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Postural Deviations and Physical Strength in Adolescents: A Comparative Study on Grip Strength, Leg Strength, Pelvic Tilt, and Shoulder Alignment in Students Aged 12 to 15

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ABSTRACT

This comparative study carefully investigated important differences among adolescents (12-15 years) regarding posture, specifically comparing healthy posture to peers with certain postural deviations. The research focused on a few key postural variables related to posture (shoulder alignment angle and pelvic tilt angle), and used a digital image analysis system to document and evaluate those key variables. Along with examining postural variables, the study also documented some basic muscular functions to indicate overall health status. In the study, handgrip strength was measured using a hand-dynamometer, and the students' explosive power of the legs was assessed using the vertical jump test, which used a force platform device to obtain vertical jump height. The total research sample contained 100 students that were broken into two groups: students with healthy posture compared to students with examples of pelvic imbalance and visible shoulder deviation or irregularities. Statistical analysis to compare the group's differences identified clear and statistically significant observable differences between each group and the other on the postural angle measurements or position related to shoulder and pelvis. This outcome provides evidence that postural deviations are demonstrably related to postural imbalance for the complete body, however, one of the largest points that stood out was the differences in overall strength levels were not different (for grip strength or maximum leg power) in the two groups. Also, correlation analysis indicated there was no significant statistical correlation between the measured postural variables (shoulder angle/pelvic tilt) and measured muscular capabilities (handgrip strength maximum leg power) for either group.

KEY WORDS: Angle, posture, deviation, biomechanics, healthy individuals.

1. INTRODUCTION[1]

Allah Almighty distinguished humans from all other creatures with many characteristics, including proper composition in terms of form and structure. God created man in the best form and granted him intellect, giving him the ability to maintain his appearance and body so that his appearance would be harmonious and proportionate. As stated in Allah's saying: "We have certainly created man in the best of stature" (Surah At-Tin, verse 4), He also described the excellence of creation and balance in His saying: "Who created you, proportioned you, and balanced you" (Surah Al-Infitar, verse 7). However, through the growth stages that one passes through, proper posture is considered one of the main factors that affect the motor and functional capabilities of the body, as it is linked to muscle and joint functions, as well as the effect of gravity on motor balance.

"Proper posture enhances the functional capacity of the body's vital systems and reduces the rates of physical stress on muscles, joints, and ligaments. Many diseases related to the body's muscular, nervous, and skeletal systems result from postural defects and deviations, and this negatively affects the body's mechanics and its good performance of daily tasks, in addition to its psychological, social, and economic effects on the individual" (Hasanin & Ragheb, 2003, p. 5). Postural deviations such as abnormal pelvic tilt and incorrect shoulder alignment are common problems among

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adolescents and can directly affect physical capabilities such as grip strength and leg strength. These deviations lead to muscular imbalances and increased effort during physical activities, which can limit motor capabilities and physical efficiency in those affected.

"Postural deviations are defined as abnormalities in the shape of a body organ or part of it, and the anatomical deviation of these parts from what is commonly accepted results in a change in the relationship of this part or organ to the rest of the other parts or organs" (Al-Samidai, 2002, p. 152). Additionally, weak muscle strength can be a contributing factor in the development of postural deviations, creating a link between muscle strength and skeletal stability.

Correct posture is one of the main factors in maintaining balance and body health, where a straight back and proper alignment of the pelvis and shoulders depend on the equal distribution of muscle and bone strength. However, some bad habits such as incorrect sitting, lack of movement, unhealthy work positions, or even some genetic factors, can lead to postural deviations that affect the stability and functions of the skeletal system.

Pelvic tilt is considered one of the most common postural disorders, which occurs as a result of an imbalance between pelvic and lumbar muscles, leading to its tilting forward, backward, or even to the side. This tilt can directly affect shoulder alignment, causing spinal curvature or body tilt to one side, leading to asymmetrical positions that can cause chronic pain or long-term injuries.

Postural deviations are common problems among school students that affect movement mechanics and musculoskeletal system functions. Pelvic tilt affects force distribution in the lower extremities, which can impact leg strength and overall physical activity. For example, anterior pelvic tilt can lead to increased lumbar spinal curvature, increasing pressure on posterior leg muscles, while posterior pelvic tilt leads to excessive tension in posterior thigh muscles.

"The spine adapts to the upright position and is characterized by physiological curves represented by thoracic kyphosis ranging from 20 to 40 degrees, cervical lordosis ranging from 10 to 30 degrees, and lumbar lordosis ranging from 34 to 42 degrees" (Mrozkowiak et al., 2018).

