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CORRELATIONS BETWEEN ANTHROPOMETRIC CHARACTERISTICS AND MOTOR ABILITIES IN ADOLESCENTS WITH POSTURAL DISORDERS AFFECTING THE SAGITTAL PLANE

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Abstract

A group of adolescents with postural distortion in the sagittal plane were used as a sample group to study the relations between anthropometric characteristics and motor abilities. The total sample included 202 students (79 boys and 123 girls). Their posture was evaluated using the somatoscopic method by Napoleon Wolanski. Anthropometric characteristics (11) and motor abilities (12) were brought into correlation with the aim of determining causal links of the postural disorders affecting the sagittal plane. The results show considerable individual differences in anthropometric characteristics and the level of motor abilities in both genders. Generally speaking, we may conclude that the respondents with the postural distortion in the sagittal plane have either a similar body-build or poorly developed certain motor abilities.

Keywords: posture, sagittal plane, anthropometrics, motor skills.

Introduction

Good posture is reflected in forming and maintaining the right balance between tonostatic and kinetic musculature on the one hand, and the force of gravity on the other (Radisavljević, 2001), while the imbalance between these two factors leads to its distortion.

Postural distortion is a complex problem. The body segments have to be aligned in the optimal equilibrium position, so that their centres of gravity are positioned at the common vertical going straight to the center of the support surface. The body reaches its maximum height

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when in the upright position, rendering the best conditions for starting a movement, and normal conditions for thoracic and abdominal cavity functioning (Radisavljević, 2001). There are numerous causes of postural disorders, whereas Jevtić (2001) argues that the principal cause of deviation from the normal upright posture is to be found in the distorted tonic agonist-antagonist balance, which causes sagging musculature, otherwise designed to confront the external forces in order to keep the body parts in the normal upright position. This results in postural disorders and spinal deformities in both sagittal and frontal planes.

Postural disorders cannot be observed isolated from one another, therefore, in order to get a better picture of postural distortion anthropometric characteristics (constitutional) and motor abilities (joint mobility and muscle condition, the level of how well one is trained). The period of adolescence, which the respondents in this research pertain to, lasts between the age of 11 and the time when ossification has been completed. Except for the last critical point of deformity occurrence in child's growth and development, the period of adolescence also denotes the period in the life of children when their biological transformation takes place (puberty). This is the period when the level of motor abilities seems to decrease, and the goal of this research was to determine relations between anthropometrics characteristics and motor abilities in adolescents with postural disorders affecting the sagittal plane, also their relations. This period is also known as a rapid acceleration period when the accelerated bone growth takes place (Jovović, 1999). Turbulent hormone changes represent another reason why the occurrence of postural disorders in the period of adolescence cannot be observed individually.

Method

The total sample included 202 students aged 15 years (±6 months) attending the first grade of the High School of Economics in Novi Sad. The entire sample was divided into two subsamples according to gender: 79 of them were male respondents and 123 female respondents. The data were collected for the large-scale study (Krsmanović, 2010). Upon detecting the postural disorders, of the entire sample numbering 400 respondents, 202 respondents with postural disorders in the sagittal plane were singled out. Their posture was evaluated using the modified somatoscopic method by Napoleon Wolanski (Radisavljević, 2001). The following segments were evaluated: cervical, thoracic and lumbar curves.

Anthropometric measurements were carried out in accordance with the IBP principles, whereas the battery is made up of 11 anthropometric measures: body height (AVIS), body mass (AMAS), arm length (ADRU), leg length (ADNL, ADND), a chest circumference (AOGK), a belly circumference (AOTR), an upper arm circumference (AONA), a calf circumference (AOPO), biceps skinfold (ACNE), abdominal skinfold (AKTR), subscapular skinfold (AKLE). For motor abilities assessment, 12 motor tests were used offering the most important information on motor skills space of adolescents - for agility assessment: deep stretches - bending over with one's feet apart (MPRE), side bend (MOTL, MOTD) and shoulder rotation test holding a bar (MISK); for assessing explosive strength endurance: long jump (MTRO) and a basketball throw (MBAC); for assessing segmentary speed, i.e. movement frequency the following was applied: hand tapping (MTPR), foot tapping (MTPN), tapping in the corner (MTPU) and for assessing repetitive strength: torso lifting (MTRB), straightening (MLED) and push-ups (MSKL).

