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Contents

rasto

Milan Čoh[1] and Nusret Smajlović[2]

DIFFERENCES BETWEEN THE ELITE AND SUB-ELITE SPRINTERS IN KINEMATIC AND KINETIC VARIABLES OF DROP JUMP

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Abstract
The aim of the study was to examine differences in an area of take-off strength between the elite and sub-elite sprinters. Drop jump – 45 cm tests were used as criteria of take-off strength. Sample of measured subjects included 12 best sprinters. They divided in two subgroups with the official 100-metre sprint running result being used as a grouping criterion. Biomechanical parameters of both jumps were measured with the use of bipedal tensiometric platform and a system of 9 infraspectral CCD cameras with a 200 Hz frequency. Differences between the groups of sprinters were examined with the use of ANOVA variance analysis. Statistically significant ($p<0.05$) differences between the sprinters of both groups were revealed in three kinematic and kinetic parameters. In drop jump, elite and sub-elite sprinters differentiated in the realisation of movement velocity in the eccentric and concentric phases (a difference between the groups is statistically significant $p<0.05$). Elite sprinters better utilise the stretch reflex, which allows them to more efficiently transfer elastic energy from first into second phase of take-off action.

Key words: **muscular activity, take-off strength, stretch reflex, bipedal tensiometric platform**

Introduction

Sprinting speed is defined with the frequency of strides and the length of stride. Parameters are mutually dependant with their optimal ratio enabling a realisation of maximal sprinting speed. Increase of speed can be achieved with the increased length of stride or increased frequency of strides. Increase of both parameters simultaneously is not possible due to mutual dependency. Increased frequency results in shorter stride length and vice versa. Therefore the increase in stride length must be directly proportionally with the decrease of stride frequency especially at the beginning of the race – the initial acceleration phase (Mackala, 2007). This relationship is individually conditioned with the processes of neuro-muscular regulation of movement, morphological characteristics, bio-motor abilities and biochemical energetic resources (Mann &Sprague, 1980; Harland &Steele, 1997; Novacheck, 1998; Prampero et al., 2005).

The length of stride depends on the length of lower extremities and the impulse of ground reaction force. According to the biomechanical studies of some authors (Bruggemann & Glad, 1990; Mero et al., 1992) the stride of sprinters is defined with the optimal execution of contact phase, which consists of two connected subphases: braking phase and propulsion phase. Basic criterion of rational sprinting technique is the smallest possible impulse of force in braking phase and the largest possible impulse in propulsion phase (Man & Sprauge,1980).

The second parameter of sprinting speed is a frequency of strides, which to the greatest extent depends on the regulation of functioning of central neural system, particularly conductivity of neuromuscular synapses in the conditions of maximum excitation (De Luca, 1997). High frequency of strides requires precise and regulated alternating work of agonists and antagonists (muscular groups) of lower extremities. Frequency of strides is a sum of support and flight phases. In elite sprinters, the ratio between the support and flight phase is between 1: 1.3 and 1: 1.7 (Mero et al., 1992, Glize & Laurent, 1997; Novacheck, 1998).

Sprinting is a natural movement of people, its movement structure comprises of the series of jumps from one leg to another. According to biomechanical characteristics, jumps can be divided into vertical and horizontal jumps. Vertical jumps are important training tools as well as a diagnostic method for examining the take-off strength of lower extremities in sprinters. Basic criterion of efficient sprinting velocity is developing highest possible ground reaction force in the shortest time possible during the contact phase of sprinting stride (Mann & Sprague, 1980; Mero et al., 1992; Mero et al., 2006). Contact time in the elite sprinters equals 80 to 95 milliseconds with ground reaction force exceeding three- to four-times body weight of the athletes. Movement structures in jumps and sprint running are very similar in relation to the muscular contractions. Development of force is a result of connection between eccentric and concentric muscular contractions. Majority of natural movements comprises of active stretching of muscles in the amortisation phase (eccentric contraction) followed by an extension (concentric contraction).

Drop jumps are important tools in the training of sprinters. They can be used to improve a function of eccentric-concentric muscular action of lower extremities. In addition, these jumps represent one of the most important diagnostic methods of take-off strength in athletes. The purpose of the present study is to find differences in the test drop jump - 45 cm between the elite and sub-elite sprinters with a hypothesis that better sprinters also have better results in vertical and drop jumps. Findings in biomechanical parameters of drop jumps and their differences according to the quality of sprinters can provide better planning and control of training process in sprinters. Fallowed this assumption the present paper was mainly intended to examine differences in an area of take-off strength between the elite and sub-elite sprinters.

Methods

Experiment included 12 best sprinters (age 22.4 ± 3.4 years, body height 177.6 ± 6.9 cm, body weight 74.9 ± 5.2 kg. Average of best results in 100-metre sprint was 10.82 ± 0.25 s (best result 10.39 s). All the measured subjects were notified about the purpose of experiment and measuring procedures and they have all signed a declaration of participation in accordance with the Helsinki-Tokyo declaration, stating that their participation is voluntary and that they can end the participation at any time. Selected measured subjects had to train track and fields at least five years and were specialised in either 60-, 100- or 200-metre sprint running. According to the goal of the study, sprinters were divided in two groups. Criterion for grouping of elite and sub-elite sprinters was a result at an official competition in 100-metre sprint event. Basic characteristics of the two groups are shown in Table 1.

Measuring procedure protocol (data collection and data analysis methods)

Drop jumps were executed from a 45 centimetre high bench, landing was performed on a surface – tensiometric plate – followed by an immediate vertical take-off. Drop jump was also executed without the arm movement (Figure 1). A system of 9 CCD cameras (BTS Smart-D, BTS Bioengineering, Padua, Italy) with a 200 Hz frequency of 200 and resolution 768 x 576 pixels was used in order to carry out a 3-D kinematic analysis of vertical jumps. A programme BTS SMART Suite was used to analyse kinematic parameters.

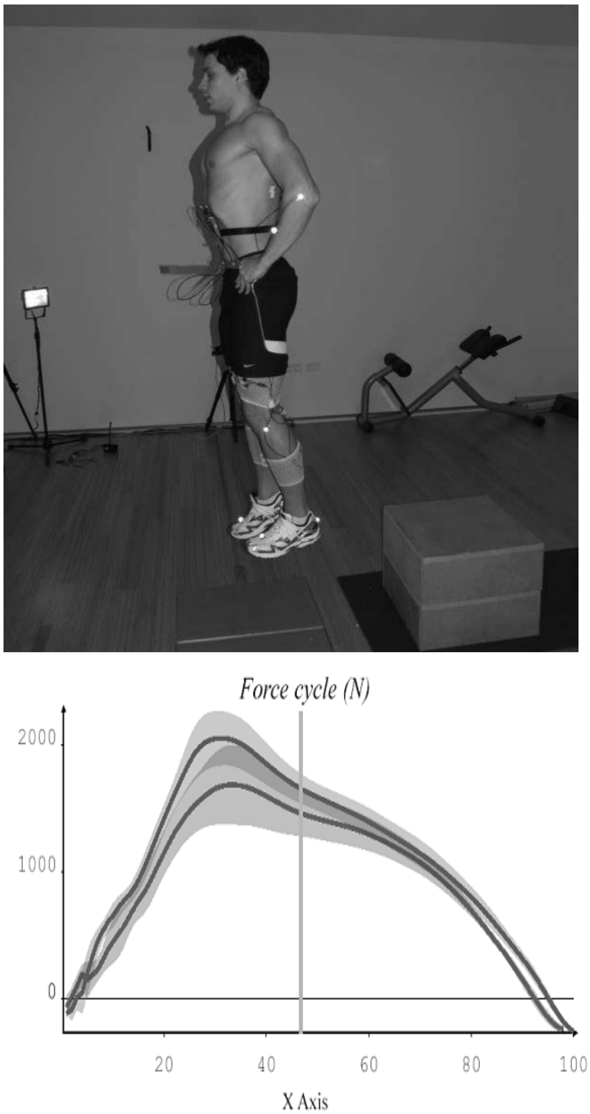

Figure 1. Measurement protocol for kinematic and kinetic parameters of the drop jump - 45 cm

Table 1. Basic characteristics of the samples of elite and sub-elite sprinters

		ELITE (6)		**SUB-ELITE (6)**	
Parameter	Unit	Mean	SD	Mean	SD
Age	yrs	23.67	3.26	22.67	3.55
Height	cm	179.17	7.65	176.17	6.58
Body mass	kg	77.50	5.32	72.33	3.98
100m	s	10.66 *	0.18	10.96	0.16

** A difference between the groups is statistically significant (p<0.05).*

Kinetic variables of vertical jumps were examined with the use of two separate force platforms (600x400, Type 9286A, Kistler Instrumente AG, Winterthur, Switzerland) at a sampling rate of 800 Hz. Analysis included the following kinetic variables: maximal ground reaction force, impulse of force, impulse of force in eccentric and concentric phases. Ground reaction force (GRF) was measured unilaterally and bilaterally. Force has further been normalised according to the body weight of measured subjects (N/kg).