As for shoulder alignment, it plays a vital role in upper body stability, where differences in shoulder position can lead to changes in muscle balance, which can affect grip strength, which depends largely on upper spinal stability and neuromuscular system coordination. "Human posture depends on the proper organization and composition of the motor system and its balanced growth according to the characteristics of each stage of human growth. Therefore, posture is related to the structure and harmony of bones and their connection to each other, as well as the muscles and ligaments that fix them, whether directly or indirectly" (Abdul Rahim, 2020, p. 12).

"Natural curves help maintain a stable body position when affected by excessive internal and external loads. When changes occur in spinal alignment, anterior, lateral, and posterior curves appear, such as increased lordosis or increased kyphosis when angles exceed 40 degrees, and lateral curvature when it is greater than 10 degrees" (Batista Junior et al., 2011, p. 231).

The importance of this research lies in the fact that correct posture or proper body alignment is a fundamental factor for maintaining optimal physical performance and general health, especially among adolescents who are going through a period of rapid growth that affects their muscular and skeletal structure. Studying the effect of postural deviations on muscle strength in the upper and lower extremities, as well as their relationship to pelvic tilt angles and shoulder alignment, contributes to a deeper understanding of how postural deviations affect motor functions, which helps in developing appropriate corrective and rehabilitative strategies.

This study emphasizes its importance by identifying muscular and mechanical differences between students suffering from postural deviations and their healthy peers, allowing for a deeper understanding of the consequences of poor postural balance. It explains the relationship of grip strength and leg strength to pelvic tilt angles and shoulder alignment, helping to determine how these variables affect physical performance and postural stability.

Despite numerous studies on the effect of postural deviations on physical performance, the relationship between these deviations and muscle strength, especially grip strength and leg strength, still requires more research, particularly in the age group of 12 to 15 years, which witnesses rapid physical changes.

1.1 Research Objectives

1. To identify grip strength, leg strength, and the angles of pelvic tilt and shoulder alignment for students who suffer from postural deviations and healthy students in the age group of 12-15 years.
2. To identify the differences between students with postural deviations and healthy students aged 12-15 years in grip strength and maximum leg strength.
3. To identify the relationship between pelvic tilt angles and shoulder alignment with grip strength and leg strength in the age group of 12-15 years in both groups.

1.2 Research Hypotheses

1. There will be statistically significant differences between students who suffer from postural deviations and healthy students in grip strength and leg strength.

2. There will be statistically significant correlation between grip strength and leg strength with pelvic tilt angles and shoulder alignment in both groups.

1.3 Research Scope

Human Scope: A sample of middle school students totaling 100 students.

Temporal Scope

The period from December 19, 2024, to January 10, 2025.

Spatial Scope: Erbil - The hall of one of the schools named (Deraw Boys School), along with the school playground.

1.4 Definition of Terms

Leg Strength The ability of lower extremity muscles (such as thigh and leg muscles) to produce force to support movements such as walking, jumping, and running. This is usually assessed using vertical jump tests or dynamic force tests through force platform devices. (Komi, 2003)

Grip Strength This is the maximum force that the hand and fingers can exert when gripping a specific object. It is used as an indicator of overall body strength and muscle health, as it correlates with upper extremity strength and physical fitness indicators and can be measured using a dynamometer device. (Bohannon, R. W., 2001)

2. RESEARCH METHODOLOGY AND FIELD PROCEDURES

2.1 Research Method

"Research methodology is the approach adopted by the researcher to determine the steps of his research through which he can reach a solution to the problem" (Mahjoub, 1990, p. 81).

The descriptive method: It is the accurate conception of mutual relationships between society, trends, tendencies, desires, and development so that the research covers a picture of life reality and establishes indicators and builds future predictions. Scientists tend to divide this method into studies called descriptive studies, and some call this study the descriptive method. There is also another pattern, which is the case study method and growth study. Whatever the type of study, it falls into one method, which is the descriptive method, because it describes the situation regardless of how the study direction changes (Mahjoub, 2005, p. 243).

The researcher used the descriptive method with a comparative approach between students with postural deviations and students with normal posture, as well as used the method of analyzing relationships between the variables under study. "Research procedures to describe the phenomenon based on collecting facts and data, classifying, processing, and analyzing them precisely in order to reach results that can be generalized about the phenomenon under research" (Shehata and Mohammed, 2005, p. 337).

