ORIGINAL ARTICLE
HEALTHY LIVING

Mobility of thoracic spine and flexibility of the spine in relation to the size of the anteroposterior curvatures in school children

Authors' Contribution:
A Study Design
B Data Collection
C Statistical Analysis
D Manuscript Preparation
E Funds Collection

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Received: 13 August 2021; **Accepted:** 02 November 2021; **Published online:** 25 November 2021

AoBID: 16031

Abstract

Background & Study Aim: A correct body posture is one of the factors necessary for harmonious functioning of the human body. However, a significant part of youth and children's population have postural defects, interfering with their proper physical development. Joint mobility, particularly within the spine, is one of basic functions in general evaluation of motor apparatus in men. The aim of this study was knowledge of selected indicators defining to the size of the anteroposterior curvatures and mobility of thoracic spine in school children.

Material & Methods: The study was conducted in a group of 59 school children. Was used for the study Otta and Thomayer tests and a computer set to evaluate the subjects' body posture. The results were analysed using adequate statistic methods.

Results: The results obtained were statistically significant as for thoracic spine flexion. Higher values of thoracic kyphosis indicators were found in patients with abnormal mobility of the thoracic spine. The range of spinal mobility was greater in people with less thoracic kyphosis. The correlation analysis in the study group showed a moderate negative correlation between the values of the thoracic kyphosis angle indices and the mobility of the thoracic spine and its suppleness.

Conclusions: In connection with the selected functional tests, Moiré topography can be an important factor towards the improved effectiveness of screening for postural asymmetry and monitoring the effects of therapy. There is a clear linear correlation between the angle of thoracic kyphosis measured with Moiré topography and the mobility of the spine.

Key words: photogrammetric method • sagittal plane • spine mobility

Conflict of interest: Author has declared that no competing interest exists

Ethical approval: The study was approved by the Bioethics 86 Committee at the Regional Medical Chamber in Krakow (No. 68/KBL/OIL/2021)

Provenance & peer review: Not commissioned; externally peer reviewed

Source of support: Departmental sources

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INTRODUCTION

A correct posture is one that ensures a harmonious and effortless arrangement of body parts in relation to the long axis of the body and optimal functioning. When correct posture is held, individual segments of the body ensure smooth movements and stable support with the least energy required [1, 2]. The type of posture depends not only on sex but also on the stage of ontogenetic development and environmental conditions [3, 4]. Freedom of movement and stable posture are ensured by the spine [5, 6]. Each change in the arrangement of one section of the spine in relation to another section affects individual parts of the skeleton, both those closer and distant from the deformed region. For example, increased cervical lordosis results in a compensatory increase in thoracic kyphosis and lumbar lordosis [3, 4]. Change in the position of spinal segments deteriorates conditions of the nervous system function by disturbing the coordination, as well as the static and dynamic balance of the body [7-9]. In 25-60% of children and adolescents, body posture disorders occur in the form of a rounded back, sloped shoulders or excessive pelvic tilt [10-13]. The thoracic spine is the stiffest part of the vertebral column due to the structural differences compared to the cervical and lumbar spine but also due to the thorax [14, 15]. Biomechanical investigations regarding the thoracic spinal flexibility are scarce. The first comprehensive in vitro study on thoracic spine flexibility was carried out by White in 1969 [16].

Therefore, an early assessment of changes in sagittal plane of the spine seems justified in the context of their prevention and treatment with the use of the photogrammetric method and the projection moire effect. To the best of author knowledge, there are few scientific reports unambiguously describing the problem of assessing the influence of spine mobility on the range of angular changes of the thoracic spine in the sagittal plane.

The aim of this study was knowledge of selected indicators defining to the size of the anteroposterior curvatures and mobility of thoracic spine in school children.

MATERIAL AND METHODS

Participants

Author qualified 63 children from primary schools from Małopolskie, Silesian and Podkarpackie regions to the study. Due to the withdrawal of the parent/guardian's written consent, 59 children were qualified to the final stage of the tests (Table 1).

Eligibility criteria: age 9-13 years; no coexisting diseases which could affect the test results; written consent of a parent (guardian) for the patient to participate in the study; consent of the school directors for the tests to be performed.