The obtained data were analyzed by means of a descriptive statistics: arithmetic mean, standard deviation, minimal and maximum values. The relation between anthropometric characteristics and motor abilities was established using a correlation analysis.

Results

After gathering and statistically processing the data, the first to analyze were the central and dispersion parameters of the respondents. Male respondents have a normal data distribution in all anthropometric variables except in the case of calf circumference and all skinfolds (Table 1).

Table 1

Central and dispersion parameters of anthropometric variables in male respondents

Variables:	SV	SD	MIN	MAX	KV%	IP		P
AVIS	1784.09	75.90	1506.0	1963.0	4.25	1767.08	1801.09	.767
AMAS	655.76	103.33	401.0	980.0	15.76	632.61	678.91	.893
ADRU	812.03	37.60	680.0	900.0	4.63	803.60	820.45	.556
ADNL	1060.13	57.28	890.0	1190.0	5.40	1047.30	1072.96	.606
ADND	1060.00	56.99	890.0	1190.0	5.38	1047.23	1072.77	.631
AOGK	846.92	59.77	735.0	999.0	7.06	833.53	860.32	.908
AOTR	742.94	58.98	645.0	910.0	7.94	729.72	756.15	.393
AONA	301.53	73.75	229.0	498.0	24.46	285.01	318.05	.106
AOPO	369.83	51.37	325.0	467.0	13.89	358.33	381.34	**.043**
AKNA	9.99	4.19	4.8	30.0	41.92	9.05	10.93	**.034**
AKTR	12.45	6.82	4.0	44.0	54.72	10.93	13.98	**.012**
AKLE	9.13	2.96	5.4	19.8	32.46	8.47	9.79	**.018**

The studied group of male respondents is homogenous based on the measures related to longitudinal skeleton dimensionality: body height, arm and leg lengths.

Given the anthropometric characteristics, calf circumference and all skinfolds are the variables contributing to heterogeneity of this group of respondents. Individual differences within the group are remarkable, and thus there are respondents whose heights vary from 150 cm up to 196 cm. Furthermore, the difference regarding the body mass is even more conspicuous: ranging from 40.1 kg, to 98 kg among the respondents in his group.

In terms of motor abilities (Table 2), heterogeneity is reflected in the variables used for assessing coordination and repetitive strength of the arms and shoulder area. Doing push-ups as part of a test for assessing the repetitive strength of arms and shoulder muscles was an exquisitely difficult task for some of the respondents who did not manage to do even a single push-up. However, there are respondents who did as many as 40 of push-ups, which is an outstanding achievement at this age.

Table 2

Central and dispersion parameters of motor variables in male respondents

Variables:	SV	SD	MIN	MAX	KV%	IP		P
MPRE	59.62	10.31	31.0	82.0	17.28	57.31	61.93	.888
MOTL	254.90	39.49	175.0	375.0	15.49	246.05	263.74	.938
MOTD	265.87	37.46	180.0	390.0	14.09	257.48	274.27	.471
MISK	82.40	15.42	50.0	121.0	18.71	78.95	85.86	.999
MSKO	213.80	22.81	130.0	255.0	10.67	208.69	218.91	.885
MTRO	605.38	69.28	230.0	710.0	11.44	589.86	620.90	.326
MBAC	602.59	106.93	350.0	860.0	17.74	578.64	626.55	.944
MTPR	31.04	3.64	19.0	39.0	11.72	30.22	31.85	.338
MTPN	20.83	2.36	13.0	27.0	11.31	20.31	21.36	.121
MTPU	5.37	2.56	.0	10.0	47.75	4.79	5.94	.652
MTRB	26.90	3.97	20.0	37.0	14.75	26.01	27.79	.157
MLED	26.09	3.11	17.0	35.0	11.92	25.39	26.78	.493
MSKL	12.92	9.51	.0	40.0	73.56	10.79	15.05	.462

In this group, there are respondents who could not repeat once coordination task (tapping in the corner), but also the respondents who managed to perform this exercise 10 times in 30 seconds. The assumption is that considerable individual differences can be a reflection of a neglected physical education and physical activity in general, but also an indicator that motor abilities at this age in male respondents are not clearly differentiated.

