Validity of the Moshkov Test Regarding a Spine Asymmetry in Young Patients

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ABSTRACT: An aim of the research is to improve validity of the Moshkov test in relation to the body dimensions of young patients. This short report presents a new research that adds to previous studies about validity of the Moshkov test regarding a spine asymmetry in young patients. Because children body's dimensions are smaller than adults' ones, results indices of the Moshkov test are less as well. These results have been corrected proportionally to a half sum of rhombus sides' lengths. Mechanical and mathematical modeling using Wolfram Mathematica computer package has been done during Moshkov rhombus modification. The modified rhombus model made it possible to improve validity of the test regarding smaller dimension of young patients' bodies. The results are presented in a graph nomogram that is comprehensive for practical specialists which are not familiar with using of mathematical methods.

KEYWORDS: Posture, scoliosis, Moshkov rhombus, young patients, validity

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Introduction

Childhood posture disorder is a massive phenomenon in modern primary school, threatening the health of students.[1,2] During last decades, near two-thirds of Ukrainian first graders have health-threatening posture defects, and 8.4% have scoliosis.[3]

Validity and reliability are two main properties of tests in human movement spatially in measurements of body asymmetry.[4] Test validity refers to the appropriateness of interpreting the results of an experiment; in the latter case, validity is concerned with the appropriateness of interpreting the scores of a test.[5]

This short report presents a new research that adds to previous studies about validity of the Moshkov test regarding a spine asymmetry in young patients.[6-8] The modified Moshkov rhombus model made it possible to improve validity of the test regarding smaller dimension of young patients' bodies.

It is a test on asymmetry of a body in the coronal plane (Figure 1). The result of the test is a difference between distances of a spinous process of the seventh cervical vertebra (*A*) to the lower corners of the shoulder-blades (*B, D*):

$$I_U = \left|\overline{AB} - \overline{AD}\right|, \tag{1}$$

where $\overline{AD}$ is a left side and $\overline{AB}$ is a right side of the upper part of the Moshkov rhombus.

An aim of the research was to improve validity of the Moshkov test regarding to the body dimensions of young patients.

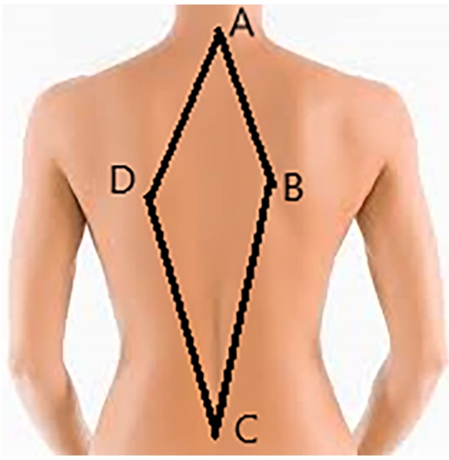

Figure 1. Moshkov's rhombus scheme: (A) is spinous process of the seventh cervical vertebra, (B and D) are lower corners of the right and left shoulder-blades correspondingly, and (C) is spinous process of the fifth lumbar vertebra.[6]

Materials and Methods

Thirty-four pupils aged 6 to 17, who are studying in one of the schools and living in a Ukrainian city with the million population, have been studied using Moshkov test with a purpose to determine a spine asymmetry in the coronal body plane. This study was approved in advance by Ethical Committee of Lviv State University of Physical Culture named after Ivan Boberskij, Ukraine. Parents of each the pupil participant voluntarily provided written informed consent before participating. The procedures followed were in accordance with the ethical standards of the Ethical Committee on Human Experimentation. Patients were in a good health status and participated in school physical education lessons.

The Moshkov rhombus has been drawn using a dermographic pencil. The lengths of the rhombus sides have been measured using a millimeter rule with an error ±5 mm. Mechanical and mathematical modeling of the modified Moshkov rhombus has been done in the frames of elementary trigonometry. Calculations have been done using Find Root function (ie, a computer program) from the Wolfram Mathematica computer package.[9] This Find Root function was derived based on the modified Newtonian method for a system of transcendental equations.

Results and Discussion

Modified index

Because dimensions of a body in children are smaller than in adults, results of the Moshkov test are less as well. Therefore, these test's results should be evaluated taking into account corresponding body dimensions, for example—a body length. But more reasonably to state that the results should be corrected relatively the lengths of the symmetrical sides of the Moshkov rhombus. Really, the Moshkov rhombus is not an ideal geometrical rhombus; mathematically it is a simple fourangle, not a rhombus. First of all, upper sides of it are significantly shorter than lower sides. Second, upper sides are not equal one another (as well, as lower sides too) because human body is not symmetric ideally in geometric sense. There are no sides of the ideal real rhombus, but virtual lengths of the upper sides have been assumed as a half sum of left and right upper sides' lengths of the fourangle named Moshkov rhombus:

$$U^* = \frac{\overline{AB}+\overline{AD}}{2}, \tag{2}$$

where U^* is virtual lengths of the upper sides; here and farther parameters with an asterisk (*) relate to the modified Moshkov index model.