2.2 Research Population and Sample

"The sample is the part that represents the original population or the model on which the researcher conducts the entirety and focus of his work. Research cannot succeed unless the researcher uses special methods for selecting samples. When studying individuals and communities, the researcher cannot take all individuals or the entire community for his study because this requires tremendous effort, time, and material costs. Therefore, the researcher selects a specific sample from this community for his study. The larger the original population, the smaller the percentage, and the smaller the percentage, the larger the original population for samples" (Mahjoub, 2005, p. 152).

Therefore, the sample is the main and representative element of the original population and accurately reflects its main characteristics. In this study, a sample of 100 students was selected from schools in the center of Bansalawa district, affiliated with Erbil Governorate, consisting of 5 schools. The researcher relied on students from 3 schools, and all tests were conducted at (Deraw Boys Middle) School. Their ages ranged between 12 and 15 years. This sample represents an important part of the studied population, allowing for comprehensive analysis and drawing accurate conclusions based on the results.

The selection of this sample was based on scientific principles, according to what Wajih Mahjoub indicated, that research success depends largely on the correct selection of the sample, which reflects the characteristics of the original population. This is because studying all members of the original population is often impractical due to the great requirements of time, effort, and material resources. Through studying this sample, the researcher seeks to achieve accurate and complete representation of the original population. Selecting students from a specific age group and from a particular geographical area ensures achieving research objectives and reduces the possibility of bias.

The school principal's approval was obtained as a preliminary step, followed by parents' approval for the students by sending a special paper to their guardian, in accordance with the Helsinki Agreement of 1975 and ethical principles for conducting research involving humans.

2.3 Sample Homogeneity

Table 1
Analysis of sample homogeneity between the two student groups (those with postural deviations and healthy ones) using descriptive statistics and skewness coefficient

Variable	Mean	Standard Deviation	Median	Skewness
Age	14.16	0.85	14.0	-0.11
Height (cm)	162.97	9.10	164.0	0.13
Weight (kg)	54.11	10.50	54.4	0.72

2.4 Data Collection Methods and Tools and Equipment Used in the Research

Information Collection Methods

- Arabic and foreign sources and references
- Measurements and tests used
- Expert opinion questionnaire form regarding the quality of angles and physical capabilities
- Biomechanical analysis using various programs

To achieve the research objectives, a questionnaire was specifically prepared for specialists and experts in physical tests with the aim of determining the most appropriate tests for application to the research sample, which consists of secondary school students (first grade, second grade, and third grade). These experts were selected based on their scientific and practical experience in physical education, sports rehabilitation, and measurement and evaluation. After presenting the questionnaire content to the experts, they were invited to determine the most appropriate age groups for conducting the tests, and they agreed to include all middle school stages (first, second, and third middle school) due to their importance in the physical growth and postural development stage.

Advantages: This is a simple and commonly used test for general strength level.

Disadvantages: The distance of the force gauge spring must be adjusted for hand size; the success of this will affect measurement accuracy.

Figure 1: Shows the grip strength test and measurement

Force Platform Device

The Force Plate is a device used to measure mechanical forces resulting from human interaction with its surface. It is connected to a computer for data analysis through a special program, where forces are converted into electrical signals displayed as graphs and numbers.

How to Use: The device is calibrated and connected to the computer for data analysis. The person stands on the platform to analyze body balance or mass. They are asked to perform movements such as vertical jumping. The resulting forces are recorded, including vertical force, reaction time, and movement speed.

Vertical Jump Strength Measurement Test: To measure vertical jump strength, the person is asked to jump vertically with maximum force. The platform records the derived force, interaction duration, and jump height to accurately analyze physical activity.

"The vertical force analysis platform is Swedish-made, with measurements of 120 cm in length, 88 cm in width, and 8 cm in height. It consists of two parts, right and left, each part containing two sensors divided into numbers. The right part carries numbers (1, 2) and the left carries numbers (4, 3), with high specifications and precision for identifying vertical force indicators" (Nihad and Hadi,

Figure 2: Shows the vertical jump strength test and measurement3-6 Biomechanical Variables

2.5 Biomechanical Variables:

1- Pelvic Tilt Angle

The pelvic tilt angle represents the degree of pelvic

inclination forward or backward relative to the horizontal plane, where this inclination affects spinal mechanics and overall body posture. Excessive anterior tilt can lead to an increase in lower back curvature called hyperlordosis (Florence et al., 2005).