In order to examine the relations between anthropometric characteristics and motor abilities and their mutual connections, correlation analysis was carried out, and significant of correlation coefficient was determined. Table 3 shows the analysis of results regarding the correlation of certain anthropometric characteristics. Given the results, we may observe that there are statistically significant positive correlations of the body height with other variables related to the longitudinal dimensionality, as well as with the circumference variables (chest, abdominal and calf circumference). As far as correlations between the body height and skinfolds, the only relevant and positive ones are with the subscapular skinfold.

Table 3

Correlation coefficient of the anthropometric variables in male respondents

N=79	AVIS	AMAS	ADRU	ADNL	ADND	AOGK	AOTR	AONA	AOPO	AKNA	AKTR	AKLE
AMAS	.575*											
ADRU	.854*	.537*										
ADNL	.844*	.371*	.811*									
ADND	.846*	.377*	.812*	.999*								
AOGK	.397*	.892*	.337*	.217*	.225*							
AOTR	.333*	.881*	.374*	.191	.197	.828*						
AONA	.193	.332*	.151	.078	.082	.334*	.229*					
AOPO	.222*	.444*	.162	.006	.007	.334*	.362*	.086				
AKNA	.137	.658*	.178	.115	.121	.688*	.638*	.179	.204			
AKTR	.069	.581*	.084	-.006	-.002	.670*	.630*	.191	.204	.836*		
AKLE	.228*	.756*	.228*	.141	.147	.721*	.748*	.247*	.300*	.809*	.829*	

* Statistically significant correlation coefficient

However, the body mass has statistically significant positive correlations with all anthropometric variables. Arm and leg lengths (both left and right) have statistically significant correlation with all the longitudinal dimensionalities, as well as with chest circumference (which is in a statistically significant relation with all the anthropometric variables). Upper arm skinfold and abdominal skinfold have statistically significant positive correlations with the body mass, chest and abdominal circumference. Subscapular circumference is in a statistically significant relation with all the variables except for the leg length (both left and right).

Having observed the variables used for assessing motor abilities (Table 4), it is possible to determine statistically significant and positive correlations of the variables for agility assessment (bending to the left side) with bending to the right side, triple jump and hand tapping. Bending to the right side stands in a statistically significant and positive correlation with the variable used for assessing movement frequency (hand tapping).

Table 4

Correlation coefficient of the motor variables in male respondents

n=79	MPRE	MOTL	MOTD	MISK	MSKO	MTRO	MBAC	MTPR	MTPN	MTPU	MTRB	MLED	MSKL
MPRE													
MOTL	.005												
MOTD	-.175	.604*											
MISK	-.119	-.073	-.107										
MSKO	.035	.063	-.178	.093									
MTRO	-.067	.250*	.117	-.071	.434*								
MBAC	-.007	.122	.139	.149	.247*	.287*							
MTPR	.169	.278*	.271*	.117	.215*	.234*	.281*						
MTPN	.074	.014	-.085	-.007	.224*	.223*	.130	.443*					
MTPU	.278*	.021	-.029	-.100	-.075	.017	.108	.052	.157				
MTRB	.220	-.050	-.124	-.135	.221*	-.011	.121	.176	.301*	.168			
MLED	-.074	.050	.089	-.155	.141	.104	-.093	.094	.310*	.076	.381*		
MSKL	.069	-.079	-.086	.033	.403*	.179	.403*	.183	.197	.175	.497*	.103	

In the group of the male respondents with the postural disorders in the sagittal plane, it is possible to observe statistically significant and positive correlations of the variable for coordination assessment with the variable for agility (bending over with one's feet apart). Variables used for the explosive strength assessment have mutual positive correlation, which is understandable. Apart from the already mentioned correlations, standing long jump is also in a positive correlation with the variables: hand tapping, foot tapping, torso lifting and push-ups, on a statistically significant level. The data obtained are the result of different muscle strength levels in arms and shoulder area, due to swinging movements of the arms that are involved in the movements and contribute considerably to the better results, as well as the abdominal and lower extremities muscles. The long jump and triple jump tests are rather demanding in terms of coordination, since the participants have to deal with the problem of correlating the arms swinging movements with the simultaneous bounce. The assumption is that the respondents who managed to do all these exercises properly, achieved better results, too. The variables for explosive strength assessment also show mutual and statistically significant and positive correlation.

