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TWO DIFFERENT METHODS COMPARATIVE ANALYSIS OF DETERMINING BODY DEFORMITIES IN STUDENTS

Original research

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ABSTRACT
A research study was conducted on a sample of 110 male and female participants aged 11 and 12 years (±1.2 years) to compare two different methods for identifying spinal deformities. The aim was to determine which of the two methods is better and more applicable in practical school conditions. The methods compared were Napoleon Wolanski's method with 8 variables and the 3D method from Contemplas GmbH TEMPLO General Motion, assessed with a total of 11 variables. By analyzing the table of central dispersion parameters of body posture according to Napoleon Wolanski's method, the participants were classified into 5 groups based on the results. Participants with scores up to 8 points were considered to have good posture, while those with scores from 9 to 16 points were treated as having poor posture. The research revealed that a total of 66 out of 110 participants had poor posture, accounting for 60%. Results from the Contemplas method showed deviations from proper posture in almost all variables. The analysis indicated significant deviations in shoulder rotation, pelvic rotation, sagittal distances, and flexion/extension variables. Overall, the results demonstrated a high prevalence of body deformities in 11- and 12-year-old students.
Analyzing the results of both methods for determining body deformities, it can be confidently stated that the frequency of body deformities in students aged 11 and 12 is significantly high. Napoleon Wolanski's method identified that 60% of participants had some form of spinal deformity, while the Contemplas method showed more pronounced results, with some variables indicating deformations in 80-85% of participants. Despite providing more detailed information about students' posture, the Contemplas method is less applicable in practical school conditions due to its significant cost. Therefore, Napoleon Wolanski's method remains indispensable in school settings.

Keywords: Morphological characteristics, body composition, physical deformities

INTRODUCTION

Posture describes the relative position of body segments during rest or activity. Maintaining good posture is crucial for minimizing spine load and muscle work. A sedentary lifestyle contributes to various diseases, especially spinal deformities, associated with reduced physical activity. Poor posture and body deformities are prevalent in individuals leading sedentary lifestyles. Body posture involves the static and dynamic behavior of the body in space and its relationship with the environment. Proper posture includes an upright stance with a natural curvature of the spine, emphasizing cervical lordosis, thoracic kyphosis, and lumbar lordosis. Poor posture deviates from these physiological norms, resulting in the first-degree deformation, which disappears with given movements, or the second and third-degree deformations, which persist after relieving the affected segment. Assessing posture and selecting reliable indicators to detect irregularities in children's and adults' posture has been a focus of scientific research. Professor dr. Napoleon Wolanski proposed a method suitable for the school population and their working conditions, providing a simple and principled approach. Back pain affects about 80% of the population in industrialized countries, with varying injury rates across different age groups. Invasive and non-invasive methods exist for determining body deformities and poor spinal posture in children and youth. While invasive methods are primarily used in medical institutions for severe conditions, non-invasive methods are recommended in school practice and for milder deformities. This study aims to compare two different methods for identifying spinal deformities to determine which is superior and more applicable in school conditions. The first method is Napoleon Wolanski's, and the second is the modern 2D and 3D method from Contemplas GmbH TEMPLO General Motion Analysis.

METHODS

Sample of Participants The study included 110 male and female students aged 11 and 12 from Bihać, Bosnia and Herzegovina, attending the "Gornje Prekounje" Elementary School in Bihać. The choice of this population was based on the observation of physical education teachers regarding the prevalence of spinal deformities and a sudden increase in obesity among children in this population.

VARIABLES

The variables used in this study can be categorized into three groups:

Method - variables sample for assessing body deformities (assessment according to Napoleon Wolanski): VODRGL: Head posture, VODRRA: Shoulder posture, VORGK: Chest shape, VDRLO: Scapula posture, VOSKO: Scoliotic posture, VODRTR: Abdominal wall posture, VOOBNO: Leg shape, VOSVST: Foot arch Assessment of Spinal Deformities

For the assessment of back deformities, we used the Contemplast measurement tool (professional motion analysis software), a modern tool for diagnosing postural disorders.

RESEARCH DESCRIPTION

Evaluation of body posture according to Napoleon Wolanski's method (Skender, et al., 2018)

To obtain an assessment of body posture or the posture of a specific component, scoring is performed.