Figure 3 demonstrates the measurement of the pelvic inclination angle.

Shoulder Alignment

Refers to shoulder balance relative to the torso, where the shoulder level should be equal without abnormal tilt or rotation, which helps prevent pain and muscle injuries. (Magee, 2013).

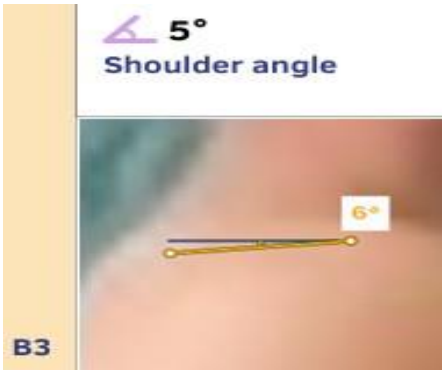

Figure 4 shows shoulder alignment measurement.

These angles were obtained through body analysis using a specialized program for analyzing the body during movement and rest, namely the Artificial Intelligence and Manual Body Posture Assessment and Correction System (APECS). This program is an advanced application for analyzing and correcting body posture using artificial intelligence techniques and photography, without the need for sensors or complex equipment. it is used to assess angles and deviations in various body postures, making it an effective tool for physical therapists, sports trainers, and movement rehabilitation and biomechanical specialists.

Main Functions of the Program

Comprehensive body posture analysis:

The program evaluates body posture from the front, back, and sides using photographs. The researchers relied on imaging from the right side only.

Specialized tests: Includes assessments for specific areas such as the head, neck, shoulders, and spine.

Adam's Forward Bend Test: Used to detect spinal curvatures.

Body symmetry analysis: Evaluates symmetry between the right and left sides of the body.

Range of motion assessment: Used to measure the joint range of motion.

Detailed report generation: The program produces reports in PDF or JPEG format containing analysis results and recommendations.

Common Uses

Rehabilitation and physical therapy: Helps monitor patient progress and identify areas of weakness.

Sports training: Used to improve athletic performance by correcting improper postures.

Injury prevention: Contributes to early detection of deviations that may lead to future injuries by biomechanics specialists.

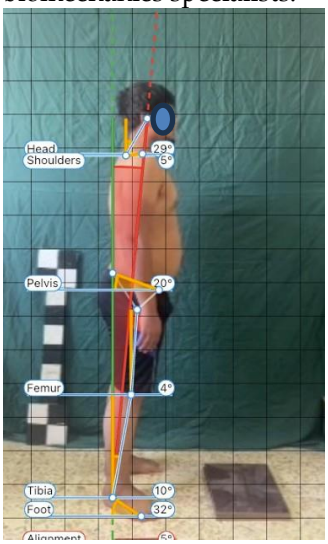

Figure 5 shows lateral body measurement.

3. Discussion and Results

Table 2

Shows descriptive statistics for the healthy group and those with postural deviations

Variables	Healthy		With Postural Deviations	
	Mean	Standard Deviation	Mean	Standard Deviation
Shoulder Angle (FSP)	12.78	7.017	19.78	14.838
Pelvic Tilt	9.76	3.191	12.25	7.617
Grip Strength	22.07	7.601	23.47	8.663
Maximum Leg Strength	307.43	101.450	320.23	119.931

Table 3
Shows the statistical results of the difference between the healthy group and those with postural deviations

Variables	t-value	Sig. (2-tailed)	Significance
Shoulder Angle (FSP)	-2.807	.006	-6.99860
Pelvic Tilt	-2.022	.046	-2.54062
Grip Strength	-.819	.415	-1.39916
Maximum Leg Strength	-.549	.585	-12.80055

From the table, it is clear that there are statistically significant differences between students with postural deviations and healthy students in shoulder angle and pelvic tilt angle, where the sample was divided into two groups based on these two angles. This indicates the presence of clear imbalances and violations in body alignment among the deviated group, and this dysfunction is considered an indicator of muscle imbalance or the presence of spinal curvatures. "Changes in shoulder alignment often reflect postural deviations resulting from muscle imbalance or spinal curvature" (Kendal et al., 2005). The apparent difference and noticeable variation in pelvic tilt angle also reflect dysfunction or disorder in postural alignment and may indicate unbalanced muscle tension or differences in the lower extremities. "Pelvic tilt is considered a primary indicator of lumbar vertebrae and pelvic posture, and excessive anterior or posterior tilt negatively affects spinal alignment and overall postural balance" (Neumann, 2010).

