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INCREASING POSTURAL DEFORMITY TRENDS AND BODY MASS INDEX ANALYSIS IN SCHOOL-AGE CHILDREN

NARAŠČUJOČI TRENDI POSTURALNIH DEFORMACIJ IN ANALIZA INDEKSA TELESNE TEŽE PRI ŠOLOOBVEZNIH OTROCIH

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ABSTRACT

Introduction: The aim of the study was to analyse the deviations of the body posture and to assess the occurrence of spine deformities. Additionally, Body Mass Index in school children was related to the trend in postural deformities for different age groups (5-8 years old, n=112; 9-11 years old, n=205; 12-14 years old, n=212) as part of the project "Spine Lab", granted from the European Commission IPA founds, investigating the importance of public health issues.

Methods: Body posture was measured using Contemplas 3D software analyser, based on video image trajectory and BIA weight scale (Tanita BC 420). Overall, 17 variables were assessed, and differences were confirmed using MANOVA analysis.

Results: The results showed that there is a significant difference between age groups for the measured variables (F=9.27; p<0.01; η2=0.26), suggesting a moderate difference across the age span.

Conclusion: The study results showed that there is a negative trend of increasing Body Mass Index within the first and youngest age group. The fact is that the trend of increasing deformity of the shoulder belt has been noted, often inclining towards the formation of milder forms of kyphotic posture. Other forms of deformity that are accentuated in the survey results are the negative trend of increasing pelvic rotation and pelvis rotation which inclines towards the formation of lordotic posture for all three age groups.

Ključne besede: *presejalni testi hrbtenjače, javno zdravje, stopnja razširjenosti, spremembe v trendih*

IZVLEČEK

Uvod: *Namen študije je analiza odstopanj telesne drže in ovrednotenje pojava deformacij hrbtenice. Poleg tega je indeks telesne teže pri šoloobveznih otrocih povezan s trendom posturalnih deformacij pri različnih starostnih skupinah (5-8 let, n=112; 9-11 let, n=205; 12-14 let, n=212) kot del projekta »Spine Lab« (sl. Laboratorij hrbtenice), ki ga financira Evropska komisija IPA, ki raziskuje pomembnost vprašanj javnega zdravja.*

Metode: *Telesna drža je bila izmerjena z uporabo programske opreme za analiziranje Contemplas 3D, ki temelji na krivulji video posnetkov in lestvici teže BIA (Tanita BC 420). Ocenjenih je bilo 17 spremenljivk, razlike pa so bile potrjene z analizo MANOVA.*

Rezultati: *Rezultati prikazujejo, da obstaja občutna razlika med starostnimi skupinami za izmerjene spremenljivke (F=9,27; p<0,01; η2=0,26), ki kaže na zmerno razliko v starostnem razponu.*

Zaključek: *Rezultati študije nakazujejo na negativen trend naraščajočega indeksa telesne teže v prvi in najmlajši starostni skupini. Dejstvo je, da je trend naročujoče deformacije ramenskega pasu opazen, pogosto pa se nagiba k oblikovanju blažjih oblik kifotične drže. Ostale oblike deformacij, ki so izražene v rezultatih študije, je negativen trend naraščajoče medenične rotacije in rotacije medenice, ki se nagiba k oblikovanju lordotične drže za vse tri starostne skupine.*

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1 INTRODUCTION

The posture stands for the body position, i.e. the relation between different body parts analysed within a specific timeframe and space (1). The key role in quantitative posture evaluation is placed on feet and legs, pelvis, spine, shoulders and head (2). Posture is defined as the alignment and orientation of the segments of the body when held in upright position (3). If the muscles are strong enough to fight the earth's gravity, then the body will stay in the upright position, but if the muscles are not strong enough, one might feel fatigue and the body will loosen itself (4). Taking all of this into consideration, this work will focus on diagnosing these specific body segments. The whole-body posture as well as the other parts of the body depend on the position of one of the body parts. The condition of proper body posture is to have minimum stress on the position of each body part. Every time some activity changes, the body posture category likewise changes. Good body posture is defined as a blending mechanism for obtaining customisable full-body behaviour. Several theories for maintaining body posture exist, such as ankle and hip postural strategies (5).