0 POINTS: The component is within the given criteria, considered normal.

1 POINT: The first degree of posture disturbance, a noticeable deformity.

2 POINTS: The second degree, a significant deviation.

This system allows for a detailed assessment of minor deviations in specific elements of body posture. It also enables an overall assessment of posture based on the sum of negative points. Based on these indicators, we determined the prevalence of poor body posture and spinal deformities. We formed two groups, with participants scoring up to 8 points treated as the first group, characterized as having good body posture. Participants scoring from 9 to 16 points were treated as the second group, indicating poor body posture and spinal deformities.

0 POINTS: Excellent body posture
1-4 POINTS: Very good body posture
5-8 POINTS: Good body posture
9-12 POINTS: Poor body posture
13-16 POINTS: Very poor body posture

Assessment Procedure Participants were in underwear, adopting their usual upright posture without forced correction at a marked location. The assessors observed them from a sufficient distance to gain a better impression of observation elements and the overall posture. Adequate lighting was essential to avoid incorrect perceptions of symmetry. The room temperature was kept comfortable to prevent participants from assuming forced postures. Each participant had to face the assessor correctly for each assessed element.

VODRGL – Head posture
0 POINTS: The participant's nose is not protruding beyond the imagined plane tangential to the upper part of the sternum.
1 POINT: The face is not protruding beyond the plane tangential to the upper part of the sternum.
2 POINTS: The face is protruding beyond the plane tangential to the upper part of the sternum.

VODRRA – Shoulder posture
0 POINTS: The top of the shoulder projected on the sagittal plane falls on the back of the silhouette of the neck.
1 POINT: The top of the shoulder projected on the sagittal plane falls on the front of the silhouette of the neck.
2 POINTS: The top of the shoulder projected on the sagittal plane falls in front of the silhouette of the neck.

VORGK – Chest shape
0 POINTS: Well-built chest.
1 POINT: Slightly flattened chest.
2 POINTS: Flat chest, significantly flattened.

VDRLO – Scapula posture
0 POINTS: The scapulae do not form a unified surface with the shoulders.
1 POINT: The scapulae separate from the unified surface of the shoulders by more than one finger width.
2 POINTS: The scapulae separate from the unified

surface of the shoulders by more than two finger widths.

VOSKO – Scoliotic deviation
0 POINTS: The spine shows no lateral deviations in the frontal plane.
1 POINT: The line of vertebral spinous processes deviates more than two centimeters from the sagittal plane passing through the spinous process of the seventh cervical vertebra.
2 POINTS: The line of vertebral spinous processes deviates more than four centimeters from the sagittal plane passing through the spinous process of the seventh cervical vertebra.

VODRTR – Abdominal wall posture
0 POINTS: The abdomen is retracted.
1 POINT: The abdomen is in line with the chest.
2 POINTS: The abdomen is protruding in front of the plane tangential to the chest, hanging, or lowered.

VOOBNO – Leg shape
0 POINTS: Limbs are straight, knees and heels touch (normal position).
1 POINT: Knees or heels are not close. The gap is more than two fingers of the participant.
2 POINTS: The distance between knees or heels when limbs are extended is more than three fingers of the participant.

VOSVST – Foot arch
0 POINTS: The foot arch is well-formed, footprints (at the narrowest part) are wide from 1-4 cm.
1 POINT: The foot arch is lowered, and footprints are wide from 5-6 cm.
2 POINTS: The foot is flat, and footprints are wide from 7-10 cm (classification according to Bunak).

Measurement of body deformities was conducted in the morning between 8 am and 12 pm, in a well-lit room, with five students in each group. The assessments were made by three physical education and health teachers, who were thoroughly familiarized with the measurement technique. All assessors had years of experience in the field and had undergone a pilot study on measuring body deformities.

Sample of Variables for Assessing Body Deformities using Contemplas GmbH TEMPLO General Motion Analysis, II Method, and Research Description:

For the assessment of spinal deformities, we used the measurement tool Contemplas GmbH TEMPLO General Motion Analysis. The instrument was installed in the elementary school whose children were the participants. A plate of the Contemplas measurement instrument was placed on the surface and affixed to it to prevent movement when participants stood on it. Then a 3D calibrator was placed on this surface, with illuminated markers attached to it. The 3D calibrator had to be precisely centered on the center of the measurement plate, whose upper and lower parts, as well as the vertical, had to be ideally flat, verified using a level. The next task was to set up the "U" frame with three cameras enabling 3D analysis. The distance from the cameras to the center of the measurement plate had to be at least 2 meters and 15 centimeters. The images captured by the cameras needed to be sharpened in the software itself.

