agility; Explosive Power; Balance; Motor skills; Children.

Introduction

Many studies related to the problems of flat feet usually dealt with their symptoms. Experts who deal with this issue believe that flat feet entails a series of negative consequences. Most frequently mentioned symptoms are pain in his foot during a long standing and relatively rapid fatigue during physical activity. Based on complex clinical observations Hunter (2002) concludes that there are people with flat foot who never complain of these symptoms, and there are those with normal arches who complain of foot pain and fatigue. According to this author, causes pain in the foot to be found in peripheral vascular disease, degenerative lumbar disc disease, arthritis foot, neuromuscular diseases, before awarding the pain flat feet. Besides being considered that this problem is not an impediment in dealing with recreational activities, he emphasizes that a flexible flat foot does not constitute a nuisance to athletes in dealing with their activities.

Many years ago it was thought that people with flat feet can not exert their maximum capability in terms of physical activity. Young men with flat feet were once exempted from military service.

Not enough attention was paid to the impact that would have flat feet in the expression of motor performance of athletes or fitness enthusiasts who have this problem. In fact, it seems that the negative effect of flat feet on the expression of physical activity rather than the means precisely determined. In new studies, however, this opinion is marked as a myth. This study indicates that flexible flatfoot can completely replace the normal structured foot in its function (Pedowitz & Kovatis, 1995). Flexible
flatfoot can be considered a normal contour, rather than the result of weakness or muscle structure of the foot that run it (Harris & Beath, 1948).

Foot with its specific structure formed a sort of shock absorber to regulate the contact with the ground. Impaired foot structure disrupts its function to a greater or lesser extent, loses its ability to amortize, since there are no muscle pump effect (Radisavljević, 2001). However, flat feet is not a predisposition to injury in sports. Also, the use of orthopedic insoles as a prophylactic measure, for the foot injury, has not been established (Michelson, Durant & McFarland, 2003).

The process of formation and spontaneous development of foot arch is carried out by the end of the first decade of life, index of the foot during childhood decreases but slightly increases with age (Staheli et al., 1987; Chen, Chung & Wang, 2009).

The results of studies that cover the relationship between the manifestation of motor abilities of persons with flat and those with normal structured foot, show that there is no difference between them (Twomey, 2006). Namely, those with flat foot showed significantly worse results in lateral jumps on one leg, significantly better in the vertical jump, and slightly better in the test strength of plantar and dorsal flexors. In other functional tests (proprioceptive ability, balance on a board) it is no significant difference.

The aim of this study was to assess the status of foot and determine the differences between the motor performance of boys and girls with different status of the foot. Explosive power, agility and balance are covered by this survey because the consequences of these movements and motor skills tests that could be most affected by a change in the foot status. Explosive power is the ability of the manifestation of force at high speed. It is characterized by mastering the submaximal load maximum acceleration (Kukolj, 1996). With repetitive and static strength, is one of the power factor (Malacko & Popović, 2001). This factor is manifested in all the movements in which the whole body, parts, or load (device) extend their movement due to the obtained initial acceleration. The consequences of this kind of power is the result obtained in tests such as the high jump with both feet, long jump from the place, speed of movement in short sections and others.

Agility is the ability to change direction of motion and body orientation based on internal and external information without significant loss of speed. As a complex ability is a product of balance, speed, strength and coordination (Gambetta, 2007). Besides the general factors of speed, the speed factor with the change in direction (agility) is one of the most isolated factors in previous research that are focused on the motor speed (Malacko & Popović, 2001).

Balance is the ability to maintain the body in a balanced position, but also the ability to maintain a stable position around the body in different movements and trends (Nićin, 2000). The balance can be divided into static and dynamic balance and balance open and closed eyes.

Method

This study was cross-sectional. The research was carried out on a sample of 507 students of both sexes from two elementary schools „Sveti Sava” and "Momčilo Živoinović“ from Mladenovac (243 boys and 264 girls). They were selected according to the principle of group sample. The subjects were children from urban and rural areas, aged from 12 to 14. Parents have given written permission for their children to be tested. Pre-test respondents were thoroughly explains the procedures of execution of tasks.