Healthy posture includes well-positioned and stable feet and ankles, adequate movement of the knee, hips and pelvis, along with spine, shoulder blade and head movement (6). The deformation in posture is considered as everything that violates the proper body posture in any position. The quantification of body posture is mainly done by small detections of the movement of posture centre (using force plates), or by radiographic side asymmetries (7, 8). In the third age population, body posture is characterised by higher posture centre displacement, inappropriate balance ability, elevating the risk for falls along with highlighted bone malformities, such as spine lordosis and spondylosis (9). Movements become difficult since joints become stiff due to degenerative changes in connection tissue (10).

In the working population, they exhibit themselves due to constant movements or positions, or improper sitting positions followed by heavy physical work (overexertion). This mainly weakens muscles for a long period of time and causes strength imbalances, which are the main cause of postural changes. In early childhood, they are noticeable due to incorrect movement, and strength or muscle dysfunctions.

All the mentioned aspects are correlated with the lack of physical activity and can cause changes in body posture with the occurrence of body deformities and morphological asymmetries. The majority of the world population is dealing with physical inactivity and related health problems. Moreover, while various interventions are being adopted to increase children's physical activity, these are mostly less successful or even unsuccessful (11). Musculoskeletal system in the stage of child development, influenced by internal and external factors, is very vulnerable to deformities. Hereditary risks, bad sitting posture, too heavy school bags, specifically if the weight has not been evenly distributed among both shoulders, short-sightedness, improper school tables and chairs, insufficient body activity, long and improper sitting position all lead to deformed static qualities of spinal column, resulting in kyphosis, scoliosis and lordosis (12). The image of the body posture of children at a very early stage contributes to the overall growth, good health and development and quality of life (3).

The rapid growth in children during puberty has a bad influence on the development of already present deformities. Fallen arches and flat feet are most common (13).

These body posture deformities in children are caused by a hereditary factor, physical inactivity, obesity and inadequate shoes. The consequences include difficult walking, running and standing, pain in the legs and sometimes pain in the lower part of the back, which directly contributes to the potential of spine deformity developments and lower quality of life with age (14). The first critical period in the development of spine deformities is the age when children change from their crawling position to the upright position.

The second critical period is the period when children start going to school (13), and precisely this age group is included in this research.

Bent posture over time leads to muscle stretching on the one hand, and on the other,to the shortening of torso, which can influence deep layers of muscles, resulting in spinal column deformities. Passive and improper positions, even during free time, and an insufficient physical activity aiming at strengthening and stretching of muscles additionally increase the effect (15-17).

Posture screening, measurement calculations, using sophisticated 3D equipment for the analysis of potential body deformities, followed by a precise evaluation are a prerequisite for a realistic evaluation of changes in increasing postural deformity trends and segmental deviations of characteristic body points.

The aim of this research was to analyse the possible increase in body posture deviations from central alignment and to determine: i) the trend of posture deformities by three age groups (classified according to ACSM recommendations);as well as: ii) to relate BMI and posture variables among groups. We hypothesised that growth differences for age groups can cause a change in body, and that BMI is related to changes in body posture.

2 METHODS

2.1 Sample Characteristics

The sample consisted of school children (N=529) from Sarajevo Canton, aged between 5 and 14 years. The subjects were divided into three age groups (ACSM recommendations), so that the potential differences in the results can be considered as a growth trend projection. BMI was calculated as fraction: BMI= weight (kg)/ height 2 (m2).The first group consistent of 5-8-year olds (n=112; age: 7.34±0.79 years, height: 121.85±7.34 cm; body weight: 24.53±5.42 kg; BMI: 16.42±2.46 kg/m2), the second were 9-11-year olds (n=205; age: 9.55±0.5 years, height: 135.6±6.37 cm; body weight: 32.7±7.89 kg; BMI: 17.7±3.18 kg/m2) and the third were 12-14 -year olds (n=212; age: 12.59±0.75 years, height: 143.4±12.8cm; body weight: 38.44±10.03 kg; BMI: 18.35±3.35 kg/m2). Groups were significantly different (p<0.001) for height and BMI (Table 3). Prior to the testing all subjects were clinically examined by the experienced kinesiologist. All subjects were healthy and could participate in the testing process. Since participants were juvenile, a written contest was signed by their legal guardians, allowing for participants to withdraw from the study at any time. Procedures were done according to the declaration of Helsinki and approved by the ethical committee of the Faculty of Sport,the University of Sarajevo.