Data were statistically analysed with the use of SPSS for Windows 15.0 programme (Chicago, IL, USA). In both types of jumps three best (highest) jumps were considered. In addition to basic statistical parameters of variables the differences between the two categories of sprinters in tests drop jump were also examined with a repeated measures ANOVA variance analysis. Significance of differences was assessed at 5% risk level ($p<0.05$).

Results

Results in the Table 2 reveal that the elite sprinters are slightly older with higher body weight and height and with statistically significantly better results in 60- and 100-metre sprint running. Tables 2 present mean values and standard deviations of variables for 45-cm drop jump - 45 cm . In drop jump the difference in the height of jump between the two groups amounted to 8.7 cm. Important differences between the groups have also been noticed in the vertical take-off velocity for both countermovement and drop jumps. Furthermore, the velocity of body centre of gravity (BCG) in the eccentric phase of drop jump importantly discriminated elite sprinters from sub-elite sprinters.

Table 2. Kinematic and kinetic variables of drop jump – 45 cm

		ELITE (6)		**SUB-ELITE (6)**	
Parameter	Unit	Mean	SD	Mean	SD
Height	cm	54.76 *	5.34	46.02	5.95
Concentric time	ms	90.00	5.42	93.55	5.75
Eccentric time	ms	70.43	8.38	77.70	7.51
Contact time	ms	160.43	10.68	171.25	16.11
Peak Force /Right	N	1551.20	286.07	1516.32	309.12
Peak Force /Left	N	1433.21	170.58	1616.02	229.74
Eccentric Impulse /Right	Ns	78.33	16.35	76.03	12.77
Eccentric Impulse/Left	Ns	70.85	7.50	80.00	13.14
Concentric Impulse/Right	Ns	87.61	12.30	85.18	19.00
Concentric Impulse/Left	Ns	82.55	12.32	88.48	13.71
Take - off velocity	$m.s^{-1}$	3.18 *	0.15	2.87	0.24
Eccentric velocity	$m.s^{-1}$	3.05 *	0.11	2.81	0.07

** A difference between the groups is statistically significant (p<0.05).*

Discussion

In drop jump - 45 cm statistically significant differences between the groups of elite and sub-elite sprinters were revealed in three parameters: height of jump, velocity of body centre of gravity in eccentric and concentric phases. Previous studies indicated a high correlation between the drop jump and sprinting speed (Saraslanidis, 2000; Young, 1995; Marković, 2004). High correlation between drop jumps and starting acceleration over 10 metres have been found by Mero et al., (1992), Rimmer and Sleivert (2000), Marković, (2004) and Maulder et al., (2006). Neuro-muscular mechanisms in the execution of drop jump and sprinting strides are very similar. Faster stretching of muscular-tendon complex, shorter time and the amplitude of movement all result in higher amount of elastic energy. It is known that muscular-tendon complex (Achilles tendon, *m. gastrocnemius medialis*, *gastrocnemius lateralis, m. soleus*) can in conditions of higher velocity of eccentric-concentric cycle store higher amount of kinetic energy in a form of elastic energy (Bobbert & van Soest, 2000; Komi, 2000). Generation of elastic energy also means shorter contact times, which is a decisive factor in sprinting. If the time of contact with the surface is longer, a part of absorbed kinetic energy is transformed into chemical energy – heat (Komi, 2000). In comparison with the group of sub-elite sprinters, sprinters from elite group have shorter cumulative duration of contact phase (elites=160.4 ms, sub-elites=171.2 ms) as well as shorter duration of eccentric phase in 45- cm drop jump; however, the difference is statistically not significant. According to some studies (Gollhofer & Kyrolainen, 1991; Komi, 2000), the key mechanism to short contact time in conditions of eccentric-concentric cycle (stretch-shortening cycle – Komi & Nicol, 2000) is an efficient pre-activation of agonists and synergists of ankle joint (*m. gastrocnemius latera-*

lis, *m. gastrocnemius medialis*, *m. soleus* and *m. tibialis*). Pre-activation starts 100 ms prior to the contact of foot with the ground (Gollhofer & Kyrolainen 1991). Agonists and synergists provide increased stiffness of ankle joint, regulated by the central motor programme (joint stiffness regulation), which controls and synchronises the work of flexors and extensors in ankle prior to the contact with the ground (Gollhofer & Kyrolainen, 1991, Nicol et al., 2006). Young et al. (1999) have found that in sprinters the training of drop jumps significantly shortens contact times and improves the height of jumps. Short contact phase is one of the most important factors in sprint running, both from the point of view of higher frequency and the velocity of take-off in sprinting stride. In powerful motor structures, such as sprint running, the time available for generation of force is one of the most important limiting factors. Speed of generation of muscular force (gradient of force) is in sprint more important factor than the maximal muscular force (Zatsiorsky, 1995).

There is one significant difference between the sprint running and drop jump test evaluating elastic strength. From the biomechanical point of view, sprinting represents alternate activity of left and right leg, i.e. a unilateral activity. According to Mero et al. (1992), realisation of strength in sprint running considerably depends on intra- and inter-muscular coordination. Vertical jumps are a typical example of bilateral activity. Nevertheless, similarity between these two activities exists particularly from the aspect of ground reaction force. In the phase of maximal sprinting velocity the vertical ground reaction force amounts to 1300 to 1600 N (Mero et al., 1992) on each leg. The sum of ground reaction force on both legs is thus between 2600 N and 3200 N. In drop jump elite sprinters achieve in average a bilateral ground reaction force 2984 N and sub-elite even 3132 N. Unilateral ground reaction force amounts in elite sprinters to 1492 N and in sub-elite sprinters to 1566 N. Similarly, the impulse of force in eccentric phase of jump is in average higher in the group of sub-elite sprinters, compared to the group of elite sprinters (elite 149.18 Ns, sub-elite 156.03 Ns).

Apparently, sub-elite sprinters are despite higher ground reaction force not capable of realising higher jumps than the elite sprinters. Elite sprinters in average achieved 8.7 cm higher vertical jumps after 45-cm drop jump than the sub-elite sprinters.

According to the kinematic parameters (duration of take-off, duration of eccentric and concentric phase) and kinetic parameters (maximal force reaction, impulse of force in eccentric and concentric phase), it can be concluded that the elite sprinters use a strategy of jumping with a fast eccentric-concentric cycle, whereas the sub-elite sprinters use a strategy of slow eccentric-concentric cycle. Only a quick transformation of eccentric contraction into concentric one whilst utilizing a stretch reflex enables an efficient transfer of elastic energy from first into second phase of take-off action. In the pre-stretch phase of elongation of muscles and tendons the larger part of elastic energy is stored in serial elastic muscle elements (aponeurosis, tendon, cross-bridges) and smaller part in parallel elastic elements (muscular fascia, connective tissue, sarcolemma). This energy is released in concentric phase together with a chemical energy of a muscle. A part of elastic energy is available only for 15-120 ms, which is a lifetime of cross-bridges (Komi & Nicol, 2000). The speed of eccentric-concentric cycle in elite sprinters is mostly a result of statistically significantly higher speed of body centre of gravity in the amortisation of jump phase and the extension of jump phase. At a time of leaving the ground the average vertical velocity of elite sprinters is 0.31 ms^{-1} higher in comparison to sub-elite sprinters. Drop jump as a complex multi-joint movement, where inter-muscular coordination particularly of agonists and synergists is of high importance, has been revealed as an important diagnostic instrument of result prediction for sprint running.

Conclusion

Drop jumps are important training tools in plyometric training of sprinters. They can be used to improve functioning of eccentric-concentric muscular work in lower extremities. In drop jump, elite and sub-elite sprinters differentiated in the realisation of movement velocity in the eccentric and concentric phases (a difference between the groups is statistically significant $p<0.05$). Elite sprinters better utilise the stretch reflex, which allows them to more efficiently transfer elastic energy from first into second phase of take-off action. Furthermore, these jumps are reliable and objective measuring instrument for diagnosing and planning of training process of athletes in the area of strength.

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POSTURE AS MALFUNCTION OF FEMALE PUPILS MUSCULOSKELETAL SYSTEM IN PUBESCENT AGE

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Original scientific paper
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Abstract
Aim research is identify and point out the level of musculoskeletal system of female pupils of second degree of primary school with an intention to posture. Posture disorders are widespread in all age groups, but the upward trend over the last decade can be seen even in the school population, we therefore focus in terms of the training of prevention is focused on the status, the level of the individual segments of the body posture with standardised method for the seven grades of primary school female pupils in Liptovký Mikuláš, where the total group was consisted of 69 female pupils. Our survey indicates significantly ($p<0{,}01$) on good posture of the monitored group (60,49%). In each of the areas we examined significant changes in the amendments of physiological curvature of the spine in a sagittal and a lateral plane, which showed a slightly enlarged kyphotic curvature (Chi = 7,989; $p<0{,}01$) and position of the arms and scapula (Chi=7,551; $p<0{,}01$). Research showed the most problematic segments of the posture in oru monitored group of female pupils were significantly ($p<0{,}01$) area of the head, shoulders and scapula, which were reflected in the slightly enlarged chest kyphosis. Symptom of these disorders is back pain, which may later show in adulthood as a vertebral disorders of musculo-skeletal system, which are a often reason for visits to a doctor and sick leave.