Data on motor abilities and the status of the feet were collected in the field laboratory. Foot status were determined by plantography. Čižin method confirmed the index upon which the respondents are classified as subjects with normal, flat and very flat feet (Živković, 2001). For comparison of data, respondents were then divided into groups with normal and group with a low feet. A battery of eight tests was applied to determine motor skills: vertical jump, sprinting from a standing position at 20 meters, triple jump with a site (the explosive power of lower limbs), foot speed test, shuttle run test, zig-zag test (agility) and the "stork stance "open and eyes closed (balance). The significance of the differences in foot status with respect to gender was analyzed by means of chi-square test at the level of p=0.05. The significance of the differences in motor efficiency according to gender and the foot status was analyzed by multivariate analysis of variance (MANOVA) and univariate analysis of variance (ANOVA) at the level of p<0.01.
Results

After determining the status of the foot, the respondents in each subsample classified in the group with normal and with flat foot group. Foot status in the total sample of students in relation to gender is shown in the Table 1. The analysis shows that 67% female and 58.4% male examinees have a good foot status. The results show the statistically significant difference at the level of p<0.05.

Table 1 Frequency of the subsamples of respondents in relation to the status of foot

<table>
<thead>
<tr>
<th>Geder</th>
<th>Number/ percent</th>
<th>Normal foot</th>
<th>The foot status</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Flat foot</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>N</td>
<td>142</td>
<td>177</td>
<td>319</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>58.4%</td>
<td>67%</td>
<td>62.9%</td>
</tr>
<tr>
<td>Female</td>
<td>N</td>
<td>101</td>
<td>87</td>
<td>188</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>41.6%</td>
<td>33%</td>
<td>37.1%</td>
</tr>
<tr>
<td>Overall</td>
<td>N</td>
<td>243</td>
<td>264</td>
<td>507</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

\[ \chi^2=4.020 \quad p=0.04^* \]

* difference in the status of the foot is statistically significant (p <0.05)

The results of multivariate analysis of variance and a corresponding level of significance is shown in the Table 2. The boys show statistically better results than girls (F=33.151; p<0.01) in tests: vertical jump, the 20m sprint, triple jump from place, test“quick feet”, shuttle run test and zig-zag test (bold in the Table).

Table 2 Descriptive statistics and multivariate analysis of variance of motor test in relation to gender

<table>
<thead>
<tr>
<th>Variable</th>
<th>M (N=243)</th>
<th>SD</th>
<th>F (N=264)</th>
<th>M</th>
<th>SD</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertical jump</td>
<td>36.00</td>
<td>7.56</td>
<td>29.99</td>
<td>5.95</td>
<td>100,030</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>The 20m sprint</td>
<td>4.27</td>
<td>0.44</td>
<td>4.71</td>
<td>0.44</td>
<td>124,988</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>Triple jump from place</td>
<td>523.16</td>
<td>69.49</td>
<td>453.63</td>
<td>50.44</td>
<td>168,067</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>Quick feet test</td>
<td>3.89</td>
<td>0.54</td>
<td>4.02</td>
<td>0.49</td>
<td>7.608</td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td>Shuttle run test</td>
<td>11.32</td>
<td>0.96</td>
<td>12.43</td>
<td>1.03</td>
<td>157,460</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>Zig-zag test</td>
<td>7.74</td>
<td>0.70</td>
<td>8.58</td>
<td>0.80</td>
<td>155,385</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>„Stork attitude“ open eyes</td>
<td>5.17</td>
<td>3.07</td>
<td>5.01</td>
<td>2.35</td>
<td>0.475</td>
<td>0.49</td>
<td></td>
</tr>
<tr>
<td>„Stork attitude“ eyes closed</td>
<td>2.11</td>
<td>0.69</td>
<td>2.12</td>
<td>0.71</td>
<td>0.047</td>
<td>0.83</td>
<td></td>
</tr>
<tr>
<td>Wilks' Lambda</td>
<td></td>
<td></td>
<td>F=33,151</td>
<td></td>
<td>p=0,00</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The results of descriptive statistics and univariate analysis of variance of motor efficiency of subjects with normal foot status and the differences according to gender is shown in the Table 3. Male respondents scored significantly better results in all tests of explosive strength of lower extremities (bold in Table). Also, they scored better than girls in tests of agility. These differences were statistically significant (bold in Table).
Table 3 Descriptive statistics and univariate analysis of variance of motor efficiency of subjects with normal foot status and the differences according to gender

