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ORIGINAL ARTICLE

Evaluation of relations between body posture parameters with somatic features and motor abilities of boys aged 14 years

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Abstract

Introduction. Body posture is an individual characteristic for everyone, it shows great differentiation – especially in people during their progressive development. As a result, the variability of the development and lack of physical activity impose body posture defects in children and youth. In the literature there is a great lack of measureable data on the relations between correct body posture with somatic features, especially motor features in children at the developing age. The aim of this study was to evaluate the relations between correct body posture parameters, measured with the photogrammetric method, with some of the somatic features and motor abilities of boys at the age of 14.
Material and Methods. The study included 133 boys aged 14 attending junior secondary schools in the Kraków area of Poland. Only boys with the correct body posture were examined. Posture was examined by the Moire method, through which six parameters were obtained in the sagittal plane, seven in the frontal plane, and one in the transverse plane. The somatic measurements included basic parameters, such as body weight and body height. The measurements of motor features included: marching balance test, speed movement test of the arms and their functional strength. To evaluate the relationships between correct body posture with the characteristics of somatic and motor abilities, the Spearman rank correlation was used. The lowest level of statistical significance was accepted at $p \leq 0,05$.
Results. No correlations were noted between some of the correct body posture features and the somatic features, and some of the motor abilities of the examined boys at the level of $p \leq 0.05$ and $p \leq 0.01$.
Conclusions. The irregular correlation between the correct body posture and somatic and motor features probably results from the rather big development variability of the boys during puberty.

Key words

Moire method, body posture, somatic features, motor characteristics, puberty

INTRODUCTION

Body posture is an individual feature which shows a great differentiation, especially at the age of puberty. As a result of development variability and lack of physical activity, body posture defects appear in children and youths [1, 2]. That is why many authors have evaluated body posture defects – especially the diagnosis of idiopathic scoliosis with the photogrammetric method by Moire or the Integrated Shape Imaging System (ISIS) [3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13]. A search through data bases such as Medline, Pubmed, Science Direct, Springer Link, Wiley Online Library, revealed that there is a lack of measureable data on the relations between correct body posture and the motor abilities of children and youths. Most often, the relations between wrong body posture and somatic and motor features at the age of puberty were evaluated. Cieszkowski et. al [14] and Miałkowska et. al [15] found that schoolchildren with body posture defects had significantly lower levels of power dynamic, static strength and endurance, and interestingly presented a higher level of flexibility. Finding a relationship between the parameters of correct body posture and somatic features, especially motor features, may be have particular relevance in the effective prevention of body posture defects at the age of puberty. Research could also provide answers to questions concerning which motor features are of primary importance for posture genesis, and which should be stimulated during general training in order to promote development of the correct body posture in children and youths.

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Objectives. Insufficient data on the relationships between correct body posture parameters, measured by the Moire photogrammetric method, with selected somatic features and selected motor abilities at the age of puberty were the reason for study. According to this, the following researching questions were posed:
1. Which posture parameters, measured by the Moire method, correlated with body height and body mass in boys?
2. Which body posture parameters measured with the Moire method correlate with some of the motor features?

MATERIALS AND METHOD

The study was conducted in February 2012 in a group consisted of 133 boys aged 14 who attend junior high schools in Kraków. Only boys with the correct body posture were examined. The average body weight of the boys was 56.2 ± 12.5 kg, and body height 165.1 ± 8.2 cm. All the boys and their parents were informed about the objectives, safety and method of conducting the study, and all of them agreed to participate. The study excluded boys who were medically unfit to take part in physical education lessons. The place of the study was the gymnasium where the temperature did not exceed 20°C.

Body posture was examined by the Moire method, through which the following parameters were obtained:

– six parameters in the sagittal plane: tilt of the trunk; lumbar lordosis angle, thoracic kyphosis angle, depth of thoracic kyphosis, depth of lumbar lordosis, compensation rate;
– seven parameters in the frontal plane: inclination of the trunk, set of shoulders, set of shoulder blades, difference in deflection angles of the lower part of the spine, setting of waist triangles, difference in the height of the anterior superior iliac spine, maximum deviation from the straight line of the spine;
– one parameter in the transverse plane: maximum rotation.

The parameters were determined in accordance with the Moire technique. The photogrammetric survey was used to evaluate the CQ set posture by Electronic System_The somatic measurements included basic parameters such as body weight and height. The somatic measurements were carried out according to pre-agreed arrangements.