Excluding criteria: lack of written consent of a parent (guardian); age under 9 years and over 13 years; coexisting diseases which prevent from performing the tests or which could affect the results (injuries, limb or spinal fractures) – the qualification stages Figure 1.

Design

The method used in the study was an observational cross-sectional study. The study protocol follows the guidelines of the Helsinki Declaration. This study was conducted in compliance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement: guidelines for reporting observational studies [17].

Intervention

The examination involved:

1. Interview: date of birth, age in years and months, coexisting diseases.

Moiré Topography – a method of three dimensional morphometry in which contour maps are produced from the overlapping interference fringes created when an object is illuminated by beams of coherent light issuing from two different point sources.

Sagittal plane – *noun* the division of the body along the midline, at right angles to the coronal plane, dividing the body into right and left parts. Also called **median plane** [35].

Thoracic – *adjective* relating to the upper back [35].

Hyperlordosis – *noun* excessive forward curvature of the lower part of the spine [35].

Cross-sectional study – the collection and analysis of information relation to peson in a population or group at a defined point in time (or within a defined period), with particular reference to their individual characteristics and exposure to factors thought likely to predispose to disease. *See also* prevalence rate [36].

Table 1. Data of the observation group (n = 59).

Variable	Statistical indicators		
	M	SD	min ÷ max
age [years]	11.1	1.10	9.1 ÷ 13.4
body weight [kg]	42.02	6.50	24 ÷ 58
body height [cm]	149.02	9.4	123 ÷ 165

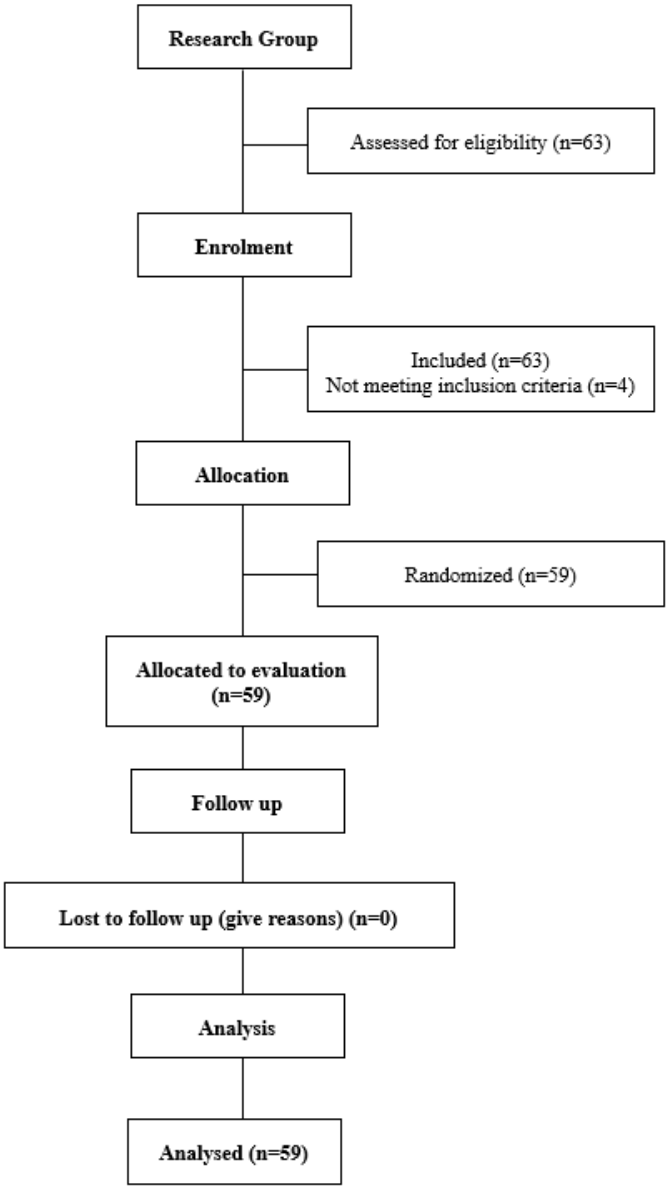

Figure 1. Flow diagram.