Finally, correlations between anthropometric and motor skill space were also analyzed (Table 5). Mutual statistically significant and positive correlations were observed.

Table 5

Correlation coefficient of the anthropometric and motor variables in male respondents

N=79	AVIS	AMAS	ADRU	ADNL	ADND	AOGK	AOTR	AONA	AOPO	AKNA	AKTR	AKLE
MPRE	.091	.133	.095	.164	.169	.081	.106	.067	.065	.044	-.004	.036
MOTL	.174	.006	.192	.144	.137	-.040	-.100	.073	-.051	-.155	-.128	-.068
MOTD	.149	-.017	.097	.066	.059	-.040	-.053	-.011	-.032	-.056	-.018	-.053
MISK	.268*	.196	.206	.239	.241	.207	.146	.032	.036	.179	.120	.142
MSKO	.080	-.079	.140	.034	.039	-.093	-.113	-.035	-.053	-.421*	-.412*	-.376*
MTRO	.111	-.023	.065	.041	.039	-.029	-.105	.016	.075	-.177	-.257*	-.180
MBAC	.418*	.538*	.378*	.266*	.271*	.508*	.381*	.256*	.228*	.180	.009	.144
MTPR	.133	.144	.073	.079	.082	.207	.182	.029	.013	.027	.025	-.028
MTPN	-.157	-.070	-.100	-.051	-.043	-.015	-.053	.099	-.069	-.011	-.155	-.110
MTPU	.024	-.014	-.028	.105	.106	.002	.014	.005	.144	-.007	-.125	-.034
MTRB	-.188	-.148	-.217	-.115	-.114	-.149	-.091	.033	-.010	-.238*	-.223*	-.221*
MLED	-.200	-.294*	-.281*	-.276*	-.268*	-.275*	-.285*	-.030	-.044	-.196	-.218*	-.233*
MSKL	-.065	.076	-.118	-.162	-.160	.078	.117	.096	.038	-.196	-.212	-.176

The variable for assessing explosive strength of the arms and shoulder area stands in a statistically significant and positive correlation with all the variables for anthropometric characteristics assessment, except for the skinfold variables. The explosive leg strength, however, has a statistically significant negative correlation with the abdominal skinfold. As for the repetitive force, the torso-lifting variable has negative correlations with all the skinfolds. The variable of torso straightening has negative correlations with: body mass, arm length, leg length, chest and abdominal circumference and skinfolds (abdominal and subscapular). The obtained variability is logical, since adipose tissue has a negative effect on the motor test results.

The female subsample (n=123), has a normal distribution, except in the case of two variables of the anthropometric characteristics: abdominal and subscapular skinfolds (Table 6).

Table 6

Central and dispersion parameters in female respondents

Variables:	SV	SD	MIN	MAX	KV%	IP		P
AVIS	1668.50	56.77	1520.0	1808.0	3.40	1658.37	1678.64	.998
AMAS	558.88	77.09	398.0	842.0	13.79	545.11	572.64	.722
ADRU	729.35	29.37	660.0	790.0	4.03	724.11	734.59	.546
ADNL	936.06	38.14	845.0	1050.0	4.07	929.25	942.87	.634
ADND	935.93	39.12	845.0	1060.0	4.18	928.95	942.92	.706
AOGK	816.73	44.70	680.0	940.0	5.47	808.75	824.71	.241
AOTR	688.57	49.51	585.0	820.0	7.19	679.73	697.41	.253
AONA	254.50	21.25	210.0	320.0	8.35	250.70	258.29	.298
AOPO	352.02	24.80	300.0	450.0	7.04	347.60	356.45	.397
AKNA	16.57	4.53	9.4	30.6	27.36	15.76	17.38	.521
AKTR	20.82	8.15	7.4	49.2	39.15	19.36	22.27	**.024**
AKLE	13.39	5.84	6.4	37.4	43.60	12.35	14.44	**.000**

