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Relations between Biomechanical Parameters and Static Power of Arms in Children with Disturbed Posture

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A B S T R A C T

This study is aimed at determining the parameters and biomechanical analysis of their impact on the static arm strength in children with impaired posture as poor kyphotic posture, lordotic poor posture and children with flat feet. A transversal study included a sample of 67 children on the territory of the municipality of Subotica. The structure of the sample is as follows: 22 subjects with impaired kyphotic posture, 18 patients with impaired lordotic posture, and 27 subjects with flat feet. Measuring the level of static arm strength was done by the standardized "folding endurance" test. Observing the morphological development of children with kyphotic, lordotic poor posture and flat feet determined statistically significant differences in biomechanical variables.

Key words: *biomechanical parameters, static power, children, disturbed posture*

Introduction

Any deviation from the standard dimensionality in terms of biomechanics and anthropometry parameters can clearly lead to impaired body posture, and thus lead to muscle inefficiency regarding motor functioning. Functional posture disorders commonly occur in preschool and early school age, while the adolescent age is characterized by the appearance of structural spinal deformities (Adar, 2004; Demeshi, 2007). During the schooling period, the child's posture is opposed to many external influences, leading to inadequate postural habits. Posture changes the most between 7 and 12 years of age under the influence of body changes and psychosocial factors, in order to achieve balance in accordance with the new proportions of the body (McEvoy & Grimmer, 2005; Penha, Joao, Casarotto, Amino, & Penteado, 2005). As stated by McEvoy and Grimmer (2005), postural control develops in segments in cephalo-caudal direction, starting from establishing the control of the head, then the torso and finally achieving postural stability while standing. The motor and sensory system that is responsible for postural stability goes through a transition at the age of 4-6 years, and achieves adult maturity between the ages of 7-10 years. Posture evolution in the sagittal plane between 4th and 12th year of age is considered a normal consequence of musculoskeletal maturation or the result of the process of adaptation in terms of maintaining balance in the sagittal plane (Lafond, Descarreaux, Normand, & Harrison, 2007). The posture of primary school boys and girls is characterized by the head protrusion, bent shoulders, winged shoulder blades, front pelvis inclination, which is often accompanied by a pronounced lumbar lordosis and abdominal protrusion. These changes in the shoulder-blade region are connected (Penha et al., 2005). Motor performance can be significantly hampered if there is biomechanical disproportion. Biomechanical imbalance in children with postural disorders *de facto* influences the movement, i.e. the manifestation of motor abilities in whatever form. All motor abilities have equal opportunity to be in insufficient state, of course according to the postural disorder. Changes in bone-articular apparatus may arise not only from biological physiological reasons, but also from social and cultural aspects. Numerous studies determined the more common poor posture in the early school age than in the adolescent age followed by more structural changes (Adar, 2004; Demeshi, 2007; Kratenova, Žejlicova, Maly, & Filipova, 2007). A high percentage of poor posture in lower grades of primary school is the result of the relative instability of the musculoskeletal system which becomes more stable with the development of musculature over the years (Adar, 2004). Adolescence includes more structural deformity of the spine, which can be a result of accelerated growth and disproportion in the growth of bone and muscle structures (Gandreault, Ansenault, & Laviere, 2005; Wong, Hui, Rajan, & Chia, 2005; Yilkoski, 2005).

The aim of the study is to determine the parameters and biomechanical analysis of their impact on the static arm strength in children with impaired posture as poor kyphotic posture, lordotic poor posture and children with flat feet.

Methods

Methodic approach has included an assessment of the static strength of arms and shoulders, and a measurement of biomechanical parameters on a sample of 67 children with an existing diagnosis by a physician. Data processing was done using statistical procedures: descriptive statistics for calculating basic descriptive statistics of all the analyzed variables: arithmetic

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mean (AM), standard deviation (S), minimum (MIN) and maximum (MAX) value of the measurement results. Regression analysis was used to determine the influence of a set of biomechanical variables, which represented the predictor variables, on the motor variable, which was the criterion variable.