2. Anthropometrics tests: weight and height measurement while standing using a verified medical column scale C315.60/150. OW-3 – a 100–200 cm height measuring device (UNIWAG – Professional electronic scales, Krakow, Poland), assessment of the course of the spinous processes of thoracic and lumbar vertebrae, assessment of the set of selected anatomical trunk points: shoulder processes and bottom angle of the shoulder-blades, waist triangles, anterior superior and posterior superior iliac spines, greater trochanter of the femurs. A medical skin marker from Covidien was used to mark the characteristic anthropometric points on the skin (Medtronic, Minneapolis, MN, USA),

3. Subject examination:

   a. photogrammetric posture assessment using projection Moiré (MORA 4G system, Computer Postural Assessment Device, Wroclaw, Poland) [18];

b. Thomayer Test – assessment of contraction of the ischiocrural muscles and mobility of the entire spine. Execution: patients bends forward from the standing position with straight legs and tries to touch the ground with their fingertips. Interpretation: the distance from the tip of the third finger of the hand to the ground was measured.

c. Otto Test – the patient is in a standing position. The beginning of the tape measure is applied to the spinous process of the seventh cervical vertebra (C7) and marks a point 30 cm below in a straight line. Then check the change in distance from C7 to that point when the subject leans forward. Starting position – standing (first measurement). Final position – the patient bends forward (second measurement). Interpretation: The difference in length between the marked points is measured.

Outcome measures

In order to assess the shape of the back surface, the photogrammetric method and Moiré topography by means of the device made by Q Elektronik System from Wrocław were used. To perform the examination, the room had to be darkened, the distance of 2.6 m between the camera and the examination spot was set and the equipment and central unit were positioned (Figure 2).

Prior to the examination, selected anatomical points were marked on a patient's body: spinous processes of the vertebrae C7 to S1, posterior superior iliac spines and inferior angles of the blades. The examination was performed in standing position, with legs slightly apart and heels set on the previously set line 2.6 m from the camera. Patient looked straight ahead with their upper limbs hanging relaxed along the torso. Several to several dozen of images were recorded in this position. Out of them, one was selected, which met the criterion of proper positioning of the pelvis and reflected the most typical posture of the patient. Indicators showing changes in sagittal and frontal plane of the spine were analysed: ALPHA angle [α] – the inclination of the lumbosacral section; BETA angle [β] – the inclination of the thoracic-lumbar section; GAMMA angle [γ] – the slope of the thoracic-upper segment.

Statistical analysis methods

All analyses were carried out using the STATISTICA 12.0 software package. The distribution of the variables was characterized by means of Shapiro-Wilk test. The main measures of the descriptive statistics were calculated. The correlations between the variables were analysed using Spearman rank correlation coefficient. In case of statistically significant correlations, the regression analysis was performed. The differences between the qualitative variables were determined by means of chi-squared test. Rho – Spearman's rank correlation coefficient or Spearman's is a nonparametric measure of rank correlation (statistical dependence between the rankings of two variables). The remaining statistical symbols are explained in the descriptions of Tables.

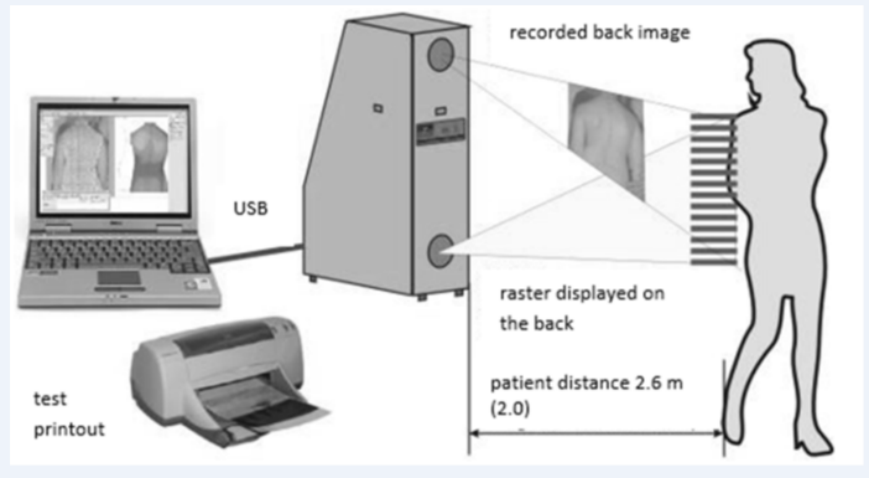

Figure 2. The Moiré system [20].