<table>
<thead>
<tr>
<th>Variable</th>
<th>Gender</th>
<th>N</th>
<th>M</th>
<th>SD</th>
<th>min</th>
<th>max</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>142</td>
<td>36.49</td>
<td>7.73</td>
<td>18.00</td>
<td>58.00</td>
<td></td>
<td>70.718</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>177</td>
<td>30.15</td>
<td>5.72</td>
<td>12.00</td>
<td>51.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Σ</td>
<td>319</td>
<td>32.97</td>
<td>7.39</td>
<td>12.00</td>
<td>58.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vertical jump</td>
<td>M</td>
<td>142</td>
<td>4.23</td>
<td>.44</td>
<td>3.46</td>
<td>5.7</td>
<td></td>
<td>107.110</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>177</td>
<td>4.72</td>
<td>.41</td>
<td>3.72</td>
<td>6.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Σ</td>
<td>319</td>
<td>4.50</td>
<td>.49</td>
<td>3.46</td>
<td>6.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The 20 m sprint</td>
<td>M</td>
<td>142</td>
<td>527.17</td>
<td>74.75</td>
<td>300.00</td>
<td>721.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>177</td>
<td>454.92</td>
<td>46.77</td>
<td>339.00</td>
<td>601.00</td>
<td></td>
<td>111.165</td>
</tr>
<tr>
<td></td>
<td>Σ</td>
<td>319</td>
<td>487.08</td>
<td>70.58</td>
<td>300.00</td>
<td>721.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Triple jump from place</td>
<td>M</td>
<td>142</td>
<td>3.86</td>
<td>.48</td>
<td>2.72</td>
<td>5.09</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>177</td>
<td>4.05</td>
<td>.49</td>
<td>2.93</td>
<td>5.59</td>
<td></td>
<td>12.047</td>
</tr>
<tr>
<td></td>
<td>Σ</td>
<td>319</td>
<td>3.97</td>
<td>.49</td>
<td>2.72</td>
<td>5.59</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test “quick feet“</td>
<td>M</td>
<td>142</td>
<td>11.20</td>
<td>.94</td>
<td>9.47</td>
<td>14.25</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>177</td>
<td>12.45</td>
<td>1.02</td>
<td>10.31</td>
<td>15.53</td>
<td></td>
<td>125.892</td>
</tr>
<tr>
<td></td>
<td>Σ</td>
<td>319</td>
<td>11.89</td>
<td>1.16</td>
<td>9.47</td>
<td>15.53</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shuttle run test</td>
<td>M</td>
<td>142</td>
<td>7.68</td>
<td>.67</td>
<td>6.22</td>
<td>9.85</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>177</td>
<td>8.59</td>
<td>.74</td>
<td>6.85</td>
<td>11.07</td>
<td></td>
<td>126.388</td>
</tr>
<tr>
<td></td>
<td>Σ</td>
<td>319</td>
<td>8.19</td>
<td>.84</td>
<td>6.22</td>
<td>11.07</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zig-zag test</td>
<td>M</td>
<td>142</td>
<td>5.16</td>
<td>3.16</td>
<td>1.03</td>
<td>18.15</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>177</td>
<td>5.10</td>
<td>2.03</td>
<td>2.00</td>
<td>11.34</td>
<td>0.040</td>
<td>0.841</td>
</tr>
<tr>
<td></td>
<td>Σ</td>
<td>319</td>
<td>5.12</td>
<td>2.59</td>
<td>1.03</td>
<td>18.15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>“Stork stance“ with open eyes</td>
<td>M</td>
<td>142</td>
<td>2.13</td>
<td>.69</td>
<td>1.00</td>
<td>4.72</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>177</td>
<td>2.13</td>
<td>.69</td>
<td>1.00</td>
<td>4.81</td>
<td></td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>Σ</td>
<td>319</td>
<td>2.13</td>
<td>.69</td>
<td>1.00</td>
<td>4.81</td>
<td></td>
<td></td>
</tr>
<tr>
<td>“Stork stance“ with closed eyes</td>
<td>M</td>
<td>142</td>
<td>2.08</td>
<td>.69</td>
<td>1.00</td>
<td>4.72</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>177</td>
<td>2.10</td>
<td>.76</td>
<td>1.00</td>
<td>4.81</td>
<td>0.050</td>
<td>0.824</td>
</tr>
<tr>
<td></td>
<td>Σ</td>
<td>319</td>
<td>2.09</td>
<td>.72</td>
<td>1.00</td>
<td>4.81</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The results of descriptive statistics and univariate analysis of variance of motor efficiency of subjects with flat feet and the differences according to gender is shown in the Table 4. Male respondents scored significantly better results in all tests of explosive strength of lower extremities (bold in Table). They scored better than girls in two tests of agility: shuttle run and zig-zag test. These differences were also statistically significant (bold in Table).