1. Body weight was determined with medical scales with accuracy to 100 g.
2. Body height was measured with an anthropometer by Martin's technique between the *basis* and *vertex* points with an accuracy of 1 mm.

The motor features measures included: march balance test, examination of the speed of the upper limbs move and their functional strength which, in the opinion of the authors, may have a beneficial influence on the correct body posture during puberty.

1. The balance test was conducted to assess the ability to march in a straight line – foot-by-foot while blindfolded over a distance of 5 m. This was divided into five sectors, length of 1 m on each side of a centre line, drawn at intervals of 25 cm on three lines parallel to the main line. The nominal value of the line and the middle section was 5 points and the subsequent external zones, respectively: 4, 3, 2 points. If the task was completed successfully, i.e. without deviation from the central section, the maximum number of 25 points was awarded. This result is the product of the number of meters and the point value of the external section. Thus, 2 was the minimum number of points obtainable, which meant going beyond the outer zone of section I in only the first meter [16].
2. To measure the speed of movement of the upper limbs (tapping into rings), a gymnasium box was used. Two horizontally stable circles (small frisbee – 20 cm diameter) were attached, while trying to divert and stay still. The diameter of the bigger one was 80 cm. Between the pulleys there was a rectangular wooden plate with dimensions of 10 x 20 cm. The examined person stood at a designated spot. His first task was to identify his more efficient hand; the other hand has placed on the rectangular plate. The subject's task was to alternately touch the more efficient hand and lift above the hand lying on the plate. The tapping started with the commands 'ready' and then 'start'. The examiner measured the time and counted aloud the number of strokes, and terminated the test at 50 strokes. The test was performed twice, and the best result was recorded with an accuracy of one second [17].
3. To measure the strength of the functional (overhang of arms bent), a horizontal rod mounted at a height of 30–40 cm above the body of the subject was used. The examined person stood on a low chair or stool under the rod. Slightly bending the knees, the boy grabbed the rod with both hands, fingers on top and thumb on the bottom, at shoulders width and the chin above the bar. At the 'ready' signal the examiner pulled away the chair and the boy began the self-test of overhanging with bent arms, timed by a stopwatch. The trial ended when the boy's eyes were below the bar. The test was performed once, and the result recorded with an accuracy of 0.1 seconds [17].

Measuring the speed of movement of the upper limbs (tapping into rings) and functional strength (overhanging with bent arms) was conducted in accordance with the methodology of the Eurofitn test (Tab. 1).

Table 1. Features of body posture and motor skills of boys aged 14 years

Feature	$\bar{x}$	± SD	V
sagittal plane			
1. Tilt of the trunk (°)	5.3	2.3	43.4
2. Lumbar lordosis angle (°)	156.7	5.1	3.2
3. Thoracic kyphosis angle (°)	155.4	5.5	3.5
4. Depth of thoracic kyphosis (mm)	13.0	5.7	43.8
5. Depth of lumbar lordosis (mm)	16.5	6.6	40.0
6. Compensation rate (°)	4.1	3.1	75.6
frontal plane			
1. Inclination of the trunk (°)	0.9	0.6	66.7
2. Set of shoulders (mm)	4.8	3.7	77.1
3. Set of blades (mm)	4.7	3.4	72.3
4. Difference deflection angles of the lower blade of the spine (mm)	5.2	4.4	84.6
5. Setting the waist triangles (mm)	6.2	4.2	67.7
6. Difference of the height anterior superior iliac spine (mm)	0.6	0.2	33.3
7. Maximum deviation from the straight line of the spine C_7–S_1 (mm)	4.6	2.8	60.9
transverse plane			
1. Maximum rotation (mm)	10.1	9.4	93.1
motor efficiency			
1. Marching balance (point)	22.3	5.1	22.9
2. Speed of the upper limbs – tapping into rings (second)	12.5	1.9	15.2
3. Functional strength – overhang on arms bent (second)	351.3	328.4	93.5

In the data analysis, the basic measurements of descriptive statistics were used. For all the parameters, the arithmetic mean, standard deviation and coefficient of variation were performed. Great attention was paid to the high ratios of differentiation probably caused by the great development variability of boys during at the age of 14. The statistical distributions of the analyzed characteristics were compared using the Kolmogorov-Smirnov test, which proved that they did not have a normal distribution. Therefore, the relationships between the parameters of body posture with the somatic characteristics and motor abilities were assessed with the Spearman rank correlation. For the coefficients correlations, p-values were determined. In the individual rankings, taking into account the value of the calculated correlation coefficients, the level of statistical significance: $p \leq 0.05$ was accepted [18]. The calculations were performed by MedCalc software, version 11.4.3.0, in the Department of Computer Science at the Academy of Physical Education in Kraków.