RESULTS

The estimation of empirical variables informs about the lowest variability of β (Table 2) and Otto test vs. Thomayer test (Table 3).

Table 2. Characteristics of the size (n = 59) of spinal curvatures in the sagittal plane.

Variable	Statistical indicators		
	M	SD	Me
α [°]	9.1	1.4	9.0
β [°]	8.3	1.16	7.9
γ [°]	10.2	1.54	9.5

α alpha angle – the inclination of the lumbosacral segment; **β** beta angle the inclination of the thoracic-lumbar segment; γ gamma angle – the slope of the upper thoracic segment; **M** mean; **SD** standard deviation; **Me** median

Table 3. Characteristics mean values (n = 59) of the indicators of changes Thomayer and Otto tests.

Variable	Statistical indicators		
	M	SD	min ÷ max
Thomayer test	2.86	2.64	0 ÷ 8
Otto test	2.64	0.64	2 ÷ 4

The strong correlation is setting between β and Otto indicators (rho = −0.50; p<0.001), between β and Thomayer indicators (rho = −0.43; p<0.001), between γ and Otto indicators (rho = −0.41; p<0.01), between γ and Thomayer indicators (rho = −0.44; p<0.01), between γ and α indicators (rho = 0.42; p = 0.0049) and between γ and β indicators (rho = 0.52; p<0.0001).

The results obtained were statistically significant as for thoracic spine flexion. Higher values of thoracic kyphosis indicators were found in patients with abnormal mobility of the thoracic spine. The range of spinal mobility was greater in people with less thoracic kyphosis. The correlation analysis in the study group showed a moderate negative correlation between the values of the thoracic kyphosis angle indices and the mobility of the thoracic spine and its suppleness.

DISCUSSION

The results of the original research show positive correlation between α and γ angles and positive correlation between β and γ angles. Negative correlation was found between the results of Thomayer and Otto tests and the executioners determining the size of thoracic kyphosis. Lower values of the results obtained in the Otto and Thomayer tests correlated with an increase in the angle of thoracic kyphosis.

According to the subject matter literature, primary school age is challenging in terms of posturogenesis. In this period, children's bodies are the most vulnerable to posture alterations [19]. About 50% of children show postural changes in the frontal plane and 2-3% have idiopathic scoliosis [20]. Modern electronic devices offer children and adolescents various forms of spending free time while reducing the need for natural movement which is a necessary element of correct psychomotor development. Such lifestyle can contribute

Table 4. Spearman Correlation coefficient.

Indicator		Otto	Thomayer	α	β
α	Rho p	−0.15 0.2372	0.20 0.4163		
β	Rho P	**−0.50** **<0.001***	**−0.43** **<0.001***	−0.063 0.7425	
γ	Rho P	**−0.41** **<0.01***	**−0.44** **<0.01***	**0.42** **0.0049***	**0.52** **<0.0001***

*statistically significant

α alpha angle – the inclination of the lumbosacral segment; **β** – beta angle the inclination of the thoracic-lumbar segment; **γ** gamma angle – the slope of the upper thoracic segment; Otto test; Thomayer test.

to increasing the body weight and, consequently, developing postural defects. Posture defects are one of the major health issues in today's society. The percentage of people with incorrect body posture has been growing. According to Janiszewska et al. [19], in Poland, the rate of children and adolescents aged 7-15 years with diagnosed postural defects ranges from 65% to over 90%.

There are many publications proving that prevention which includes screening is a very important element of therapeutic activities [21, 22]. During classification analysis and body posture evaluation, particular attention is paid to the shape of the spine. Evaluation of spine shaping in the sagittal plane is very complicated. It is characterized by a high degree of individuality related to age, the stage of ontogenesis and gender [23].

The influence of spine mobility on the development of anterior-posterior spinal curves in children in primary school age has not been widely discussed in the literature.

Spine mobility is an important indicator of motor apparatus condition. The biggest movement estraint in children with increased thoracic kyphosis (rounded back). A decreased spine mobility within this range may result, among other things, from a sedentary lifestyle in children. According to McKenzie [24], maintaining a seated position for a prolonged time may result in increased thoracic kyphosis.