Key words: **Posture, Female pupils, Malfunction, Musculoskeletal system**

Introduction

The current hypodynamic and hypocinetic lifestyle of children and youth (Łubkowska & Tarnowski, 2012; Pupišová, 2013, 2014) is reflected in the upward trend in civilisation diseases, to which belong as well functional disorders in the area of musculoskeletal system (Kanásová, 2005; Pupišová & Pupiš, 2013), where belongs also the muscle imbalance. Thurzová (1992) defines a muscle imbalance as a disorder of function balance of the muscles and balance disorder in the effect on the joint. It is imbalance in the system of tonic (postural) and phasic muscles. Buran (2002) along with the other authors considered it as crucial cause of chronic pain of the locomotive system and disorders of the spine. Adversely affects the posture, locomotive stereotypes, muscle coordination, increases susceptibility to injury and limiting the range of motion in joints (Korčok & Pupiš, 2006; Véle, 2006; Pivovarniček et al., 2013a,b).
The outer manifestation of the interplay between the postural and phasic musculature is a posture that represents a relatively correct arrangement of individual segments of the body while standing, sitting, walking or doing other movement, which involved (Čermák, 2005):

- head position
- the determining factor for the posture is the spine, the axis of the body,
- a big influence on posture has position of pelvis and lower limbs,
- the last component is position of the foot arch and information input.

From the foregoing follow that one of the most important locomotive mechanisms is antigravity-postural mechanism, i.e. the holding of upright figure. In this context, it is necessary to point out the optimum level of mobility of the spine, which is considered to be one of the basic assumptions of the correct posture.
The spine is to be understood as one coherent body, which provides a number of features:

- provide upright posture,
- is co-creator of movement,
- protects an important part of the nervous system (spinal cord and spinal roots).

At the same time spine contributes to the security of the balance, ensures the horizontal position of the eyes and head and it participates on balance holding . At the moment we are talking about diseases of the spine as a civilisational diseases. These disorders occur more often at an earlier age, in particular, due to lack of support of the spine, which in the first stage are as functional disorders of posture, where faulty (wrong) posture is essentially a disorder of the postural functions of the system. Outwardly it is manifested by changes in the shape of the body, which are caused by shortening or weakening of some muscle groups and non-physiological curvature of the spine (Vojtaššák, 2000).

Functional disorders of the locomotive system are reflected in threesystematic, interrelated levels (Kolář, 2001):

a) in the area of muscle function as *muscular imbalance,*
b) in the area of central control as disorders of *locomotive stereotypes,*
c) in the area of joint function as *limitation of joint mobility or hypermobility.*

The most common symptom in the spine disorders is pain. This is a subjective feeling, from mild discontent to devastating feeling (Hart et al, 1995; Thurzová, 2003). Therefore the intensity of pain feeling does not always correspond to the severity of the damage of the spine (Buran, 2002). This is a serious economic problem, which shows also figure 1, in which is displayed an increasing number of accepted disabilities because of diseases of the spine in an interval of five years.

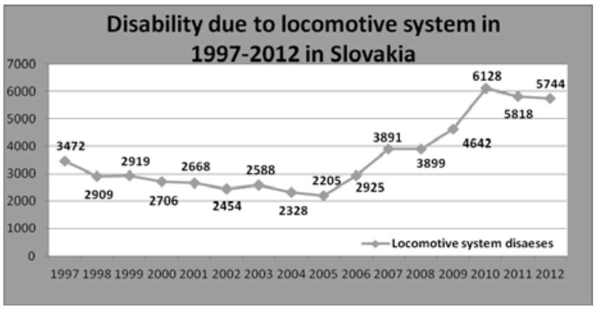

Figure 1. Disability due to locomotive system in 1997-2012 in Slovakia

Functional disorders in children and youth in the area of the musculoskeletal system are subjects of interest not only for domestic (Hubinák, 2007; Kopecký, Ely, 2007; Bendíková, 2011; Kabátová et al., 2012) but also foreign authors (Chen et al., 1998; Kania & Gudzio-Wiernicka, 2002; Żukowska, Szark-Eckardt, Muszkieta, & Iermakova, 2014; Kovač, Kajmović, Rađo, & Manić, 2014*).* High representation of incorrect posture in the population of pupils is currently significantly determined by the lack of physical activity (Bendíková & Kostencka, 2013). The correct stereotype of the posture is, amongst other features, an assupmtion for the optimal operation of the internal organ systems (especially respiratory and cardio-vascular).

The effects of muscle imbalances and dysfunctions in spine resulting from the change in the momentum and in the function of the musculoskeletal system, disorders in statics and dynamics. There is a nonphysiological load on the individual parts of the joints, followed by their functional remodeling, which can then cause premature degenerative changes. The lack of primary prevention leads to the formation of vertebral diseases in adulthood, which (Buran, 2002):

- are the leading cause of work disability in people over 45 years old,
- in the cause of hospitalization are on 5.-6. place,
- 60-90% of the population had or has vertebral difficulties,
- within the framework of rehabilitation ambulaces are 70% of the patients in Slovakia with the spine disaeses .

Listed partial discoveries are included in the grant: VEGA no. 1/0376/14 Physical activity intervention for the prevention of health of the population of Slovakia.

Aim research is identify and point out the level of musculoskeletal system of female pupils of second degree of primary school with an intention to posture. Due to the prevalence of bad posture we expect an occurrence of functional disorders in posture of monitored group.

Methods

Exploratory group was consisted of 69 female pupils in pubescent age from Liptovský Mikuláš, who were willing to participate in the survey with the participation of a doctor (specialist) and teacher of physical education and sports. These were female pupils of seveth classes of primary school,second grade, in the number of 69, whose average age was 13,5 years. The primary characteristics of the group presents in Table 1.

We carried out a survey in the 3 primary stages where in the second stage we realised evaluation of musculoskeletal system with intention on posture, with the help of a doctor and support of a teachers in the school year 2013/2014, in March 2014. It was realised in the specialist ambulance – ortophedist, with Thomas - Klein method modified by Mayer (in Hošková & Matoušová, 2005).

Table 1. Characteristics of the file (n = 69)

N = 69 / factors	**Body height/cm**	**Body weight/kg**
	160,6	56,5
Age	13,5 years	
BMI kg/m^2	23,3	

Posture is divided into 4 stages: 1. Excellent, 2. Good, 3. Poor, 4. Incorrect, where each grade of posture has 5 characters and is evaluated by mark (1 to 4):

1. Holding of the head and neck
2. The shape of the chest
3. The shape of the abdomen and pelvis inclination
4. The total curvature of the spine
5. The height of the shoulders and the position of the scapula

The classification of the posture:

I. Excellent posture 5 points
II. Good (almost perfect) posture 6 – 10 points
III. Poor posture, 11 – 15 points
IV. Incorrect posture 16 – 20 points

In evaluation of lower limbs position we came out in varus from the distance between the inner parts of knee joints, while the in valgus distance from the internal ankles distance in a standing position.

To assess degrees of posture in pupils younger school age, we used the Chi-square test on 1% ($p< 0,01$) and 5% ($p < 0,05$) level of statistical significance. Next, we used methods of logical analysis and synthesis using the inductive and deductive methods, comparisons and generalizations. All data were percentage processed and compared with available literature.

Results and discussion

On the basis of partial aim and tasks of the paper, we present a part of the results, which are subject to further exact tracking and processing. We cannot generalize presented results, but it is necessary to understand them in the total context as an informative and basic in the organisation of leisure time in relation to health.

We found in our group at the general classification of posture (Table 2) significantly ($p < 0,01$) the highest percentage representation in II. qualitative grade, which is characterized as a good posture, where we recorded 60,49 % female pupils. In I. qualitative grade, which is characterized as a great posture we have seen in our group 14,37 % female pupils, while in the III. qualitative grade 23,70 % for which is characteric poor posture. The lowest percentage we found in IV. qualitative grade (1,44%), which we consider as a positive. At the same time we can say, that good posture has not only aesthetic but also power-economic requirements, which is a reflection of the external and internal environment - homeostasis.

Table 2. Classification of posture in female pupils (n = 69)

Evaluation/Sex	I. Excellent posture to 5 points	II. Good posture 6 - 10 points	III. Poor posture 11 - 15 points	IV. Incorrect posture 16 - 20 points
Girls	14,37 %	60,49 % **	23,70 %	1,44 %

*Legend:** p < 0,01*

We consider the overall level of posture in our group of female pupils in the light of our findings as a positive due to the findings of other authors (Vargová & Veselý, 2002; Adamčák, Bartík, Kozaňáková, 2011), who point to an increase in the incorrect posture in pupils not only in the secondary but also in primary schools.