RESULTS

A significant correlation was found between the angle of tilt of the trunk and body mass at the level of statistical significance of $p \leq 0.01$, and between the difference in the height of the anterior superior iliac spine and the height of the body, at the level of statistical significance $p \leq 0.01$. The direction of these relationships was always positive, which meant that the greater angle of tilt of the trunk was caused by weight gain. A greater difference in the height between the rear of the upper iliac spine promoted a greater body height. A correlation was found between the angle of the thoracic kyphosis, depth of thoracic kyphosis, and setting of the waist triangles with the marching balance – statistical significance at $p \leq 0.05$. The direction of the correlation was always negative. It was found that the greater the angle of thoracic kyphosis and the greater the kyphosis dapth and greater asymmetry of the waist triangles favoured worse marching balance. There was a significant correlation between compensation rate and speed of the upper limbs (tapping into rings) at the level of statistical significance $p \leq 0.01$. The direction of this relationship was positive, which meant that the better body posture one has, the faster top limbs and the better move coordination he reaches.

The study also showed a significant correlation between the maximum deviation from the straight line of the spine C_7-S_1 line and functional strength (overhanging with bent arms) at the level of statistical significance $p \leq 0.05$. The direction of this relationship was negative. It was found that worse body posture caused less functional strength in the upper limbs, which resulted in a lower score of the trying of the overhang with arms bent (Tab. 2).

Table 2. Spearman correlation coefficients between body posture and somatic and motor characteristics in boys at the age of 14 years

Feature	Body mass	Body height	Marching balance	Speed of the limbs tapping in to rings	Functional strength overhang – arms bent
Body posture					
1. Tilt of the trunk (°)	**0.26****	0.17	-0.02	0.07	-0.04
2. Lumbar lordosis angle (°)	-0.05	0.05	0.00	0.05	0.01
3. Thoracic kyphosis angle (°)	0.12	0.10	**-0.20***	-0.12	-0.07
4. Compensation rate (°)	0.03	-0.02	-0.01	**0.34****	0.03
5. Depth of thoracic kyphosis (mm)	-0.15	-0.02	**-0.18***	0.08	0.14
6. Setting the waist triangles (mm)	0.16	0.10	**-0.25***	-0.13	-0.01
7. Difference of the height anterior superior iliac spine (mm)	0.12	**0.27****	-0.03	-0.14	-0.12
8. Maximum deviation from the straight line of the spine C_7–S_1 (mm)	0.00	0.14	0.05	-0.09	**-0.24***

Statistical significance: $p \leq 0.05$*; $p \leq 0.01$**

DISCUSSION

In studies of body posture it is very important to assess its relationship with somatic features during the progressive stage of development. This issue has been the concern of some authors, but there is still need for further research to expand knowledge on the subject. Mrozkowiak [19] believes that the weight and posture relations are significant and varied. The authors showed that the greater forward angle of inclination of the torso, and the greater the thoracic kyphosis angle is, the greater deviation circle to the left of the line of the spinossus processes of the spine, and the greater angle of inclination of the thoraco-lumbar region are, greater depth of the thoracic kyphosis promotes greater weight**.** Lizis et. al [20] indicated in obese patients a negative correlation between body posture and body mass. It was found that hyperlordosis of the lower back, early symptoms of scoliosis, too high body weight accompany the problem.

The results of the presented study are similar to the results by other authors. This is because there is a positive correlation between the angle of tilt of the trunk and the body mass. It seems that raising of the body mass causes a bigger angle of tilt of the trunk, which means a deterioration in body posture.

A study by Mrozkowiak [19] showed that the total length of the spine, torso angle, and deviation in the course of the vertebral spinossus processes of the spine, correlates positively with body height, thoracic kyphosis angle and depth of the thoracic kyphosis. Lumbar lordosis angle, angle of rotation of the pelvis correlate negatively with body height.

The results of this study show that an increased difference in the height of the anterior superior iliac spine promotes greater body height. This means that taller people are more often liable to be at risk of assymetry of the pelvis, with the appearance of a one-sided kink in the spine. Another important issue is the study of relations between the characteristics of postural motor skills. The relationship between body posture and body balance was studied by Wilczyński [21, 22, 23]. For the assessment of posture, the author used the Moire method, and for examining balance – Cosmogamma Platform, Emildue R50300. It turned out that children with scoliosis exceeding 10° exhibit poorer hand-eye coordination and worse reaction equivalent, both with the eyes open and closed, than healthy children.