Measurements of the mobility of the spine can be made in various planes and with the use of many tests or devices, which consequently allows for a very quick determination of the type of disorder. One of the most popular tests for the global assessment of spinal mobility is the Thomayer test, colloquially and more commonly known as the "fingers-to-floor" test. In addition to assessing mobility, this test also examines flexibility, thanks to which motor skills are developed. In fact, the mobility of the entire spine will largely depend on the flexibility of individual tissues. In one of their works, Kuszewski et al. [25], state that the above-mentioned test is a good research tool because it corresponds to the mobility of the hip joints, the lumbar spine or the length of the ischio-shin muscles.

Using photogrammetrics, Barczyk et al. [26] evaluated spinal anterior-posterior curves in 94 children aged 8-13, with mild scoliosis, who participated in a 6-month program of swimming and improvement exercises in water. The analysis of their results revealed, among others, a significant increase in the total length of the spine and thoracic kyphosis in the examined sample. In addition, a decrease in the torso bending angle, thoracic kyphosis angle and lumbar lordosis angle was observed. The research described in this paper also showed lower values for thoracic kyphosis and lumbar lordosis in the group engaged in more intense physical activity which included swimming.

Greater anterior-posterior curves of the spine (thoracic kyphosis or lumbar lordosis) with accompanying increased thorax bending and head protraction has been observed in children with weak postural muscles as well as adults suffering from myofascial back pain [27]. In their study among children aged 4-12 years, Lafond et al. [28] described the differences in the sagittal plane, resulting from the lifestyle. One of the factors that determined postural defects in the sagittal plane was the amount of time spent sitting.

It can be assumed that the posture defects in question result from neuromuscular imbalance [29]. Thanks to muscular balance, individual body segments assume specific positions. It is assumed that weak stomach and buttocks muscles as well as hip flexor spasms can lead to excessive anterior pelvic tilt, which in turn, results in lumbar hyperlordosis [31, 32]. Izydorczyk-Styś A and Izydorczyk-Styś B [32], who studied flexibility in 7-year-old children. The analysis of the results showed that girls were more often characterized by limited flexibility than boys. Next, the author measured the mobility of the lumbar section and the length of the ischio-shin muscles. Both in the group of people with limited flexibility and normal, reduced mobility of the spine and shortening of the ischio-shin muscles were observed. On this basis, it can be clearly stated that impaired flexibility determines the mobility of the spine and the length of the ischio-shin muscles, which are also involved when bending forward. Often the toe-to-floor test is used to assess the state of extensibility of these muscles.

It is obvious that with the aging of the body, the flexibility of the musculoskeletal system will decrease, and thus the mobility of individual

joints will also decrease. Unfortunately, flexibility is one of those motor skills that disappears very quickly, which is why it is so important to develop it from an early age until old age. Decrease of the flexibility of the musculoskeletal system may contribute to difficulties in performing daily activities, certain exercises, or tests (for example, the Burpee test [33]). However, when mobility is limited and muscles lose flexibility, their condition can be improved through appropriately selected exercises or forms of movement or therapy, including consideration of the ability to monitor the effects in real-time exercise [34].

As seen above, numerous studies have been conducted over the years and many opinions have been formed regarding the diagnostics with projection Moiré. The method is considered good or not, but the unquestionable fact is that it may be an alternative to very expensive and invasive radiology when it comes to screening.

CONCLUSIONS

In connection with the selected functional tests, Moiré topography can be an important factor towards the improved effectiveness of screening for postural asymmetry and monitoring the effects of therapy. There is a clear linear correlation between the angle of thoracic kyphosis measured with Moiré topography and the mobility of the spine.

STUDY LIMITATIONS

This study is not without limitations. The author of this paper intend to continue research in a much larger group of children as well as boys. Author also realize that his functional evaluation of the patients was not comprehensive (only 2 tests were performed). The next stage of examinations may include the evaluation of impact of pelvic asymmetry on angles changes and evaluation of hip abductors contraction.

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Cite this article as: Kurzeja P. Mobility of thoracic spine and flexibility of the spine in relation to the size of the anteroposterior curvatures in school children. Arch Budo Sci Martial Art Extreme Sport 2021; 17: 123-130