Given the anthropometric characteristics, the greatest level of homogeneity in this group is observed in the case of body height, arm length, left and right leg lengths, chest circumference, upper arm circumference and calf circumference. The highest level of heterogeneity in this group is observed in the case of variables for adipose tissue assessment, skinfold assessment. Standard deviation (77.09) has the highest values in the case of body mass, and those, considerable individual differences are observed based on the minimum (39.8 kg) and maximum (84.2 kg) values.

Table 7

Central and dispersion parameters of motor variables in female respondents

Variables:	SV	SD	MIN	MAX	KV%	IP		P
MPRE	65.12	11.62	34.0	91.0	17.85	63.05	67.20	.515
MOTL	261.38	38.48	195.0	390.0	14.72	254.51	268.25	.315
MOTD	261.35	38.73	175.0	370.0	14.82	254.44	268.26	.550
MISK	71.70	15.30	30.0	126.0	21.33	68.97	74.43	.910
MSKO	166.22	21.19	115.0	212.0	12.75	162.44	170.00	.627
MTRO	479.98	54.22	340.0	640.0	11.30	470.30	489.66	.300
MBAC	353.58	75.12	190.0	530.0	21.25	340.17	366.99	.627
MTPR	29.22	3.65	19.0	39.0	12.50	28.57	29.87	.512
MTPN	20.19	2.04	16.0	26.0	10.10	19.83	20.56	**.009**
MTPU	5.18	2.71	.0	11.0	52.33	4.70	5.66	.760
MTRB	22.26	4.84	.0	33.0	21.73	21.40	23.12	.802
MLED	24.16	4.47	.0	32.0	18.50	23.36	24.96	.262
MSKL	2.09	3.36	.0	15.0	99.62	1.49	2.69	**.000**

In the case of two variables of motor abilities: foot tapping and push-ups, the data distribution is not normal. The results show homogeneity in most variables, as well as great individual differences in motor skills space among the respondents. The greatest heterogeneity among the female respondents is observed in the variables used for assessing the repetitive force of the arms and shoulder area (push-ups) and the variable for coordination assessment (corner tapping). The coefficient of variation has a higher percentage (100%) in the case of push-ups variable, and a slightly lower percentage in the case of a corner-tapping variable (52%). Yet, the greatest individual differences are observed in the case of explosive strength of arms and shoulder area (KV=75%), where minimum and maximum values range between 190 and 530.

Considering the obtained results of the anthropometric characteristics (Table 8), a conclusion may be drawn that there is an interrelation of a large number of variables. Body height is in a statistically significant correlation with the body mass, arm length, leg length (ADNL and ADND) and chest circumference. Arm length stands in a positive correlation with all the longitudinal measures and all the circumferences. The body mass, unlike all the given variables, has a statistically significant correlation with all the anthropometric variables. The variables for the assessment of body voluminosity and adipose tissue, which were measured by means of circumferences and skinfolds, stand in mutually and statistically significant positive correlations.

Table 8

Correlation coefficient of the anthropometric variables in female respondents

N=123	AVIS	AMAS	ADRU	ADNL	ADND	AOGK	AOTR	AONA	AOPO	AKNA	AKTR	AKLE
AMAS	.359*											
ADRU	.809*	.430*										
ADNL	.855*	.258*	.837*									
ADND	.866*	.240*	.847*	.974*								
AOGK	.204*	.829*	.335*	.167	.157							
AOTR	.129	.795*	.289*	.128	.096	.778*						
AONA	.053	.827*	.197*	.034	.018	.784*	.734*					
AOPO	.176	.847*	.243*	.066	.055	.683*	.669*	.744*				
AKNA	-.017	.613*	.108	-.015	-.056	.576*	.614*	.652*	.529*			
AKTR	-.106	.629*	.043	-.092	-.131	.596*	.660*	.580*	.526*	.714*		
AKLE	-.128	.562*	.040	-.076	-.105	.583*	.671*	.592*	.495*	.663*	.733*	