We found in each of the areas of posture the following. In the area I. evaluation of head and neck holding (Table 3) We found in our group of female pupils, that with mark 1 was ranked only 6,9%, while with mark 3 half of the female pupils (50%; Chi = 7, 878; $p < 0,01$). With mark 2 was ranked 38,8 % ($p < 0,05$) and with mark 4 only 4,31 %.

Table 3. Head and neck holding in female pupils (n = 69)

Girls/evaluation	Mark 1	Mark 2	Mark 3	Mark 4
n = 69	6,9 %	38,8 % *	50 % **	4,31 %

*Legend: **p < 0,01; *p < 0,05*

We found in the area II. chest evaluation IN our group of female pupils (Table 4), that with mark 1 was evaluated only 3,45 %, where we found the symmetrical chest, well arched, using intercostal part for breathing.

Table 4. Chest evaluation of female pupils (n = 69)

Girls/evaluation	Mark 1	Mark 2	Mark 3	Mark 4
n = 69	3,45 %	82,76 % **	12,07 %	1,72 %

*Legend:** p < 0,01*

We evaluated with mark 4 only 1,72 % female pupils. The highest percentage and significance (Chi = 9, 913; $p < 0,01$) we found in mark 2, what we consider as positive. With mark 3 was evaluated by a doctor 12,07 % of female pupils.

On the prevalence of asymmetric hull in children aged 8 - 14 years old points also Tisovský et al. (2004). We add, that the position of the chest plays an important role in the respiraton, but also for the imposition of various internal organs in the thoracic spine box, which has the protecting function.

Another monitored area was the evaluation of the abdomen and the slope of the pelvis (Table 5), which we evaluate as positive in the light of our findings and also in the light to other authors (Kováčová, 2004). While with the mark 1 was evaluated 15,52 % of female pupils, with the mark 2 it was 75,86 % (Chi = 8,326; $p < 0,01$) of female pupils. With the mark 3 was evaluated only 7,76 % of female pupils. Correct posture is conditional upon the right curvature of the spine and the right slope of the pelvis. Incorrect position and enlargement of pelvis slope is linked to the flabby tension of rectus abdominis muscles and shortening iliac-lubar thigh muscle.

Table 5. Evaluation of the abdomen and pelvis slope of female pupils (n = 69)

Girls/evaluation	Mark 1	Mark 2	Mark 3	Mark 4
n = 69	15,52 %	75,86 % **	7,76 %	0,86 %

*Legend:** p < 0,01*

Physiological, natural curvature of the spine in a sagittal and lateral plane has its justification whether in terms of health, economic, and aesthetic. In the evaluation of IV.

area the back curves (Table 6) we have come to the conclusion, that the with mark 1 was evaluated 4,31 % of female pupils, while the highest percentage with signifikance (Chi = 7,989; p < 0,01) we have seen in the mark 2. 42,24 % (p < 0,05) of female pupils had visibly rounded back, which was accompanied by a sliding of the head forward as compensation.

Table 6. Evaluation of back curve of female pupils (n = 69)

Girls/evaluation	Mark 1	Mark 2	Mark 3	Mark 4
n = 69	4,31 %	53,45 % **	42,24 % *	0 %

*Legend: **p < 0,01; * p < 0,05*

In the next evaluation of V. area, which is focused on posture in frontal plane (Table. 7) we found the highest percentage and significance in mark 3 (Chi = 7,551; p < 0,01) and the lowest in mark 4 (1,72 %).
We have noticed in these female pupils protruding scapula and shoulders, which were displaced to the front, what are according to Labudová & Vajciková (2009) typical symptoms of round back, as one of the normal weaknesses of the spine.

Table 7. Posture in frontal plane of female pupils (n = 69)

Girls/evaluation	Mark 1	Mark 2	Mark 3	Mark 4
n = 69	7,76 %	28,45%	62,07% **	1,72 %

*Legend:** p < 0,01*

Initially it may be only about malfunctioning, which may in time grow into a structural failure. Therefore, it is important prior to the maturation of the spine (about till 12 to 13 years) align the spine with active muscle effort and thus also extend it. The main cause of the external expression of the winging scapula is flabby scapula muscles and rhombic muscles, which are overdrawed with relatively more powerful pectoral muscles (Bendíková & Stacho, 2010). In 7,76 % of female pupils we found the full symmetry, the same height of shoulders, which have been released, scapula was not winging, while 28,45 % had slight differentiation.
In the area of the lower limbs (Table 8) we found significantly in 69 % (p < 0,01) correct position of the lower limbs, where slight deviation we found in 22 %. Valgus and varus position of the lower limbs we found in 9 %, while the flat feet at 42 %.

Table 8. Evaluation of the lower limbs of female pupils (n = 69)

Girls/evaluation	Mark 1	Mark 2	Mark 3	Mark 4
n = 69	69 % **	22 %	9 %	0 %

*Legend:** p < 0,01*

Rozkydal, Chaloupka (2001) add that graduated varus and valgus of the knees may be congenital or acquired, and may be affected by one or both legs. Slight symmetric varus can be hereditary and often it can be fixed during the growth.

Conclusion

In the present study we evaluated the status of the postural system with the intention to posture as one of the main determinants of the quality of the postural system, which is an important indicator of developmental trends of child organism. Is is he result of balanced activity of the nervous system and the musculo-skeletal system, postural regimen and rational nutrition. We assume that our findings are based on the primary prevention of incorrect posture creation, which consists in the sufficient volume of spontaneous but also controlled physical activities during their stay in the school but also in the leasure time of monitored group of female pupils.
The most problematic segments of the posture in oru monitored group of female pupils were significantly (p < 0,01) area of the head, shoulders and scapula, which were reflected in the slightly enlarged chest kyphosis. Symptom of these disorders is back pain, which may later show in adulthood as a vertebral disorders of musculo-skeletal system, which are a often reason for visits to a doctor and sick leave.

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DIFFERENCES IN POSTURE STATUS BETWEEN BOYS AND GIRLS 6 TO 9 YEARS OF AGE

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Abstract
The aim of this research presents detection of differences in postural status between boys and girls 6 to 9 years of age. Research was conducted on a sample of 344 respondents, of which 172 girls and 172 boys under the IPA SpineLab project financed by the European Union. The postural state was checked with 17 applied variables, and was obtained by conducting "3D Posture Compact" protocol on Contemplas measuring instrument. Mann-Whitney U test showed that there were statistically significant differences ($p < .001$) in postural status between boys and girls in Sag. Distance thoracic spine – sacrum (thoracic kyphosis), Sag. Distance lumbar spine – sacrum (lumbar lordosis), Varus/Valgus left, Varus/Valgus right (X and O legs). Girls are significantly more likely to have postural problems in relation to their male peers in terms of lumbar lordosis and valgus knees, while boys have more pronounced deformity of the thoracic kyphosis. In the end, bad posture status in children and adolescents can lead to significant health problems, and it is very important to identify them at an early stage and promptly begin preventive procedures (preventive exercise program, etc.).

Keywords: **body alignment, kyphosis, lordosis, x and o legs, varus / valgus knee, 3d screening**

Introduction

The modern way of life, has a negative impact on psychological organism, especially in the period of its development (Đokić, Međedović, & Smiljanić, 2011). Therefore, observing globally, proper posture of children and youth today presents a big challenge (Bubanj et al., 2012). Today there is a growing global problem of hypokinesia with generations who will, in the future, be the bearers of the society and the community. One of the biggest problems are long-hours of improper sitting postures during the day and which ultimately lead to different postural deformities (Le Roux, 2013). Posture is defined as the alignment and orientation of the segments of the body when held in upright position (Fortin, Ehrmann Feldman, Cheriet, & Labelle, 2011). Identification of postural disorders is of great importance, especially in preadolescent period. The reason for this lies in the fact that it is extremely necessary to create an image of the body posture of children at a very early stage, that contributes to the overall growth and development and quality of life. To determine the postural status of the individual, it is necessary to apply the screening which plays an important role in the fast and reliable assessment of the normal development of children and adolescents (Kowalski et al., 2014). Good posture is one of the basic requirements of good health, normal growth and development as a whole (Torlaković, Muftić, & Kovač, 2013). The aim of this research presents detection of differences of postural status between boys and girls 6 to 9 years of age, recorded by 3D study protocol.

Methods

Sample

The research has covered 344 respondents of school population ages 6 through 9, of which (n=172) girls and (n=172) boys. All of the subjects were in the Sarajevo Canton.

Variable sample

The variables that were used in this study are the result of a three-dimensional video and provide posture information. The sample of variables consisted of 17 parameters obtained by ''3D posture compact'' protocol of testing Contemplas measuring instrument (Kovač, Kajmović, Rađo, & Manić, 2014). Obtained parameters point at eventual deflection from null (normal) value of posture status in all three planes where postural plane shifts are shown in centimeters and degrees. Bigger value in deflection (positive or negative) implies higher level of deformity.