2.2 Postural Status Variables Measured

The first group of variables used for the purposes of this research provide the main information regarding the posture status, using Temepelo software and Contemplas 3D posture compact mode. The variable sample consists of 17 variables acquired by ''3D posture compact'' testing protocol (Table 1). The parameters indicate possible offsets from the zero-posture value for all three levels, in which case the deviations of the neutral axis are expressed in centimetres and degrees. Higher values of provided displacements, whether negative or positive, represent a higher level of deformities in subjects.

2.3 Measurement Protocols

Table 1. Variables and abbreviations for 3D posture analysis.

ShD **Shoulder displacement**	The variable expressed in centimetres indicates elevation/depression of the left/right frontal plane. Results with positive values are with regard to the right shoulder elevation, while negative values indicate the left shoulder elevation.
ShD **Shoulder displacement**	The variable expressed in centimetres indicates elevation/depression of the left/right frontal plane. Results with positive values are with regard to the right shoulder elevation, while negative values indicate the left shoulder elevation.
PeOb **Pelvic obliquity**	The variable expressed in centimetres displays elevated/lowered left/right pelvic side in the frontal plane. Results with positive values indicate the elevation of the right pelvic side, and results with negative value indicate the elevation of the left pelvic side.
ShOb **Shoulder rotation**	The variable expressed in degrees indicates the rotation in longitudinal axis (transversal plane) of the left/ right shoulder. If 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.
PeRo **Pelvic rotation**	The 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.
TrRO **Trochanter rotation**	The variable expressed in degrees indicates rotation of the left/right trochanter 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 the front, while negative results indicate the front rotation of the left side of pelvis.
Co Ro **Condylus rotation**	The 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 negative results indicate the front rotation of the left lateral condylus.
Me Ro **Malleolus rotation**	The 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 malleolus of the right foot, while the negative result indicates the opposite rotation.

Dcess **Sag. Distance cervical spine - sacrum***	The variable expressed in centimetres indicates the distance of the most protruded cervical (neck) vertebra with regards to the vertical line projection of the sacrum (the bone at the bottom of the spine) in the sagittal plane. A positive result indicates the increased flexion of the cervical spine, while negative results indicate the increased extension of the cervical spine.
Dthsc **Sag. Distance thoracic spine - sacrum***	The variable expressed in centimetres indicates the distance of the thoracic spine with regards to vertical line projections of the sacrum (the bone at the bottom of the spine) in sagittal plane. Positive results indicate an increase of flexion in thoracic spine, while 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.
Dluss **Sag. Distance lumbar spine - sacrum**	The variable expressed in centimetres indicates the distance of the lumbar (lower) spine with regards to the vertical line projection of sacrum (the bone at the bottom of the spine) in sagittal plane. A positive result indicates an increase in lumbar spine flexion, while negative results indicate an increase in the lumbar spine extension.
Val/VarL **Varus/Valgus left**	The variable expressed in degrees indicates the Varus-Valgus alignment angle of the left leg (medial/lateral) at the knee joint.
Val/VarR **Varus/Valgus right**	The variable expressed in degrees indicates the Varus/Valgus alignment angle of the right leg (medial/lateral) at the knee joint.
FlExL **Flexion/Extension left**	The variable expressed in degrees indicates the hyperextension and flexion of the left leg at the knee joint (sagittal plane). A positive result indicates the left leg flexion, while a negative result indicates hyperextension of the left leg.
FlExRFlexion/ Extension right	The variable expressed in degrees indicates the hyperextension or the flexion of the right leg at knee joint (sagittal plane). A positive result indicates the right leg flexion, while a negative result indicates the hyperextension of the right leg.
CeS **Frontal Cervical spine**	The 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, whereas the negative result indicates the left side displacement.
ThS **Frontal Thoracic spine**	The variable expressed in centimetres indicates the distance of the thoracic spine in frontal plane in relation 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.
LuS **Frontal Lumbar spine**	The 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.

A mobile laboratory was assembled in those primary schools and kindergartens whose children were tested. Regarding the testing protocol, the Contemplas testing equipment required an ideally flat surface. After acquiring an adequate surface, Contemplas testing instrument was positioned on top of it (Figure 1.) and fixed to the surface to avoid displacement during children positioning and to avoid additional space calibration.