The presented study shows a correlation between the thoracic kyphosis angle, depth of thoracic kyphosis, and waist setting triangles with marching balance. It also shows that the greater the angle of thoracic kyphosis, thoracic kyphosis greater depth, and greater asymmetry of the waist triangles, caused the deterioration of marching balance. This is why people with worse body posture show poorer marching balance. Additionally, there was a correlation between the compensation ratio and the rate speed of the upper limb (tapping into rings). The direction of the relationship was positive, which means that better eye-move coordination is accompanied by better body posture. This is an important practical implication to be applied regularly in compensating corrective exercises for children with body posture disorders.

The lack of data on this subject renders impossible any comprehensive discussion with other authors; therefore, further research is imperative.

Another issue requiring clarification is evaluation of the relationship between body posture and muscle strength. The presented study demonstrated a significant correlation between the maximum deviation from the straight line of the spine C_7-S_1 and the strength of the overhang with arms bent. The bigger the leaning of the spine from the straight line in any direction caused less functional strength in the upper limbs. However, these findings contradict the results of Kasperczyk [24], who found in a study on muscle strength of the arms and shoulders that boys with increasing scoliosis hung on a rod longer. The author believes that if the relationship between muscle strength and posture seems obvious, then the role of strength endurance to maintain good posture has not been clearly defined by these researchers. Kasperczyk [24] showed that worse muscles strength accompanied defective body posture, but he did not note the dependence between body posture and the durability of postural muscles. The lack of correlation he explained by the training effect of the exercises, because most of the children with wrong body posture took part in correctional physical classes. Also, Górniak et. al [25], in examining 14-year-old boys, did not notice any big dependences between body posture and the muscle strength of the upper limbs and the durability of the muscles of the trunk.

The authors' review of the literature showed that most often the dependence between wrong body posture and somatic and motor features were evaluated, but there was no data about the relationship between correct body posture and the above-mentioned parameters. The current study shows a seldom correlation between correct body posture features measured by the Moire method and somatic and motor features. This situation is probably determined by the movement variability of the boys during puberty. It should be pointed out that, at the same time, the presented study confirms the results of the mentioned authors but leads to the opposite results in the examined problem. The reasons for this are found in the difficulties connected with the evaluation of body posture, and not only by Moire's method. Besides, an accurate description of the body that could be accepted as being correct, is very difficult. This difficulty occurs mainly because of the differentiation and development variability, and the lack of objective norms for the correct body posture during puberty. This is why the presented results should be verified by using a more representative population group, with the aim of creating objective norms for the correct body posture in children and youths, thereby making possible early diagnosis of recifyable defects – mistakes in body postures. This, in turn, would make possible taking early preventional activities which make therapy activities appropriate for typical pathology.

The results of the presented study widen the knowledge about the correlations between correct body posture and the somatic and motor features at the age of puberty, and simultaneously, are cause for further scientific research. The results are also beneficial for the theory and practice of anthropomotorics and physiotherapy in orthopaedics, and are reason enough for the effective prevention of deformations in body posture, and allow. The results additionally allow the selection of such motor features which can be used primarily for posturegenesis: march balance, prioproceptive feeling, fitness of the limbs, coordination of eye-movement, and functional strength of the upper limbs, all of which should be stimulated during general training in order to create correct body posture during puberty.

CONCLUSIONS

The presented study on photogrammetric posture, somatic and motor features revealed the following:

1. the angle of tilt of the trunk correlated with body weight, and the difference in the height of the anterior superior iliac spine correlated with body height. This means that heavier persons are often predisposed to a round back, and that lean people frequently have an asymmetrical pelvis;
2. the thoracic kyphosis angle, depth of the kyphosis, and fixing of the triangles of the waist determine marching balance. Thus, worse body posture accompanies worse marching balance;
3. the compensation ratio correlates with the speed of the upper limbs (knocking on the circle, tapping in the rings). This means that better eye-movement coordination accompanies better body posture;
4. the correlation between the maximum leaning of the line of the spine from the upright position C_7-S_1 in the frontal plane and functional strength (overhang – arms bent) means that systematical exercises on muscle strength should be used at children with body postures defects, especially defects of the spine.

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