Table1. Explanation of results for all variables method Contemplas GmbH TEMPLO General Motion Analysis. (Mandić, 2014).

Shoulder rotation	Variable expressed in degrees indicates the rotation in longitudinal axis (transversal plane) of the left/right shoulder. If the results are positive, it indicates a rotation of the upper body in which case the right shoulder is placed forward, while negative results indicate a rotation of the upper body in which case the left shoulder is placed forward.
Pelvic rotation	Variable expressed in degrees indicates rotation in longitudinal axis (transversal plane) of the left/right pelvic side. If the results are positive, it indicates the rotation in which case the right side of the pelvis is placed forward, while in negative results the rotation of the left side of the pelvis is placed forward.
Trochanter rotation	Variable expressed in degrees indicates rotation of the left/right trochanter in longitudinal axis (transversal plane). If the result is positive, it indicates the rotation of the lower body in which case the right side of pelvis is rotated towards front, while the negative results indicate the front rotation of the left side of pelvis.
Condylus rotation	Variable expressed in degrees indicates the knee rotation in longitudinal axis (transversal plane). If the results are positive, it indicates the front rotation of lateral condyles of the right leg, while the negative results indicate the front rotation of the left lateral condylus.
Sag. Distance cervical spine - sacrum*	Variable expressed in centimetres indicates the distance of the most protruded cervical (neck) vertebra in regard to the vertical line projection of the sacrum (bone at the bottom of the spine) in the sagittal plane. Positive results indicate the increased flexion of the cervical spine, while the negative results indicate the increased extension of the cervical spine.
Sag. Distance thoracic spine - sacrum*	Variable expressed in centimeters indicates the distance of the thoracic spine in regard to vertical line projections of the sacrum (bone at the bottom of the spine) in sagittal plane. Positive results indicate an increase of flexion in thoracic spine, while the negative results indicate an increase in other extension of the thoracic spine. Higher values in the positive and negative offset do not apply for the variables "Sag. distance cervical, thoracic, lumbar - sacrum".
Sag. Distance lumbar spine - sacrum*	Variable expressed in centimeters indicates the distance of the lumbar (lower) spine in regard to the vertical line projection of sacrum (bone at the bottom of the spine) in sagittal plane. Positive result indicates an increase in lumbar spine flexion, while negative results indicate increase in the lumbar spine extension.
Varus/Valgus left	Variable expressed in degrees indicates the Varus-Valgus alignment left leg (medial/lateral) at the knee joint.
Varus/valgus right	Variable expressed in degrees, refers to the angle of the relationship between the upper leg and lower leg of the right leg (medial/lateral) in the knee joint.
Flexion/ Extension left	Variable expressed in degrees indicates the hyperextension and flexion of the left leg at the knee joint (sagittal plane). Positive result indicates the left leg flexion, while negative result indicates hyperextension of the left leg.
Flexion/Extension right	Variable expressed in degrees indicates hyperextension or the flexion of the right leg at knee joint (sagittal plane). Positive result indicates the right leg flexion while the negative result indicates the hyperextension of the right leg.

After calibrating the space, the 3D calibrator is packed, and testing can begin (Rađo, I. Kovač, S. et al., 2014). The next step involves preparing and attaching the fluorescent markers to the participant's body. These markers are applied to specific points on the participant's body, who should only be in underwear.

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In this study, the "3D Posture Compact" testing protocol was applied, so 14 markers were applied to each participant's body. The marker attachment points are as follows: acromion (left and right), cervical spine, thoracic spine (kyphosis), lumbar spine (lordosis), posterior superior iliac crest (left and right), sacrum, trochanter major (left and right), condyle lateralis (left and right), malleolus lateralis (left and right).