3D calibrator was placed on the surface with fluorescent markers attached to it. 3D Calibrator must be exactly placed in the centre of the measuring board (Figure 2.), and its upper and lower beams along with the vertical beam must be ideally aligned and levelled by the spirit level. The next step is to position a "V" frame supporting three cameras, enabling 3D analysis. The camera's distance from the centre of the measuring board must

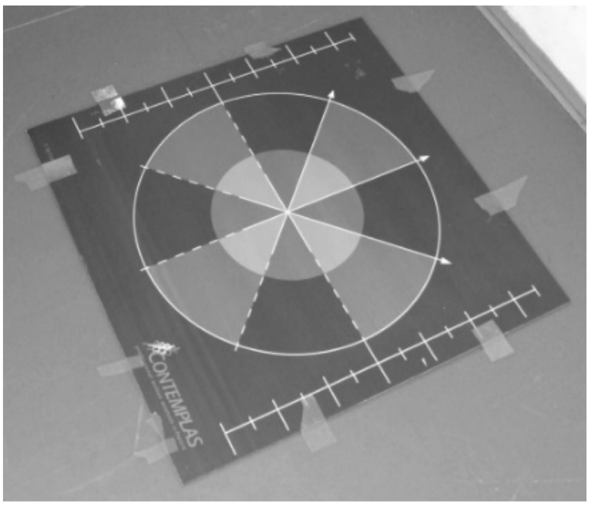

Figure 1. Screening surface.

be at least 2 metres and 15 centimetres (Figure 3.). The images taken by the camera need to be sharpened in the software programming, in order to start the space calibration. After the calibration has been concluded, the 3D Calibrator is packed away, and the testing can be initiated.

Figure 2. Calibration frame.

Next is the preparation and placement of fluorescent markers on the subjects. Markers were placed on specific points of the subject's body; subjects only need to wear their underwear. Considering that this testing protocol was the one specified by the "3D Posture Compact", it was necessary to apply 14 markers for each subject. The following represent the body points of marker placement: 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), condylus lateralis (left and right), malleolus lateralis (left and right). The subject is placed on the measurement board with his/her back to the cameras, feet placed parallel and in hip width apart; the axis along the centre of the malleolus must be paralleled with the horizontal line at the measuring board (frontal plane). The subject is then instructed to take an upright position, look straight and relax his/her arms along his/her body; then, the screening takes place for 12 seconds, but not after the 18th second of positioning. The comfort criterion adopts assumptions in terms of pose equilibrium, while the shading criterion eliminates the ambiguities of postures considering the image illumination. One can emphasise that the removal of ambiguous 3D poses related to a single image is the focus of posture analyses (18). After the screening, the markers are removed from the subject and placed on the following subject to be tested. The process of assembly and testing instrument calibration is repeated every time the location is changed, specifically with each new school and kindergarten where the testing is to take place. All the subjects have been personally informed on the testing protocol. The measuring was conducted in the morning. The subjects needed to wear only their underwear.

Figure 3. "V" camera frame.

Height was measured by Hotolin anthropometer under equal conditions for each subject by proximity of 0.01 cm.

Body Mass Index (BMI) was determined by Tanita scale BC420SMA (Tanita Corp, Tokyo, Japan), a bioelectric impedance (BIA) by foot-to-foot scale system (19), and is medically approved and reliable. For each subject, height had to be entered to get BMI output. The scale determines body composition based on the reduction of bioelectric impendence (20), providing with the results which are precise up to +/-0,1kg. Each subject was characterised as the standard regarding scale parameters.

2.4 Statistical Analysis

The data analysis was performed using statistical software for social sciences (SPSS 23, IBM Corp, New York). The normality of data distribution was assessed using Kolmogorov–Smirnov test, and outliers were adequately removed from further analysis (21). Multivariate analysis of variance (MANOVA) has been used to determine group differences. When significant difference was observed, Bonferroni test was used to determine the exact group difference in a specific variable. Partial eta-squared values were of 0.1, 0.11-0.3; above 0.3 indicated a low, moderate or high observed difference. For determining mutual relationship between measures of body posture and BMI, Spearman's rank correlation was calculated with statistical significance highlighted. Observed values higher than 0.3 and 0.7 were deemed as indicators of moderate and high relationship, and were deemed to avoid negative bias. Alpha level of 95% ($p<0.05$) was used as significant.