Table 4 Descriptive statistics and univariate analysis of variance of motor efficiency of students with flat feet and the differences according to gender

<table>
<thead>
<tr>
<th>Variable</th>
<th>Gender</th>
<th>N</th>
<th>M</th>
<th>SD</th>
<th>min</th>
<th>max</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>101</td>
<td>35.33</td>
<td>7.28</td>
<td>22.00</td>
<td>53.00</td>
<td></td>
<td>31.557</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>87</td>
<td>29.67</td>
<td>6.40</td>
<td>14.00</td>
<td>48.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Σ</td>
<td>188</td>
<td>32.71</td>
<td>7.43</td>
<td>14.00</td>
<td>53.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vertical jump</td>
<td>M</td>
<td>101</td>
<td>4.33</td>
<td>.43</td>
<td>3.59</td>
<td>5.69</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>87</td>
<td>4.67</td>
<td>.49</td>
<td>3.50</td>
<td>6.25</td>
<td></td>
<td>25.942</td>
</tr>
<tr>
<td></td>
<td>Σ</td>
<td>188</td>
<td>4.49</td>
<td>.49</td>
<td>3.50</td>
<td>6.25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The 20 m sprint</td>
<td>M</td>
<td>101</td>
<td>517.51</td>
<td>61.27</td>
<td>350.00</td>
<td>672.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>87</td>
<td>451.00</td>
<td>57.40</td>
<td>330.00</td>
<td>631.00</td>
<td></td>
<td>58.387</td>
</tr>
<tr>
<td></td>
<td>Σ</td>
<td>188</td>
<td>486.73</td>
<td>68.03</td>
<td>330.00</td>
<td>672.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Triple jump from place</td>
<td>M</td>
<td>101</td>
<td>11.47</td>
<td>.97</td>
<td>8.88</td>
<td>14.37</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>87</td>
<td>12.38</td>
<td>1.05</td>
<td>10.34</td>
<td>16.19</td>
<td>38.019</td>
<td><strong>0.000</strong></td>
</tr>
<tr>
<td></td>
<td>Σ</td>
<td>188</td>
<td>11.89</td>
<td>1.10</td>
<td>8.88</td>
<td>16.19</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test „quick feet“</td>
<td>M</td>
<td>101</td>
<td>3.94</td>
<td>.60</td>
<td>2.78</td>
<td>5.44</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>87</td>
<td>3.95</td>
<td>.51</td>
<td>2.90</td>
<td>5.38</td>
<td>0.041</td>
<td>0.839</td>
</tr>
<tr>
<td></td>
<td>Σ</td>
<td>188</td>
<td>3.95</td>
<td>.56</td>
<td>2.78</td>
<td>5.44</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shuttle run test</td>
<td>M</td>
<td>101</td>
<td>11.47</td>
<td>.97</td>
<td>8.88</td>
<td>14.37</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>87</td>
<td>12.38</td>
<td>1.05</td>
<td>10.34</td>
<td>16.19</td>
<td>38.019</td>
<td><strong>0.000</strong></td>
</tr>
<tr>
<td></td>
<td>Σ</td>
<td>188</td>
<td>11.89</td>
<td>1.10</td>
<td>8.88</td>
<td>16.19</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zig-zag test</td>
<td>M</td>
<td>101</td>
<td>8.56</td>
<td>.91</td>
<td>6.72</td>
<td>11.31</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>87</td>
<td>8.16</td>
<td>.90</td>
<td>6.31</td>
<td>11.31</td>
<td></td>
<td>37.740</td>
</tr>
<tr>
<td></td>
<td>Σ</td>
<td>188</td>
<td>8.36</td>
<td>.90</td>
<td>6.31</td>
<td>11.31</td>
<td></td>
<td></td>
</tr>
<tr>
<td>“Stork stance“ with open eyes</td>
<td>M</td>
<td>101</td>
<td>5.18</td>
<td>2.94</td>
<td>1.60</td>
<td>15.44</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>87</td>
<td>4.80</td>
<td>2.81</td>
<td>1.16</td>
<td>13.41</td>
<td>0.800</td>
<td>0.372</td>
</tr>
<tr>
<td></td>
<td>Σ</td>
<td>188</td>
<td>5.00</td>
<td>2.88</td>
<td>1.16</td>
<td>15.44</td>
<td></td>
<td></td>
</tr>
<tr>
<td>“Stork stance“ with closed eyes</td>
<td>M</td>
<td>101</td>
<td>2.08</td>
<td>.69</td>
<td>1.00</td>
<td>4.72</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>87</td>
<td>2.10</td>
<td>.76</td>
<td>1.00</td>
<td>4.81</td>
<td>0.050</td>
<td>0.824</td>
</tr>
<tr>
<td></td>
<td>Σ</td>
<td>188</td>
<td>2.09</td>
<td>.72</td>
<td>1.00</td>
<td>4.81</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Discussion