The participant is then positioned on the measurement plate with their back to the cameras, feet parallel, separated at hip width, where the axis passing through the center of the malleolus must be parallel to the horizontal line on the measurement plate (frontal plane). The participant is instructed to straighten up, look straight ahead, relax their arms by their sides, and recording is performed only during the period after the 12^{th} second and before the 18^{th} second. After recording, the fluorescent markers are removed from one participant and placed on the next.

RESULTS

By analyzing the table of central dispersion parameters of body posture according to the Napoleon Wolanski method on a sample of 110 participants (Table 2), the normal distribution of results was determined. Based on the results, participants were classified into 5 groups. The first three groups, with a total of up to 8 points, were treated as having good body posture, while participants with 9 to 16 points were considered to have poor body posture.

Table 2. Central Dispersion Parameters of Body Posture According to Napoleon Wolanski Method

	N	Range	Min	Max	Sum	Mean	SD	Var	Skew	Kurt	N	Range	Min
VODGL	110	3.0	.00	3.0	128.0	1.16	.07	.78	.61	-.18	.23	-1.10	.45
VODRRA	110	2.0	.00	2.0	131.0	1.19	.06	.67	.44	-.24	.23	-.77	.45
VORGK	110	2.0	.00	2.0	125.0	1.13	.05	.59	.35	-.05	.23	-.25	.45
VDRLO	110	2.0	.00	2.0	151.0	1.37	.05	.58	.34	-.31	.23	-.68	.45
VOSKO	110	2.0	.00	2.0	113.0	1.02	.05	.59	.35	-.00	.23	-.13	.45
VODRTR	110	2.0	.00	2.0	127.0	1.15	.05	.62	.38	.11	.23	-.47	.45
VOOBNO	110	2.0	.00	2.0	102.0	.92	.06	.70	.49	.10	.23	-.93	.45
VOSVST	110	2.0	.00	2.0	140.0	1.27	.06	.72	.53	.47	.23	-.98	.45

Table 3. Prevalence of Body Deformities Divided into Two Groups by Method I (According to Napoleon Wolanski)

Ordinal No.	Point range	Body Posture	No.	Group	Total
1.	0 points	Excellent body posture	2	1	44 40%
2.	1-4 points	Very good body posture	10	1	
3.	5-8 points	Very good body posture	32	1	
4.	9-12 points	Poor body posture	43	2	66 60%
5.	13-16 points	Very poor body posture	23	2	
Sum			110		110

According to these findings, a total of 66 out of 110 participants had poor body posture (Table 3). Similar results were obtained by Skender in 2001 with participants in grades I and II of high school. This shows that more than 50% of the participants in this population had poor body posture, indicating an increased incidence of poor body posture in 11 and 12-year-old students. Such a frequency of poor body posture (scoliotic, kyphotic, and lordotic posture) in elementary school students indicates the need for systematic examinations in schools to take preventive measures and develop corrective exercise programs. By using the latest equipment provided by the Faculty of Sport and Physical Education at the University of Sarajevo for the purposes of this research, we obtained significant descriptive and numerical indicators regarding deviations from proper body posture in a sample of 110 participants. Through the analysis of Table 4, which includes central dispersion parameters of body postures measured using the Contemplas GmbH TEMPLO General Motion method, we found that the results for all 110 participants follow a normal distribution, allowing us to proceed with the analysis.

Table 4. Central Dispersion Parameters of Body Posture According to the Contemplas GmbH TEMPLO General Motion Method

	N	Range	Min.	Max.	Mean	SD	Var	Skew	Kurt
SR	110	24.5	-12.8	11.7	1.18	4.83	23.4	-.190	.113
PR	110	19.7	-10.8	8.8	-.41	4.29	18.4	-.061	-.347
TR	110	22.1	-12.7	9.4	-1.47	4.4	19.6	.090	.131
CR	110	24.1	-8.9	15.2	.947	3.59	12.9	.467	2.07
DCSS	110	11.7	-.62	11.1	3.66	2.62	6.87	.666	.133
DTSS	110	9.56	-5.4	4.1	-.95	2.13	4.54	.201	-.081
DLSS	110	5.32	.65	5.9	2.89	1.10	1.22	.016	-.223
V/VL	110	15.4	-5.4	10.0	1.14	2.82	7.95	.312	.613
V/VR	110	15.2	-5.4	9.7	.978	2.87	8.27	.241	.452
F/EL	110	33.4	-12.4	21.0	5.29	6.08	37.0	.134	.583
F/ER	110	32.6	-17.6	15.0	-2.73	6.08	36.9	-.151	.300