3 RESULTS

MANOVA showed (Table 2) that there is a significant difference between age groups for the measured variables ($F=9.27$; $p<0.01$; $\eta2=0.26$), suggesting moderate difference between age groups. As expected, age groups differed in height, BMI and body mass (Table 3). The third group had a significantly lower value compared to the second group for ShOb ($p<0.001$) and PeRo ($p<0.05$), while for FlExR, the result was higher ($p<0.05$) compared to the first age group. No significant differences were observed between groups for CoRo, FlExL, MeRO, Dcess, ShD, CeS, PeOb, Dthsc, ThS, LuS, Dluss, Val/VarL, TrRo and Val/VarR. No significant relationship between BMI and variables of body posture was observed. Moderate correlations were observed between PeOb – ThS ($\rho=0.45$), PeRo –TrRO ($\rho=0.63$), PeRo – CoRo ($\rho=0.47$), TrRO – CoRo ($\rho=0.55$), MeRO – CoRo ($\rho=0.53$), Dthsc – Val ($\rho=0.36$), Dluss – Val/VarL ($\rho=0.58$), FlExL – Val/VarR ($\rho=0.65$), FlExL – Ces ($\rho=-0.53$), Ces – MeRo ($\rho=0.37$). High correlation was observed between Lus – ThS ($\rho=0.72$) and Dthsc – Dluss ($\rho=0.76$).

Table 2. Multivariate test results between age group differences of anthropometric and body posture measures.

	Value	F	df	Error df	p	η2
Wilks' Lambda	**0.551**	**9.273**	**38**	**1016**	**<0.001**	**0.258**
Pillai's Trace	0.462	8.042	38.000	1018	<0.001	0.231

df- degrees of freedom p – statistical significance; η2 – partial eta squared

Table 3. Outcome measures differences between age groups.

Variable		Mean	SD	Variable	Mean	SD	Variable	Mean	SD
Height (cm)	Age 5-8	121.85	7.34	**CoRo (deg°)**	-2.51	4.84	**FlExL (deg°)**	-0.95	7.67
	Age 9-11	135.61**	6.37		-2.13	5.25		-1.34	6.97
	Age 12-14	143.40**¥¥	12.79		-1.95	6.14		-0.77	8.02
BMI (kg/m2)	Age 5-8	16.42	2.46	**MeRO (deg°)**	0.00	0.00	**FlExR (deg°)**	-2.21	7.70
	Age 9-11	17.69**	3.18		0.00	0.00		-1.18	7.51
	Age 12-14	18.36**¥¥	3.36		0.00	0.00		-0.34*	7.73
ShD (cm)	Age 5-8	0.22	0.85	**Dcess (cm)**	2.75	2.49	**CeS (cm)**	-0.34	0.87
	Age 9-11	0.38	0.83		2.76	2.29		-0.18	1.03
	Age 12-14	0.35	0.90		2.50	2.31		-0.25	1.02
PeOb (cm)	Age 5-8	0.15	0.42	**Dthsc (cm)**	-0.67	2.11	**ThS (cm)**	-0.24	0.99
	Age 9-11	0.13	0.40		-0.44	1.81		-0.39	0.67
	Age 12-14	0.12	0.36		-0.56	1.83		-0.41	0.82
ShOb (deg°)	Age 5-8	-1.13	5.60	**Dluss (cm)**	2.39	1.11	**LuS (cm)**	-0.45	0.79
	Age 9-11	0.02	5.58		2.55	1.19		-0.15	0.35
	Age 12-14	-1.51¥¥	5.22		2.61	1.17		-0.17	0.41
PeRo (deg°)	Age 5-8	-0.57	5.92	**Val/VarL (deg°)**	1.01	3.09			
	Age 9-11	0.01	6.16		0.73	2.74			
	Age 12-14	-1.30¥	6.22		0.92	3.32			
TrRo (deg°)	Age 5-8	-1.29	5.55	**Val/VarR (deg°)**	0.65	3.38			
	Age 9-11	-1.15	6.69		0.73	2.95			
	Age 12-14	-2.28	6.97		0.54	2.97			

Data are expressed as mean ± SD

** p<0.001 different compared to Age 5-8 group;

* p<0.05 different compared to Age 5-8 group

¥¥ p<0.001 different compared to Age 9-11 group;

¥ p<0.05 different compared to Age 9-11 group;

Table 4. Significant correlations between assessed variables.