Table 1. Variables by ''3D posture compact'' protocol of testing Contemplas measuring instrument

Shoulder displacement	Variable expressed in centimetres indicates elevation/depression of the left/right frontal plane. Results with the positive values are in regard to the right shoulder elevation, while the negative values indicate a left shoulder elevation.
Pelvic obliquity	Variable expressed in centimetres displays elevated/lowered left/right pelvic side in frontal plane. Results with positive values indicate the elevation of right pelvic side, and results with negative value indicate the elevation of left pelvic side.
Shoulder rotation	Variable expressed in degrees indicates the rotation in longitudinal axis (transversal plane) of the left/right shoulder. If the results are positive it indicates a rotation of the upper body in which case the right shoulder is placed forward, while negative results indicate a rotation of the upper body in which case the left shoulder is placed forward.
Pelvic rotation	Variable expressed in degrees indicates rotation in longitudinal axis (transversal plane) of the left/right pelvic side. If the results are positive it indicates the rotation in which case the right side of the pelvis is placed forward, while in negative results the rotation of the left side of the pelvis is placed forward.
Trochanter rotation	Variable expressed in degrees indicates rotation of the left/right tronchanter in longitudinal axis (transversal plane). If the result is positive it indicates the rotation of the lower body in which case the right side of pelvis is rotated towards front, while the negative results indicate the front rotation of the left side of pelvis.
Condylus rotation	Variable expressed in degrees indicates the knee rotation in longitudinal axis (transversal plane). If the results are positive, it indicates the front rotation of lateral condylus of the right leg, while the negative results indicate the front rotation of the left lateral condylus.
Malleolus rotation	Variable expressed in degrees indicates the rotation of the axis which runs through malleolus of ankle joint. If the result is positive it indicates the front rotation of the lateral malleoulus of the right foot, while the negative result indicates the opposite rotation.
Sag. Distance cervical spine – sacrum*	Variable expressed in centimetres indicates the distance of the most protruded cervical (neck) vertebra in regards to the vertical line projection of the sacrum (bone at the bottom of the spine) in the sagittal plane. Positive result indicates the increased flexion of the cervical spine, while the negative results indicate the increased extension of the cervical spine.
Sag. Distance thoracic spine – sacrum*	Variable expressed in centimetres indicates the distance of the thoracic spine in regards to vertical line projections of the sacrum (bone at the bottom of the spine) in sagittal plane. Positive results indicate an increase of flexion in thoracic spine, while the negative results indicate an increase in other extension of the thoracic spine . *Higher values in the positive and negative offset do not apply for the variables "Sag. distance cervical, thoracic, lumbar – sacrum"
Sag. Distance lumbar spine – sacrum*	Variable expressed in centimetres indicates the distance of the lumbar (lower) spine in regards to the vertical line projection of sacrum (bone at the bottom of the spine) in sagittal plane. Positive result indicates an increase in lumbar spine flexion, while negative results indicate increase in the lumbar spine extension.
Varus/Valgus left	Variable expressed in degrees indicates the Varus-Valgus alignment angle of the left leg (medial/lateral) at the knee joint.
Varus/Valgus right	Variable expressed in degrees indicates the Varus/Valgus alignment angle of the right leg (medial/lateral) at the knee joint.
Flexion/Extension left	Variable expressed in degrees indicates the hyperextension and flexion of the left leg at the knee joint (sagittal plane). Positive result indicates the left leg flexion, while negative result indicates hyperextension of the left leg.
Flexion/Extension right	Variable expressed in degrees indicates the hyperextension or the flexion of the right leg at knee joint (sagittal plane). Positive result indicates the right leg flexion, while the negative result indicates the hyperextension of the right leg.
Frontal Cervical spine	Variable expressed in centimetres indicates the distance of the cervical spine in frontal plane in relation to the vertical line projection of the sacrum. If the result is positive it indicates the right displacement of the cervical spine, and the negative result indicates the left side displacement.
Frontal Thoracic spine	Variable expressed in centimetres indicates the distance of the thoracic spine in frontal plane in relations to vertical line projection of the sacrum. If the result is positive it indicates the right displacement of the thoracic spine, while the negative result indicates the left side displacement.
Frontal Lumbar spine	Variable expressed in centimetres indicates the distance of the lumbar spine in frontal plane in relation to vertical line projection of sacrum. If the result is positive it indicates the right displacement of the lumbar spine, but if the result is negative it indicates the left side displacement.

Testing protocol

Testing and assessment of posture on the measuring instrument Contemplas require ideally flat surface and outstanding precision. It is necessary to find the ideal base to set up the plate of measuring instrument Contemplas (Figure 1) on it. To avoid moving plate while children step on it, which would lead to repetition of the calibration process space, it is glued to the surface.

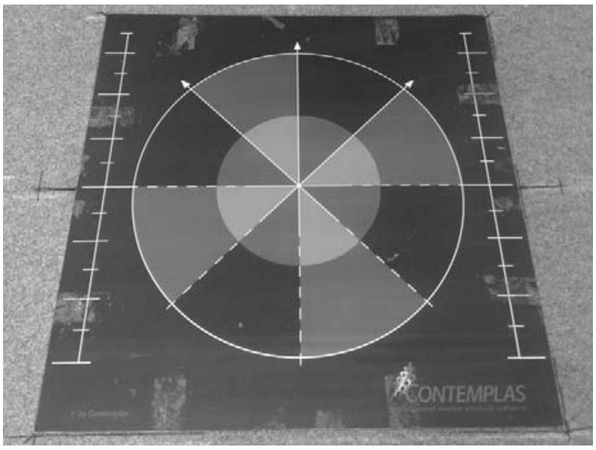


Figure 1. Screening surface

After proper plate installation, 3D calibration frame, which contains reflective markers (Figure 2) is set on it.

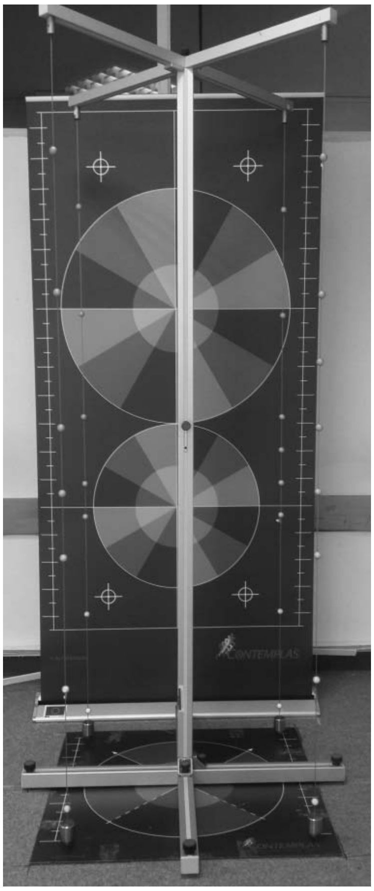


Figure 2. Calibration frame

Calibration frame is positioned in the middle of the Contemplas plate. All parts of the calibration frame must be ideally aligned, which is checked by using a spirit level. After setting the calibration box below, comes the setting of "V" frame in which there are 3 cameras that provide a three-dimensional analysis (Figure 3).

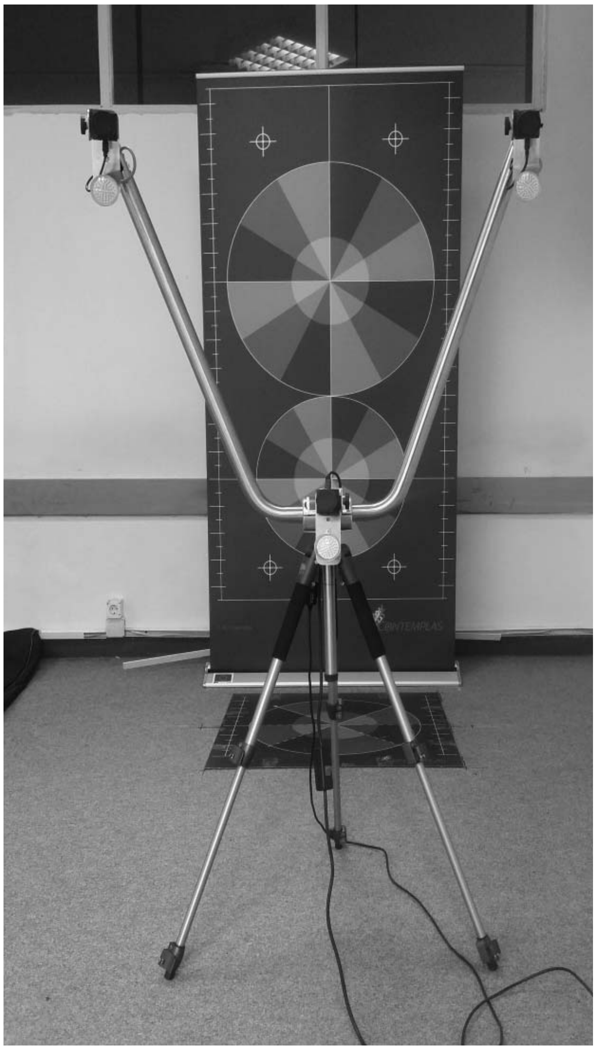


Figure 3. „V" Camera Frame

The distance of camera from the measuring board should be at least 2 meters and 15 cm (230 cm in this study). The next step requires the software quality check of the image and the camera starts with the calibration area. Calibration process is based on the calibration box gathering width, depth and height. The next step involves preparing and placing reflective markers on specific points (depending on the test protocol) in a patient's body. "3D Posture Compact" protocol was used in this research, which requires placing 14 markers on the body of each subject and the following specific places: the acromion (left and right), cervical spine, thoracic spine (kyphosis), lumbar spine (lordosis) crista iliaca posterior superior (left and right), sacrum, trochanter major (left and right), condyluslaterallis (left and right), malleolus laterallis (left and right) (Figure 4).