SR-Shoulder rotation, PR-Pelvic rotation, TR-Trochanter rotation, CR-Condylus rotation, DCSS-Distance cervical spine – sacrum, DTSS-Distance thoracic spine – sacrum, DLSS-Distance lumbar spine – sacrum, V/VL-Varus/Valgus left, V/VR-Varus/Valgus right, F/EL-Flexion/Ext left, F/ER-Flexion/Ext right

We applied logic based on previous research, considering rotations in variables measured in degrees. Anything above +5 or below -5 is considered poor posture for rotation variables, while for variables with displacement, deviations from good posture are considered above +2 and below -2. The following table 5 presents the results of the prevalence of poor posture for specific variable characteristics.

Table 5. Prevalence of poor body posture and spinal deformities

N^0	VAR	u +	u-
1.	Shoulder rotation	29	14
2.	Pelvic rotation	15	18
3.	Trochanter rotation	7	27
4.	Condylus rotation	14	6
5.	Sag.distance cervical spine sacrum	85	0
6.	Sag.distance thoracic spine sacrum	14	47
7.	Sag.distance lumbal spine sacrum	99	0
8.	Vargus/Valgus left	10	2
9.	Vargus/Valgus right	10	5
10.	Flexion/extension left	57	3
11.	Flexion/extension right	11	38

Analyzing the table above, it is evident that there are significant deviations from proper body posture in almost all variables. For instance, in the variable "Shoulder rotation," 29 participants show a positive deviation, indicating a forward movement of the right shoulder, while 14 participants show a deviation with the left shoulder turned forward. Similar patterns are observed in other variables, with notable instances in the "Sag. distance thoracic spine sacrum" variable where 47 participants show a negative result. Additionally, the variables "Flexion/extension left" and "Flexion/extension right" show deviations in 57 and 38 participants, respectively.

DISCUSSION

In the first variable "Shoulder rotation," expressed in degrees, indicating rotation along the longitudinal axis of the left and right shoulders, deviations are observed in 43 participants, suggesting a flexion of the shoulder or poor shoulder positioning, potentially indicating kyphosis or scoliosis. The second variable, "Pelvic rotation," indicates rotation along the longitudinal axis of the pelvis, with 33 participants showing deviations, possibly leading to lumbar or thoracic scoliosis. The third variable, "Trochanter rotation," reveals rotations of the left/right femur along the longitudinal axis, with 7 participants showing rotation on the right side and 27 on the left side. The analysis of the "Sag. distance" variables provides information about flexion or extension in the cervical, thoracic, and lumbar spine, with notable deviations observed in several participants. The "Flexion/extension" variables for the left and right legs indicate hyperextension in the left leg for 57 participants and hyperextension in the right leg for 38 participants. Similar results were found in a study by Radjo, I. et al. in 2014.

From the above results, it is evident that deviations from proper body posture are significant in almost all variables, classifying them as poor body posture in this study. For some variables measured by the CONTEMPLAS method, up to 80-90% of students exhibit pronounced disagreement with good body posture ("Sag. distance cervical spine sacrum" with 85 participants). According to the experience with the Contemplas method, it is concluded that the "Compact 3D mode" analysis of posture provides precise and valid results for individuals taller than 150 cm. However, it is less applicable in our conditions, especially for small children due to variations in marker placement.

CONCLUSION

Analyzing two methods for determining body deformities in students, both methods applied are suitable for measurements in school conditions, practical, and applicable. While the Contemplas method provides excellent data, its significant cost makes it less feasible for widespread use in schools, especially considering its limitations for shorter individuals. The method by Napoleon Wolanski remains indispensable in school settings, particularly for detecting poor posture and bodily deformities. In cases of identification, additional methods can be employed to localize deformities, followed by prescribing exercises within the physical education curriculum or specific kinesiotherapeutic exercises in specialized laboratories or institutions for correcting bodily deformities and poor body posture.

Conflict of Interest

The authors do not have any conflicts of interest to disclose. All co-authors have reviewed and concurred with the manuscript's content, and no financial interests need to be reported.

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