VAR	VAR	r_0	p-valule
PeOb	ThS	0.45	<0.001
PeRo	TrRO	0.63	<0.001
PeRo	CoRo	0.47	<0.001
TrRO	CoRo	0.55	<0.001
MeRO	CoRo	0.53	<0.001
Dthsc	Dluss	0.76	0.001
Dthsc	Val	0.36	<0.001
Dluss	Val	0.58	<0.001
FlExL	Var	0.65	<0.001
FlExL	Ces	-0.53	<0.001
Ces	MeRo	0.37	<0.001
Lus	ThS	0.72	<0.001

4 DISCUSSION

The present study demonstrated that children across the age span from 5 to 14 tend to differ in height, BMI and postural status, as it was presumed. The highest diversification was observed for body height and Body Mass Index, which is a normal body development trend in healthy children. The difference in height between 5-8-year olds and 9-11-year olds was around 14 cm, with slower rate of around 8 cm at the age of 12-14 years compared to 9-11 years. A similar trend was seen for BMI with 7.2% and 4.1%higher value for the second age group compared to the first group and for the third age group compared to second age group, respectively. This could be a decrease in growth rate of BMI.

Shoulder oblique deformities were highlighted in the third age group, but were similar to the deformities observed in the youngest age group, suggesting that during rapid body height development, youths tend to exhibit unstable body posture development. Almost the same relationship was observed for pelvis rotation deformities. The assumption of a significant relationship of BMI with postural deformities was not met with even one significant correlation.

A group of authors (22) underlined the fact that children with the lowest content of muscle tissue showed the highest difference in the height of the inferior angles of the scapulas in the coronal plane. Children with excessive body fat had less slope of the thoracic-lumbar spine, agreater difference in the depth of the inferior angles of the scapula and a greater angle of the shoulder line. Their conclusion indicated that the content of muscle tissue, adipose tissue and physical activity level determined the variability of the parameter characterising the body posture.

A study of different groups in post-adolescent age (23) concludes that there is no significant relationship between BMI and kyphosis as well as scoliosis. However, the inverse relationship between BMI and lordosis suggests an increasing risk of developing lordosis as BMI increases. There is a significant gender difference in kyphosis and lordosis, with the female students having a higher prevalence of these postural deviations, compared to the males. There is a need to educate as well as to design intervention measures to correct bad posture among students, as this could cause irreversible musculoskeletal, neurological and pathological damage in future.

However, in this research, moderate positive correlations were noticed for indicators of body deformities, suggesting a possible chain-induced reaction for the disruption of body posture integrity. This effectively means that occurrence of one body deformity creates foundations for forming new ones (1). Presented results were the most consistent findings in the present study.

5 CONCLUSION

The results of this research allow us to conclude that there is an increasing trend of the BMI starting with the first and the youngest group and moving towards the third one. Apart from this fact, one may notice the trend in the increase of the shoulder deformities, which often inclines towards the development of lesser forms of kyphotic posture. The second deformity which is reflected in the results is the negative trend in the increase of pelvic rotation, which inclines towards the development of lordic posture, visible in all three age groups. The fact that obese children exhibit pelvic deviation is more interesting when conditioning the BMI relation with the potential body deformities in the population which underwent Contemplas screening in 3D compact mode. Once the correlation between measured and recorded variables is analysed, it is noticeable that there are no significant correlations between subjects' BMI and deviations in posture status. Within this group of tested children, one cannot claim that an increased Body Mass Index relates to the negative trend of increased body deformities. The very correlation between some specific deformities is existent, which allows for the conclusion that one body deformity greatly conditions the development of another deformity, which very often happens in connected segments, where the deviation in proper postural status is caused by its dysfunctionality.

Results presented can be used as valid indicator for creating daily exercise programme to prevent the occurrence of body posture deformities. Good posture and painless development is a part of health-related physical fitness components. Practitioners and therapist should pay attention to children's body posture and proscribe daily exercise routine emphasising the development of shoulder and pelvic mobility and stability from early childhood (age of 5). Additionally, there should be strengthening of muscles which are contributing to maintain upright shoulder and pelvic position to help excluding the occurrence of inappropriate tilt or rotation. Everyday life activity must be created on the basis of exercise for maintaining upright body posture and reducing the degree of obesity.

This study has several limitations. Firstly, the trend and projection of body posture deformities occurrence was not observed in one sample through time, but rather the difference was indicated with different participantsof each group. Secondly, no valid measures for determining the level or degree of deformity was notable. It was mainly done according to the presumption that the number which describes a segment of posture was more deflected from zero and the deformity was more emphasized. Further research should include additional anthropometric measures and the rating of biological and chronological growth factors.

CONFLICTS OF INTEREST

The authors declare that no conflicts of interest exist.

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ETHICAL APPROVAL

The study was approved by the Ethical committee of the Faculty of Sport and Physical Education, the University of Sarajevo, BiH.

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