The sample of variables and measurement instruments

The sample consisted of 67 children with a diagnosis already given by a physician (22 subjects with kyphotic, 18 subjects with lordotic poor posture, and 27 subjects with flat feet from Subotica, of 10-11 years of age. The assessment of motor abilities in patients with kyphotic, lordotic poor posture and flat feet, of younger school age was administered using a standardized folding endurance motor test. From the biomechanical parameters that may have an impact on the manifestation of static strength in children with impaired posture represented supredictor variables in the study. For the assessment of longitudinal dimensionality of the skeleton: body height (mm), sitting height (mm), upper arm and forearm length (mm). For the assessment of the volume and body mass, body weight (kg). Measurements were conducted using anthropometer (height, sitting height, upper arm length, forearm length were measured) and decimal digital scales (body weight was measured), following the *IBP* standard for each dimension.

Results

Table 1 presents the results of descriptive statistics of biomechanical parameters in three pre-formed sub-samples: patients with kyphotic impaired posture (labeled as K group), patients with lordotic impaired posture (marked as L group), and patients with flat feet (labeled as FF group).

Table 1. Descriptive Statistics of Biomechanical Variables for Different Groups of Subjects

Variable	Group	AM	S	MIN	MAX	Sk	Kurt
Body height (mm)	K	1543.86	63.28	1390	1630	-0.66	0.07
	L	1556.11	84.32	1375	1705	-0.39	-0.12
	FF	1511.67	77.78	1370	1660	0.30	-0.87
Sitting height (mm)	K	702.23	41.71	625	790	0.20	0.21
	L	708.33	70.79	560	815	-0.36	-0.57
	FF	695.15	66.74	565	820	0.14	-0.96
Upper-arm length (mm)	K	221.55	10.23	200	241	0.27	-0.07
	L	221.67	10.91	204	250	1.03	1.51
	FF	217.41	7.92	202	232	-0.06	-0.60
Forearm length (mm)	K	206.05	12.94	184	236	0.39	-0.22
	L	210.00	13.81	190	240	0.17	-0.27
	FF	203.96	8.60	190	219	-0.07	-0.87
Arm length (mm)	K	595.05	21.31	535	636	-0.84	2.31
	L	598.00	28.15	551	666	0.70	0.77
	FF	577.41	28.96	521	629	-0.22	-0.64
Body weight (0.1 kg)	K	49.57	8.86	36.40	67.00	0.33	-0.96
	L	47.77	9.36	34.00	67.00	0.19	-0.57
	FF	44.18	10.48	32.00	74.00	1.33	1.62

Based on the value of descriptive statistics of biomechanical variables, balanced growth of the longitudinal skeleton can be determined in all three subsamples considered through variables: *body height, sitting height, upper-arm length, forearm length and arm length*. Such data are the result of pre-puberty and is present in a given sample of children. Subjects are of similar body height, i.e. the length of tubular bones which provide body growth in height. There were remarkable differences between the lowest and highest recorded results primarily in the height variable, which points to the fact that individuals already show the intensive growth of bone tissue, which is the result of pubertal period of individuals (human).

Table 2. Results of Descriptive Statistics of Motor Variables

Variable	Group	AM	S	MIN	MAX	Sk	Kurt
Folding endurance (s)	K	14.70	10.20	0	32.10	0.40	-1.16
	L	12.58	7.20	0	23.30	-0.56	-0.37
	FF	23.81	21.41	0	78.85	0.90	0.13

Slightly larger variability was recorded in the variables for the assessment of body volume and mass, *Body weight*, in all three subsamples.

Table 2 shows the descriptive statistics of motor variables. The results are shown in particular for all three pre-formed samples.

Table 3. Regression Analysis of the *Folding Endurance* in Subjects with Impaired Kyphotic Posture

Variable	R	p	r_{part}	p_{part}	Beta	Pbete
Body height	-0.13	0.28	0.05	0.86	0.04	0.86
Sitting height	-0.17	0.23	-0.08	0.76	-0.06	0.76
Upper-arm length	0.24	0.14	0.09	0.72	0.13	0.72
Forearm length	0.16	0.24	.016	0.53	0.21	0.53
Arm length	0.16	0.24	-0.17	0.52	-.015	0.51
Body weight	-0.78	0.00	-0.80	0.00	-0.81	0.00

Based on descriptive statistics shown in the table, it can be concluded that the subjects were of different levels of static strength of arms and shoulders. The extraordinary result variability is the consequence of the unevenness of strength development in a given sample of subjects and weaknesses of individual muscle regions in the uneven ratio in all subjects.