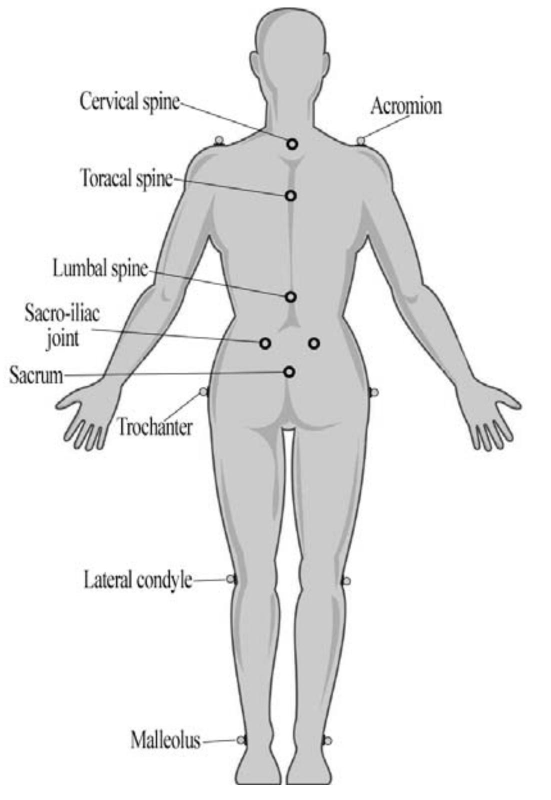


Figure 4. Setting markers "3D Posture Compact" protocol

After placing a marker, the respondent stands on the board so that his back is to the camera, with a parallel set feet hip-width apart, where axis passing through the center malleolus must be parallel with the horizontal line on the measuring board (frontal plane). Respondent is said to stand still and stare straight ahead, after which the recording begins (between the 12^{th} and 18^{th} second). After recording, markers are removed from the subjects and put on the next one and the process of pasting markers and recording repeats. Testing protocol is used as recommended by the author Kovač et al., 2014.

Data analysis method

Results were processed in IBM SPSS 22 software package. Since the data did not meet normality of distribution, statistically significant differences between boys and girls were found by non-parametric Mann-Whitney U test.

Results

The results for the treatment group of participants from 172 girls (the AS 7.80, SD 0.91) and 172 boys (the AS 7.65, SD 7.1) revealed statistically significant differences. Looking at the spine in the sagittal plane, the two variables showed the greatest statistical difference between boys and girls ($p < .001$). These are variables Sag. Distance thoracic spine - sacrum and Sag. Distance lumbar spine - sacrum (Table 2, Figure 1). The values in sagital plane were caused by physiological curves of the spine at the cervical, thoracic and lumbar region, and based on the distance from the outermost part of the sacrum (Kovač et al., 2014). In addition to spinal deformity, a statistically significant difference ($p < .001$) is noticeable with leg deformities, or varus and valgus's left leg and right leg (Table 2, Graph 1).

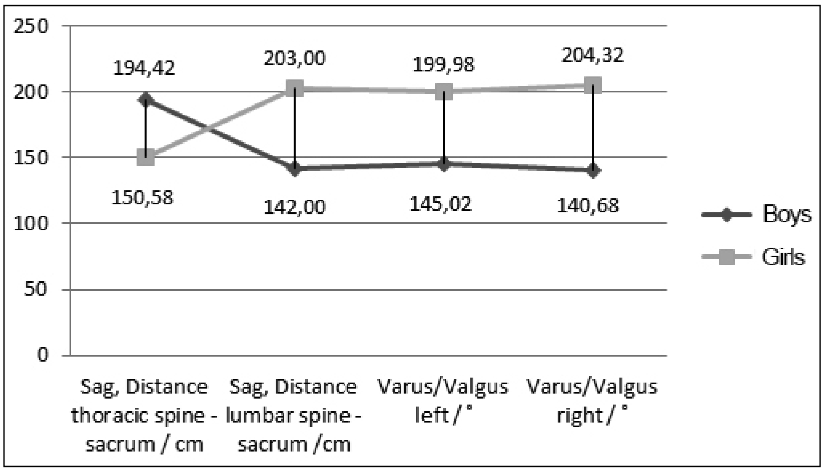
Discussion

Spinal column is vital for good and proper body posture. The assumption for normal posture, with minimal muscle extensibility and energy consumption, is optimal relationship between the spinal structures and joints (Muyor, López-Miñarro, & Alacid, 2013). The results of this research indicate that boys tend to have more prominent thoracic kyphosis deformity (76 boys, constituting 44.18 per cent) in relation to girls, while girls have greater predisposition for lumbar lordosis (48 girls, constituting 44.18 per cent). Improper kyphotic body posture is manifested through increased backward physiological curvature of thoracic region of the spine (Simov, Milinić, & Stojanović, 2011). Longitudinal research results indicate greater incidence and increased tendency among boys toward thoracic kyphosis deformity, while lumbar lordosis is principally prevalent among girls (Poussa et al., 2005). The finding of this research are further confirmed by the results that indicate that thoracic kyphosis is growing among boys ages 8, 11, and 15, but not among girls of this age (Widhe, 2001). One of the most probable causes of kyphotic posture is improper sitting body posture (bending of head toward sternum) (Simov et al., 2011), along with a growing contemporary age problem, that is, excessive computer use. Among girls, excessive computer use leads to greater incidence of lumbar lordosis, which is a result of lower body weigth in relation to boys and consequent trunk extension to raise eye height toward monitor (Straker, O'Sullivan, Smith, & Perry, 2007). Inactivity and weakening of muscle tonus, along with consequent weakening of spinal muscles, which is accompanied by incorrect sitting posture and extensive sitting periods, could lead to spinal column deformities and inadequate body posture. Considering the femur-tibia angle and the activity of epiphysis core of of the distal parts of femur and proximal tibia (Varus/Valgus knees), the research results indicate that girls are more predisposed to valgus angulation (three of six girls have prominent valgus angulation). Among possible causes of the high incidence of increased valgus are specific build features (pelvis width, pelvis inclination, weakeness of individual pelvic muscle groups, flat feet, and increased feet dorsiflexion) (McLean, Huang, & van den Bogert, 2005; Paušić, 2007). Genu valgum is a very common body deformity, which affects flexibility and stability of lower extremities, and it could, if not prevented, lead to movement amplitude limitation, as well as affect functionning of the entire locomotor system. Also, one the reasons for this condition could be the fact that children no longer play as much and are no longer sufficiently physically active in their free time, and they spend most of their time in passive states, either sitting, or lying down (Cvetković & Perić, 2009).