The variables for agility assessment are in mutually and statistically significant positive correlations (Table 9). In addition to this, bending over with one's feet apart is in statistically significant positive correlations with all other motor variables except for the variable for assessing repetitive force in arms and shoulder area. Apart from the mutually positive correlations, explosive strength is in statistically significant correlation with all other motor variables, with the variables for coordination assessment excluded (MTPU). In the case of repetitive force, similar results were obtained, in terms of having mutually and statistically significant positive correlations, but not having correlations with coordination on a statistically significant level.

Table 9

Correlation coefficient of the motor variables in female respondents

n=123	MPRE	MOTL	MOTD	MISK	MSKO	MTRO	MBAC	MTPR	MTPN	MTPU	MTRB	MLED	MSKL
MPRE													
MOTL	.278*												
MOTD	.351*	.766*											
MISK	-.204*	-.194*	-.272*										
MSKO	.298*	.045	.113	-.112									
MTRO	.342*	.101	.115	.001	.626*								
MBAC	.304*	.289*	.238*	-.295*	.377*	.219*							
MTPR	.354*	.107	.126	-.005	.364*	.335*	.405*						
MTPN	.371*	.027	.057	-.067	.348*	.297*	.362*	.625*					
MTPU	.199*	-.064	-.054	-.015	.062	.093	-.071	.173	.145				
MTRB	.259*	.003	-.021	-.128	.448*	.434*	.393*	.348*	.269*	-.002			
MLED	.195*	.008	-.090	-.092	.251*	.199*	.211*	.219*	.095	.111	.501*		
MSKL	.137*	.161	.080	-.065	.418*	.328*	.355*	.280*	.248*	-.151	.395*	.207*	

Relations between certain motor abilities are such that a frequent increase in the strength level, such as repetitive force, influences the reduction in the mobility of certain body segments. Therefore, it is necessary to attend to these two abilities in such a way that they both develop in a coordinated and consistent way. It is noticeable that female respondents with a highly developed strength have difficulty solving the coordination or coordination-based tasks.

Table 10

Correlation coefficient of the anthropometric and motor variables in female respondents

N=123	AVIS	AMAS	ADRU	ADNL	ADND	AOGK	AOTR	AONA	AOPO	AKNA	AKTR	AKLE
MPRE	.193*	.182*	.281*	.205*	.207*	.228*	.118	.246*	.204*	.082	-.076	.056
MOTL	.272*	.263*	.301*	.210*	.210*	.252*	.088	.203*	.157	.044	.043	-.035
MOTD	.215*	.271*	.259*	.173	.164	.312*	.123	.186*	.150	.041	.014	-.013
MISK	.051	-.271*	-.013	.128	.146	-.281*	-.244*	-.258*	-.312*	-.162	-.192*	-.143
MSKO	.098	-.028	.113	.118	.126	.121	.004	.051	-.047	-.173	-.226*	-.126
MTRO	.239*	-.142	.291*	.323*	.338*	-.010	-.128	-.071	-.163	-.220*	-.296*	-.196*
MBAC	.285*	.442*	.349*	.200*	.210*	.364*	.279*	.376*	.356*	.109	.069	.011
MTPR	.217*	.213*	.203*	.192*	.182*	.193*	.148	.273*	.117	.127	.061	.103
MTPN	.083	.052	.121	.077	.084	.057	.029	.134	.065	.062	.042	.088
MTPU	.075	.015	.076	.130	.096	.048	.061	.041	.020	.154	.084	.096
MTRB	.169	.120	.190*	.198*	.207*	.116	.110	.143	.124	-.106	-.048	-.027
MLED	.064	.127	.140	.143	.117	.088	.155	.161	.081	.029	.088	.035
MSKL	-.109	-.057	-.095	-.085	-.065	.019	-.100	.144	-.040	-.273*	-.202*	-.190*

Agility, explosive strength and repetitive force have statistically significant correlations, with anthropometric characteristics (Table 10). Bending over with one's feet apart is in a positive correlations with all other anthropometric variables with the exclusion of abdominal circumference and skinfolds. The variables used for assessing the explosive strength (MSKO and MTRO) are in negative correlations with the skinfolds. The third explosive strength variable, basketball throw, is in statistically significant positive correlations with all the variables except for the skinfolds. As far as repetitive force is concerned, torso lifting variable has positive correlations with length measures (ADRU, ADNL i ADND), whereas the variable of the push-ups has negative correlations with all the skinfolds.