Table 4. Regression Analysis of the *Folding Endurance* in Subjects with Impaired Lordotic Posture

Variable	r	p	r_{part}	p_{part}	Beta	pbete
Body height	-0.59	0.01	0.21	0.50	0.46	0.50
Sitting height	-0.32	0.09	-0.17	0.58	-0.23	0.58
Upper-arm length	-0.49	0.02	0.08	0.81	0.16	0.81
Forearm length	0.51	0.02	-0.21	0.49	-0.43	0.49
Arm length	-0.39	0.06	0.01	0.98	0.01	0.98
Body weight	-0.71	0.00	-0.51	0.08	-0.87	0.08

Reviewing the results of regression analysis of the *Folding endurance* criteria (Table 3) suggests that there is a statistically significant effect of the predictor variables system on the criterion variable in subjects with impaired kyphotic posture (p=0.00). The obtained high values of the multiple correlation coefficient R=0.83 explain the exceptional 68% of common variability.

Table 5. Regression Analysis of the *Folding Endurance* in Subjects with Flat Feet

Variable	r	p	r_{part}	p_{part}	Beta	pbete
Body height	-0.40	0.02	-0.05	0.81	-0.07	0.81
Sitting height	-0.25	0.10	0.18	0.43	0.29	0.43
Upper-arm length	-0.33	0.05	-0.10	0.65	-0.20	0.65
Forearm length	-0.30	0.06	-0.02	0.92	-0.06	0.92
Arm length	0.06	0.39	0.05	0.83	0.04	0.83
Body weight	-0.58	0.00	-0.47	0.03	-0.60	0.03

Regression analysis of *Folding endurance* criterion variable in the sub-sample of subjects with lordotic poor posture (Table 4) revealed the absence of statistically significant correlation of the predictor variables system on the assessed criterion, because the significance of the multiple correlation coefficient p=0.11, i.e. the multiple correlation coefficient value R=0.75, which was explained with 56% of common variability.

Based on the results of the regression analysis of the *Folding endurance* criterion in Table 5, it can be concluded that there is no statistically significant correlation of the predictor system in the subsample with flat feet (p=0.10).

Discussion

Observing the morphological development of children with kyphotic, lordotic poor posture and flat feet determined statistically significant differences in biomechanical variables. The obtained data indicate the fact that the subjects with impaired poor posture of the spine possessed longer tubular bones of the upper limbs, which suggests a greater longitude of the skeleton of these subjects. It was concluded that the subsamples of subjects with kyphotic and lordotic poor posture were higher than of those with flat feet, although there were no statistically significant differences. The longitude of the skeleton may probably be associated with the formation of body deformities as poor (impaired) posture and changes in the spinal cord in children of primary school age. Brevity of chest muscles and elongation of muscles on the back side of the body (muscles of the upper third of the back) contributed to the poor results of the *Folding endurance* variable in kyphotic subjects compared to those with flat feet, as well as between the subjects with lordotic poor posture and subjects with flat feet in benefit of the subjects with flat feet. Weak and elongated musculature of back muscles, especially the upper third of the back muscles (surface and deep muscles), is responsible for the poor results of this group of subjects in the variable for the assessment of static strength of arms and shoulders. The surface back muscles that are affected by the changes are arranged in three layers. Due to the longitude of the skeleton and body weight, the condition of muscles, especially the muscles of arms and shoulders, chest muscles, abdominal muscles along with paravertebral muscles that stabilize the lumbar segment of the spinal cord in kyphotic patients with poor posture, contributed to the poorer results compared to those with the flat feet, which were primarily the lightest, thus their muscles in these areas were not as weak as in the above groups of subjects. The fact that the musculature is more insufficient in the subjects with lordotic poor posture compared to those with flat feet, which is due to the protrusion of the abdominal wall, is confirmed by the research of Ishida and Kuwajima (2001) and Penha et al. (2005). Obviously, in addition to weak abdominal muscles, these subjects possess poor, weak and underdeveloped back musculature, which can contribute to the occurrence of kypho-scoliosis, which are very common result of compensation on the spinal cord in children with lumbar lordosis.

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