Table 2. Mann-Whitney U test

Variable	Gender	N	Mean Rank	Mann-Whitney U	Z	Sig. (2-tailed)
Shoulder displacement / cm	Male	172	171.76	14664.000	-.139	.890
	Female	172	173.24			
Pelvic obliquity / °	Male	172	171.14	14558.500	-.253	.800
	Female	172	173.86			
Shoulder obliquity / °	Male	172	170.76	14492.500	-.325	.745
	Female	172	174.24			
Pelvic rotation / °	Male	172	172.71	14756.000	-.039	.969
	Female	172	172.29			
Trochanter rotation / °	Male	172	169.06	14200.000	-.642	.521
	Female	172	175.94			
Condylus rotation / °	Male	172	173.22	14669.000	-.133	.894
	Female	172	171.78			
Malleolus rotation / °	Male	172	172.50	14792.000	.000	1.000
	Female	172	172.50			
Sag. Distance cervical spine - sacrum / cm	Male	172	163.53	13248.500	-1.674	.094
	Female	172	181.47			
Sag. Distance thoracic spine - sacrum / cm	Male	172	194.42	11021.000	4.089	.000
	Female	172	150.58			
Sag. Distance lumbar spine - sacrum /cm	Male	172	142.00	9546.000	-5.688	.000
	Female	172	203.00			
Varus/Valgus left / °	Male	172	145.02	10065.500	-5.125	.000
	Female	172	199.98			
Varus/Valgus right / °	Male	172	140.68	9318.500	-5.935	.000
	Female	172	204.32			
Flexion/Ext left / °	Male	172	173.50	14620.500	-.186	.852
	Female	172	171.50			
Flexion/Ext right / °	Male	172	173.59	14604.500	-.203	.839
	Female	172	171.41			
Cervical spine / cm	Male	172	167.77	13979.000	-.882	.378
	Female	172	177.23			
Thoracic spine / cm	Male	172	163.50	13243.500	-1.679	.093
	Female	172	181.50			
Lumbar spine / cm	Male	172	174.48	14451.000	-.370	.712
	Female	172	170.52			

Graph 1. Graphical representation of statistically significant differences on results between boys and girls



Conclusion

This research leads to a conclusion that a significantly higher incidence of posture issues that are manifested through lumbar lordosis and knee valgus (Distance lumbar spine – sacrum, Varus/Valgus left, Varus/Valgus right) is found among girls aged six to nine, while thoracic kyphosis deformity is more prevalent among boys (Distance thoracic spine – sacrum). The increasing number of inactive children and youth, that is, hypokinesia and sedentary lifestyles, constitute ideal conditions for development of various locomotor system diseases and deformities. The results clearly indicate that it is necessary to engage younger school-age children in structured and systemic activities and active use of their free time. Moreover, it is crucial that parents whose children suffer from different posture deformations are educated and informed about the necessity of timely engagement in kinesitherapy programmes, which could ultimately lead to posture improvements.

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EFFICIENCY OF THE TRAINING PROGRAMME FOR NON-SWIMMERS ADAPTED FOR WOMEN WITH A PRONOUNCED FEAR OF BEING IN WATER

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Abstract

The aim of this research was to analyze the efficiency of individual training programme for adult women non-swimmers, among whom is evident a pronounced fear of being in water (swimming). The sample consisted of 20 persons, 26 to 59 years of age. In the study the variables for the evaluation of adaptation parameters needed for being in water were used as well as for swimming performance of subjects. Training programme for non-swimmers was performed individually. The activities were carried out in 20 periods each lasting 60 minutes, in a slightly incline swimming pool adapted for training of non-swimmers. Results of paired-samples t-test have shown a high statistical significance of all variables. Under the influence of the programme there have been significant changes in the values of the variables: swim across distance in meters (PRMET $p< .001$); swimming knowledge assessment (OPPL $p< .001$); assessment of swimming technique (OPT $p< .001$). Based on the results obtained in this study it can be concluded that the applied programme successfully overcame the fear factor among all examinees, which was essential for the continuation of activities. After psychological adjustment, a more advanced movement activities were efficiently implemented as well as swimming skills and elements for a safe and enjoyable time spend in the water.

Key words: **education of adults, transformational process, psychological adjustment, swimming**

Introduction

Drowning is one of the leading causes of injury resulting in death worldwide. Therefore, the need for a preventive strategy of education and overcoming the fear of being in water arises for teaching non-swimmers of all ages and improving their skills of moving in water through some form of swimming (Brenner el al., 2003). Swimming is an activity of movement of living things in the water that includes maintenance on the water surface and movement in the desired direction. In earlier studies (Stallman et al., 2008) it was noted that the training of non-swimmers represented only one of the preventive measures that were aimed to prevent drowning. Fear is probably one of the most deeply rooted emotions in the human psyche (Ziara, 2005). When we talk about the psychological concept of concern (Rychta, 1990), we can distinguish two types of anxiety: the care of a certain phenomenon, physical or imaginary (closer to the concept of fear) and abstract anxiety (closer to the concept of trepidation). The presence of fear warns the body about the dangers ahead, inhibiting harmful acts and starting actions aimed at rescuing itself from a given situation (Freud, 2000). Regarding fears of being in water, it should be noted that in children it's an integral part of the generic cluster or fear of the unknown or danger, while in adults they become independent generic fears (Graham et al., 1997). For individuals where it is evident that they have a pronounced fear of being in water, it is necessary to ensure adequate environment and to prepare them for the training of basic movement elements in order to secure a safe time spend in that environment as well as a swimming programme individually adapted to each person (Grosse, 2010; Stillwell, 2011). A significant number of adults fall into the category of non-swimmers. Many of them, aware of the above stated facts, come to the knowledge and desire that they should try to overcome the fear of being in water and to learn basic elements of swimming. Having that in mind, it is necessary to make every effort in order to reduce the percentage of non-swimmers of all ages (Gošnik et al., 2011). Interesting data from previously conducted research in the Republic of Croatia (Grčić-Zubčević, 2010) show that women have a greater interest for such education. According to the number of registered adults who want to learn how to swim, two thirds are females. Studies have also shown that the greatest interest for learning how to swim in adults of both sexes is between the ages of 25-29 years, which also classifies as adulthood (Berk, 2008). In accordance to the aforementioned, the aim of this research was to analyze the efficiency of individual training programme for adult women non-swimmers, with a pronounced fear of being in water (swimming).

Methods

The sample of participants

The research was conducted on a sample of 20 female participants, 26-59 years of age. Before conducting the research all participants signed a protocol/form where they indicated that they are non-swimmers, have felt an intensive fear of swimming in water for many years and that they have voluntarily entered the training programme for non-swimmers.

The sample of variables

The study used variables (Table 1) to assess the swimming performance of the participants (swim across distance in meters, swimming knowledge assessment and assessment of one of the swimming techniques at the option of the participants). Testing and evaluation was conducted by an expert team of evaluators/judges, using an expert assessment method according to the pre-defined criteria (Kazazović et al., 2007). Swimming knowledge assessment was defined on the basis of the evaluation test results of adaptation parameters required for spending time in water (Table 2) and swim across distance in meters. Evaluations are defined on a scale from 1 to 5 (Table 3). For the evaluation of the quality of swimming technique performance (Table 4) the participants had a free choice of selecting one of the swimming techniques which were rated from 1 to 5 (Rađo, 1997).

Table 1. Variables for swimming knowledge assessment

Variable	Assessment	Records
PRMET	Freestyle swimming	Swim across distance in meters
OPPL	Swimming knowledge assessment	Expert assessment of swimming elements (from 1 to 5)
OPT	Assessment of swimming technique	Expert assessment of swimming elements (from 1 to 5)

Table 2. Evaluation tests of adaptation parameters for spending time in water

Variable	Test	Observation of task fulfilment
GGL	Head dive	Can/Can't – dive the head under the water > 5 seconds with deep exhalation
ROP	Diving of an object	Can/Can't – dive and pick up a light object from the depth of 140 cm
SNP	Feet jump into shallow water	Can/Can't – jump feet first into 140 cm of shallow water
SND	Feet jump into deep water	Can/Can't – jump feet first into 220 cm of deep water
PNS	Floating on a belly	Can/Can't – float on a belly > 5 seconds
PNL	Back floating	Can/Can't – back float > 5 seconds

Table 3. Model evaluation for the swimming knowledge assessment variable (Kazazović et al., 2007)

Evaluation	Movement assessment
EVALUATION 5 - Swimmer	Jumps on feet into deep water on its own, swims the distance of minimum 50 meters-two styles and comes out from the pool on its own.
EVALUATION 4 – Swimmer a beginner	Jumps on feet into deep water on its own, swims using freestyle technique the distance of minimum 25 meters and comes out from the pool on its own.
EVALUATION 3 – Semi-swimmer	Jumps on feet on its own, swims using freestyle technique the distance between 10-24 meters and comes out from the pool on its own or with the help from an instructor.
EVALUATION 2 - Floater	It can, for a short period of time, keep afloat on chest and swim using freestyle technique up to 10 meters and come out from the pool on its own or with the help from an instructor.
EVALUATION 1 – Non-swimmer	Does not have any knowledge about swimming.

Table 4. Model evaluation for the quality of swimming technique performance (Rađo, 1997)

Evaluation	Movement assessment
EVALUATION 5	Technique performance with the optimal angle of attack (depending on the swimming technique), with the optimal range of motion of the body (depending on the swimming technique), around longitudinal and transverse axis, the correct entry of arms into the water and the realization of propulsive and retro propulsive part of the stroke, proper legs work, excellent coordination of arms, legs and breathing.
EVALUATION 4	Technique performance with the optimal angle of attack (depending on the swimming technique), with the optimal range of motion of the body (depending on the swimming technique), around longitudinal and transverse axis, the correct entry of arms into the water, the occurrence of defects during realization of the propulsive and retro propulsive part of the stroke, proper legs work, good coordination of arms, legs and breathing.
EVALUATION 3	Good technique performance, existence of small defects of aforementioned elements, but the whole structure of the movement is not disturbed; there is a satisfactory coordination of arms, legs and breathing.
EVALUATION 2	Technique performance is disturbed; there is existence of defects of all aforementioned elements, bad coordination of arms, legs and breathing.
EVALUATION 1	Poorly performed technique, there are significant defects of all aforementioned elements. The structure of the movement is significantly disturbed, very bad coordination of arms, legs and breathing.