Taking into account 0.5 cm error of measurements of the rhombus sides, a difference between left and right lengths of its sides have been determined less in 1 to 2 orders of magnitude than the original lengths (12-28 cm). The index values were increased hundred times with a purpose to get values of the index suitable for analysis:

$$I_U^* = 100\frac{\left|\overline{AB}-\overline{AD}\right|}{U^*} \tag{3}$$

A formula for the non-dimensional index for the upper body part asymmetry has been derivate as a ratio of the original Moshkov index to a sum of the two distances measured in the test of the upper body part multiplied of two hundreds:

$$I_U^* = 200\frac{\left|\overline{AB}-\overline{AD}\right|}{\overline{AB}+\overline{AD}}. \tag{4}$$

A similar model has been derived regarding to the lower part of a body:

$$I_L^* = 200\frac{\left|\overline{CB}-\overline{CD}\right|}{\overline{CB}+\overline{CD}}, \tag{5}$$

where C is a spinous process of the fifth lumbar vertebra; $\overline{CD}$ is a left side and $\overline{CB}$ is a right side of the lower part of the Moshkov rhombus (see Figure 1).

A common formula of the modified index regarding a total spine asymmetry has been derived as follows:

$$I^* = \frac{I_U^* + I_L^*}{2}. \tag{6}$$

Index graphs

Nomograms of the modified Moshkov index have been graphed versus the original Moshkov index (Figure 2). There were linear functions appeared between values of the original and modified indexes of the upper as well as lower parts of a spine.

The proposed modified index made possible to take into account dimensions of a patient body. For example, if body asymmetry according an original index equals 3 cm, than modified index for an adults (l* = 28) equals 11 (see the lower line of the nomogram), but for young children (l* = 12) − 25 (see the upper line of the nomogram). For adolescents (l* = 20), the index equals 15 points (see the second line of the nomogram at Figure 2).

Mathematical modeling

Mathematical model of the modified Moshkov rhombus has been derived as follows:

$$a^2 + c^2 - 2ac\cos B = b^2 + d^2 - 2bd\cos D,$$

$$a^2 + b^2 - 2ab\cos A = d^2 + c^2 - 2cd\cos C,$$

$$A + B + C + D = 2\pi. \tag{7}$$

There are four unknown values of rhombus angles (A, B, C, and D) in the system of three equations (7). If in addition to lengths of four rhombus sides: $\overline{AB} = a$, $\overline{AD} = b$, $\overline{BC} = c$ $\overline{DC} = d$ (see Figure 1), one measures a length of one of its two diagonals ($\overline{AC}$ or $\overline{BD}$), a new (i.e. fourth) equation appears. One of four equations can be used here as follows:

$$(\overline{AC})^2 = a^2 + c^2 - 2ac\cos B, (\overline{AC})^2 = a^2 + c^2 - 2bd\cos D,$$

$$(\overline{BD})^2 = a^2 + b^2 - 2ab\cos A, (\overline{BD})^2 = d^2 + c^2 - 2cd\cos C. \tag{8}$$

Computer simulation

If one determines a value of one of four angles of the rhombus, three unknown angle values remains in the system of equations (8). For example, in the Moshkov rhombus with lengths a = 19, b = 21, c = 24, and d = 26 cm one angle has been assumed as: A = 0.2 π rad. From a system of equations (8) the values of angles have been determined as: B = 2.886, D = 2.269, and C = 0.499 rad. Corresponding calculations have been done using the computer program Find Root from a computer package Mathematica Wolfram (Figure 3).

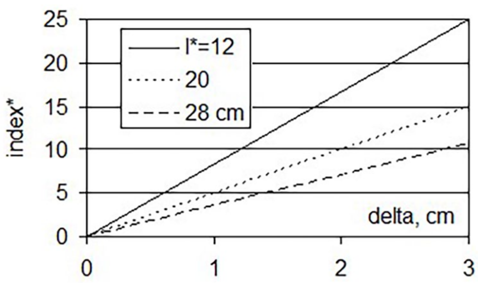

Figure 2. Graphs of the modified Moshkov index versus original model of the Moshkov index; delta is a half sum of upper $\Delta_U = \left|\overline{AB} - \overline{AD}\right|$ and lower $\Delta_L = \left|\overline{CB} - \overline{CD}\right|$ original Moshkov indexes.

```
a = 19; b = 21; c = 24; d = 26; A = .2 * π; C1 = .3 * π;
B1 = .7 * π; D1 = .7 * π;
FindRoot[
 {a^2 + c^2 - 2 * a * c * Cos[B] == b^2 + d^2 - 2 * b * d * Cos[D],
  a^2 + b^2 - 2 * a * b * Cos[A] == d^2 + c^2 - 2 * d * c * Cos[C],
  A + B + C + D == 2 * π}, {B, B1}, {D, D1}, {C, C1}]
    {B → 2.88602, D → 2.26947, C → 0.499377}
```

Figure 3. FindRoot function from Mathematica Wolfram computer package regarding Moshkov index geometry.

Corresponding indexes according to the well-known Moshkov test model[7] have been determined for the example described above (1) to (6) as follows: $\Delta_U = 2$ cm, $\Delta_L = 2$ cm, $I_U^* = 10$, $I_L^* = 8$, $I^* = 9$. The modified Moshkov test model made possible to increase validity of the index of spine asymmetry thanks taking into consideration the body dimensions (see Figure 2). Besides this, the modified model made possible to determine indexes of asymmetry of the upper and lower parts of a body, correspondingly 10 and 8 points.

Conclusion

The modified Moshkov rhombus model made it possible to improve validity of the test regarding young patients taking into account smaller dimensions of their bodies. The results are presented in a graph nomogram that is comprehensive for practical specialists which are not familiar with mathematical methods.

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Authors' Note

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Author Contributions

Ihor Zanevskyy made a substantial contribution to the concept and design of the work, approved the version to be published. Olena Bodnarchuk made a substantial contribution to the acquisition, analysis and interpretation of data. Lyudmyla Zanevska drafted the article and revised it critically for important intellectual content.

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