Searching for an answer to who is more effective in showing the motor efficiency in relation to the status of the foot, boys or girls, we started this research that was conducted on 507 subjects of both sexes, aged from 12 to 14 years. The results show that a higher percentage of total sample has a normal status of the foot, but a higher percentage of boys with a flat foot. Our findings are consistent with the results of Chen and associates (2009), whose research has found that 35% of boys have flat feet, and in the subsample of girls is much less, 20% of them.

Also, the results of Chang and associates (2009) are similar to the results of our research in terms of representation of the dropped foot in sub samples of male subjects. Besides the higher number of flat foot in the total sample, Chang and colleagues have found a greater difference between the sexes in relation to the status of the arch of the foot in favor of males. They have flat feet registered in 67% of boys and 49% of girls.

The results of Pfeiffer et al (2006) are also similar to the results of our study. They found that flat foot have 52% of boys and 36% of girls. This difference was statistically significant. It should be noted that in his sample were participants aged 3 to 6 years. No matter what the age of the subjects of our study does not coincide with age that are in his research include Pfeiffer et al (2006), however, it can be concluded that if the poor status of the foot does not improve in time, the trend of progress bad foot posture can continue into old age.

When it comes to research is the relationship between foot deformity and patient sex, our results can also comparable with the survey Staheli and associates (1987). They are in their research have concluded that the variability index foot 2 percent (p = 0.02) can be explained by differences in gender.

Investigations of this type are sporadic. The results of Georgieva et al (2009) are similar to the results of our study. They found that male respondents in the subsample of three tests of explosive (two involving the lower extremities) achieved significantly better results than the subsample of respondents are female. From a total of three tests of balance, male subjects achieved significantly better results in two, while a significantly better results are achieved female respondents.

The research conducted by Jovanović et al. (2009) was carried out based on the results of motor tests in three generations students at the time when they were in fourth grade. Males of all three generations have achieved significantly better results, among others, in tests of agility and explosive power. The results of our research and these are expected match.

The controversy that prevails concerning the relationship foot morphology and their function is still present (Tudor et al, 2009). Based on the results of a small number of studies that deal with this problem, the conclusions can not be generalized. However, it is indisputable that there is no significant correlation between the level down of the foot and motor skills necessary for sports participation. Children with flat and children with "normal" status of the foot as successfully achieved motor tests, but boys are more successful in most tasks.

References