Three evaluators (judges) conducted the testing and evaluation. The evaluators were highly educated with evident practical experience in swimming training programs. They had to meet certain criteria (to have a degree of graduate teachers of sport and physical education; to have at least three years of experience in the implementation of the training programmes for non-swimmers and learning of swimming techniques). Before starting the test, the evaluators were introduced to the procedures, process and assessment criteria. The procedures contained harmonized criteria with an emphasis on the body position, work of arms and legs, proper breathing and coordination. During evaluation, the examinees performed each test only once.

Training programme

Swimming training programme was adapted and implemented individually, during morning hours, under the expert guidance of graduates with a kinesiology degree, experts for training of non-swimmers. Activities were carried out in 20 periods each lasting 60 minutes, according to a defined curriculum (Table 5), in a slightly incline swimming pool adapted for training of non-swimmers (average water temperature was 29,3°C). Training dynamics was conditioned by a working capacity of each examinee.

Table 5. Individual training programme of teaching non-swimmers

Plan and Programme/ Hour	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Sets of warm up exercises	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Aqua gymnastics						*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Adaptation in water	*	*	*	*	*															
Breathing exercises	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*					
Diving-Seeing in water			*	*	*	*	*													
Floating on water exercises			*	*	*	*	*	*												
Sliding and moving in the water					*	*	*	*	*	*										
Legs workout exercises		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Arms workout exercises						*	*	*	*	*	*	*	*							
Arms-Legs working combination							*	*	*	*	*	*	*	*	*	*	*	*	*	*
Combination of movement crawl-back								*	*	*	*	*	*	*	*	*	*	*	*	*
Combination of movement breaststroke-back									*	*	*	*	*	*	*	*	*	*	*	*
Swimming its own style								*	*	*	*	*	*	*	*	*	*	*	*	*
Security swimming exercises																*	*	*	*	*
Jumping on feet																*	*	*	*	*
Jumping on the head																*	*	*	*	*

Methods of data processing

Data on test subjects were obtained by measuring the same variables at two time points, which is before and after programme realization. Assessment analysis of basic adaptation parameters for being in water is shown by percentage statistics. For the results analysis of initial and final testing variables for swimming knowledge assessment a paired-samples t-test was used (Field, 2013) on the level of statistical significance of 0,05% . In order to determine the effect size, an Eta-squared was used (Cohen, 1988).

Results

After the initial measurement it was evident that all participants were non-swimmers, reaching the same score for swimming knowledge and the quality of swimming technique (1), so the evaluators (judges) correlation of these assessments was not calculated. Concordance analysis between evaluators was conducted for the variable of quality of swimming technique performance in the final test (OPTF). Based on the results from the Tables 6 and 7, it can be concluded that analyzed tests of expert assessment of swimming knowledge and quality of swimming technique performance have quality in objectivity (intercorrelations between evaluators are high as well as the reliability coefficient).

Table 6. Concordance analysis between evaluators for giving evaluation during expert assessment

Variable	Evaluator/Judge	AS±SD	CA
OPTF	Judge 1	2.90±1.07	.987
	Judge 2	3.05.±1.14	
	Judge 3	3.00.±1.12	

Table 7. Intercorrelation of evaluators/judges

OPTF	Judge 1	Judge 2	Judge 3
Judge 1	1.000		
Judge 2	.948	1.000	
Judge 3	.962	.981	1.000

On the basis of results of adaptive parameters of spending time in the water (Table 8), as a result of the evident fear of spending time in water, the examinees in the initial testing showed very low level of psychological adjustment necessary for the implementation of planned activities. Even those participants, who on the final measuring managed to do a very small part of the tasks for the assessment of adaptive parameters, implemented the activities with the assistance of instructors. Results of the same parameters on the final measuring indicate maximum work efficiency, and a high level of their psychological adjustment for a safe and enjoyable time spend in water, which in fact was a fundamental precondition for a successfully implementation of training of non-swimmers.

Table 8. Percentage analysis of adaptive parameters for spending time in the water before and after programme implementation

	Initial		Final	
	N	%	N	%
GGL - Head dive	2	10	20	100
ROP - Diving of an object	1	5	20	100
SNP - Feet jump into shallow water - 140 cm	2	10	20	100
SND - Feet jump into deep water - 220 cm	0	0	20	100
PNS - Floating on a belly > 5 seconds	0	0	20	100
PNL - Back floating > 5 seconds	0	0	20	100

Results of descriptive statistics (Table 9) show that the participants managed, on the final measuring, to swim across a significant distance with a mean value around 29 meters. The average rating for the knowledge of swimming (OPPLF) on the final evaluation was 3.9 which put them in a category between semi-swimmer and swimmer a beginner. During final evaluation, the mean score for the quality of swimming technique performance of their choice was 3.0.

Table 9. Descriptive statistics of applied variables in the initial and final measurements

	Mean	N	Std. Dev.	Std. Error Mean
PRMET Initial	3.25	20	1.74	.38984
PRMET Final	29.15	20	14.91	3.33583
OPPL Initial	1.00	20	.00	.00000
OPPL Final	3.90	20	.96	.21643
OPT Initial	1.00	20	.00	.00000
OPT Final	3.00	20	1.12	.25131

Based on the arithmetic mean of the results of swimming variables at the beginning and the end of the program and on the basis of significance of occurring changes tested by a paired-samples t-test (Table 10), it is clear that the programme has made significant partial effects. Also, the value of Eta-squared for all three variables shows that the effect of the implemented programme is large. Results of paired-samples t-test (Table 10) show a high statistical significance of all the variables. Under the influence of the swimming training programme there have been significant changes in the values of the variables: swim across distance in meters (PRMET $p < .001$); swimming knowledge assessment (OPPL $p < .001$); assessment of swimming technique (OPT $p < .001$).

Table 10. Results of paired-samples t-test

	Mean	Std. Dev.	t	df	Sig. (2-tailed)	Eta-squared
PRMETI - PRMETIF	-25.90	13.52	-8.56	19	.000	0.79
OPPLI - OPPLF	-2.90	.96	-13.39	19	.000	0.90
OPTI - OPTF	-2.00	1.12	-7.95	19	.000	0.77

Discussion

Results of previous studies have shown that the process of psychological adjustment in the training of non-swimmers is a very important factor that instructors often neglect (Leite et al., 2007). However, on the basis of a clearly defined plan and programme under which the survey was conducted (various exercises for the proper breathing technique, floating, diving and sliding on water), it is evident that the optimal quality of the psychological adjustment of all examinees, especially in the beginning of programme activities, was taking care of. Also, these exercises have been repeated periodically until the end of the planned programme activities. In kinesiology education, that among other things includes the improvement and transformation of the level of motor and theoretical awareness and motor achievements, individualization in working with participants in the most efficient way. The results obtained confirm the conclusions of authors of earlier studies in which the efficiency of the individualization of work is emphasized, giving priority to individual approach in kinesiology education whenever possible (Findak, 2003; Keškić, 2012). The movements in the water were gradually adopted, resulting in easier composition of fine combinations of posture and movement. During the implementation of the swimming training programme, the test subjects went through internal changes that determined the ability of each individual for the correct movement performance. This confirms the findings of earlier studies (Rađo, 2000; Schmidt et al., 2004; Torlaković et al., 2012), that the level of adoption of the quality of movement and each motor learning is improved by practise and the system of individual parts of the movement significantly changes and improves over time. Although it was an individual approach to education, working with adults can very often be challenging for swimming instructors because it contains many problems such as the age range of participants, psychological maladjustment to aquatic medium, levels of anxiety, health problems and reduced motor and functional abilities, which was already stated in the conclusions of previous studies with similar sample (Grčić-Zubčević, 2010). It should be noted that after a successfully completed programme the participants should continue to work on improving their swimming performances, because if a swimmer fails to assess its skills and does not take into account the conditions on the water (the sea, pool, lake, river, etc.) there is a constant danger of drowning, so precautions are necessary (Budimir et al., 2010).

Conclusion

Although the participants had, before the start of the program, a pronounced fear of being in water and swimming, which was determined by the survey conducted before the start of the research, it can be concluded that after completion of the programme they have successfully adapted to being in water and moving through water. In fact, it was crucial for the dynamics and continuation of educational activities of the basic elements of swimming. After adaptation to the water, a more advanced movement activities were implemented efficiently for a safe and enjoyable time spend in the water. Circumstantially, the participants in this research did not have a chance during growing up and regular schooling years to access education for non-swimmers in order to overcome the fear of being in the water during their childhood.

Therefore, it should be emphasized that the introduction of teaching how to swim as part of the regular educational process of physical education would be very useful for future generations.

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