Discussion

There are plenty of factors which may cause problems in growth and development of children and adolescents, such as reduced motor ability caused by hypokinesia, rapid growth, various health conditions (obesity, disorders caused by inadequate diet, type 2 diabetes, asthmatic diseases, etc.). In addition to this, it is frequently the case that the imposed bad patterns of unstable civilization values result in postural disorders (Brettschneider & Naul, 2004, 2007; James, 2004).

The lifestyle of today's adolescents usually consists of passive mental activities that do not change over time and unhealthy habits which, among other things, include a sedentary way of life and bad eating habits at an alarming rate. Lack of the physical activity and improper eating habits lead to obesity or overweightedness reaching epidemic proportions in the developed world (James, 2004).

If these conditions "combine" in the adolescence period, which is when the rapid bone growth takes place leading to the disproportionality in their length and muscle strength, then postural disorders and even deformities are well expected to occur. The transition to the full biological maturity, which takes place about the age of 24, does not happen abruptly, but in a series of gradual uneven transformations. Specifically prominent is the interrelation between posture and anthropometric characteristics, body height and body mass (Vlaškalić, Božić-Krstić, Obradović i Srdić, 2006). Spinal postural disorders in the sagittal plane seem to occur at a higher rate in female adolescents, 48.1%, than in male adolescents, 36.9% (Jovović, 2007). The impaired posture in the sagittal plane can be diverse. As far as the sagittal plane is concerned, what we understand by postural disorders are all the movements of body segments in a forward-backward direction. The spinal column has four physiological curves. If any increase in concavity or convexity of any these curves was observed, the respondent was classified in the group of postural disorders in the sagittal plane. Male respondents with a distorted posture in the sagittal plane, as far as their body-build and motor abilities level are concerned, do not differ much from their peers. The results showed considerable individual differences in anthropometric characteristics and motor abilities level. Generally, it is not possible to draw a conclusion that the respondents with a distorted posture in the sagittal plane have similar body-build (physique) nor that they have poorly developed certain motor abilities. Torso straightening, as a motor test representing a variable for assessing the repetitive force of the back of the body has negative correlations with: the body mass, arm length, leg length, chest and abdominal circumference and skinfolds (abdominal and subscapular). The obtained variability is logical since the adipose tissue negatively affects the motor test results. A fatty component, aside from being a burden, is related to the movement regime, which is why the children who move less have lower motor efficiency. Just their moving less provides the basis necessary for accumulating the adipose, fatty tissue. When it comes to negative correlations of the repetitive force of the torso and the skinfolds, we may say that they suggest that taller children achieve poorer results when compared to relatively shorter children who have shorter limbs. Furthermore, since this is the situation where the respondents have lordotic, kyphotic bad posture and flat back, another assumption is that there may exist an imbalance between the abdominal flexor muscles and paravertebral muscles. Repetitive trunk muscle strength and shoulder area flexibility account for the difference between a remarkably improper or proper sagittal body posture (Paušić, 2007). Similar results were obtained using the subsample of female respondents. The most prominent individual differences were observed in the explosive strength of arms and shoulder area. The results obtained in this way can be accounted for by the weak musculature of the respondents with kyphotic posture or flat back. The results of a correlation analysis show that the explosive strength of arms and shoulder area and repetitive force of arms and shoulder area have negative correlations with all the skinfolds.

Therefore, physical activity as an indicator of a healthy adolescent lifestyle (Poček, 2010) represents a real resource of usefulness that physical exercise can provide for female high school students (Bonacin, 2010).

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