These results collectively indicate the importance of examining both regions (shoulder and pelvis) when diagnosing postural deviations in the studied age group due to their mutual and interconnected effect on overall body alignment.

Regarding the research objective of identifying differences between students with postural deviations and healthy students aged 12-15 years in terms of grip strength and maximum leg strength, the results showed no statistically significant differences between the two groups. The researchers attribute this to the fact that the body may sometimes adapt to postural deviations, where muscles allow compensation for imbalance. For example, in cases of pelvic tilt or abnormal shoulder alignment, other muscles may develop to compensate for the loss of balance, resulting in grip strength and leg strength remaining approximately unchanged compared to healthy individuals.

Studies indicate that grip strength correlates with lower limb strength, but correlates weakly with postural control in older adults. Although this study focuses on older adults, it suggests that the relationship between muscle strength and postural control may be weak or non-existent in some age groups (Strandkvist et al., 2021).

For this age group, there is another study published in PubMed that supports our study results showing no statistically significant correlation between postural control variables and muscle strength in this group. This suggests that factors affecting postural control may be independent of muscle strength in adolescents (Granacher and Gollhofer, 2011).

Based on these results, it is clear that the body may be able to adapt to these deviations without significant impact on muscle strength. Therefore, it is recommended to conduct further studies to understand the potential effects of postural deviations more deeply.

Table 4
Shows the statistical results of the correlation matrix for research variables in the healthy group

Variables	Shoulder Angle (FSP)	Pelvic Tilt	Grip Strength	Maximum Leg Strength
Shoulder Angle (FSP)	-	-.174	-.172	.065
Sig. (2-tailed)		.269	.277	.681
Pelvic Tilt		-	-.043	.053
Sig. (2-tailed)			.789	.740
Grip Strength			-	.295
Sig. (2-tailed)				.057
Maximum Leg Strength				-
Sig. (2-tailed)				

Based on the statistical results of Table 4 above, there is no statistically significant relationship between shoulder angle and pelvic tilt with grip strength and maximum strength among healthy students. These results are explained by the fact that the postural and muscular systems in healthy individuals operate in harmony and balance, without compensations or disturbances that affect functional balance. Each of the mentioned variables represents an independent indicator that does not directly depend on other variables in terms of performance or muscle composition.

For example, grip strength is an indicator of muscle strength in the upper extremities, especially the forearm and hand muscles, and there is no direct or functional relationship between it and shoulder angles or pelvic tilt. As for maximum strength, it is an indicator of lower extremity efficiency and depends on thigh and leg muscles. It is illogical to expect shoulder angle to affect this in healthy individuals.

These results support what researchers Akınoğlu and

Kocahan (2021) found in their study, which found no significant relationship between muscle posture and body position on one hand, and grip strength on the other hand among university students. The study by Miyachi et al. (2022) showed that pelvic tilt is not directly related to lower extremity function or explosive performance, confirming the absence of a relationship between pelvic angle and muscle performance in this study.

Table (5)
Shows the statistical results of the correlation matrix for research variables in the group with postural deviations

Variables	Shoulder Angle (FSP)	Pelvic Tilt	Grip Strength	Maximum Leg Strength
Shoulder Angle (FSP)	-	-.149	-.062	-.082
Sig. (2-tailed)		.293	.661	.563
Pelvic Tilt		-	-.130	-.048
Sig. (2-tailed)			.358	.736
Grip Strength			-	.301*
Sig. (2-tailed)				.030
Maximum Leg Strength				-
Sig. (2-tailed)				

The results in Table (5) also indicate the absence of statistically significant relationships between: shoulder angle, pelvic tilt, with grip strength, and maximum strength among students with postural deviations. These results suggest that minor postural deviations did not have a significant or direct impact on muscular or motor activity in representatives of this group. It is likely that the neuromuscular system has adapted to these deviations, allowing muscles to maintain functional efficiency despite the presence of postural disturbances.

For example: Despite the deviation in shoulder angle, no effect on grip strength was observed, indicating that the peripheral muscles of the arm and forearm perform their function independently of the shoulder axis. Similarly, pelvic tilt did not affect maximum strength, meaning that the lower muscles (such as thigh and leg muscles) maintain their efficiency despite the slight shift in the pelvis.

In addition to what was mentioned above, the results showing no statistically significant relationship between the four variables (shoulder angle, pelvic tilt, grip strength, maximum strength) in individuals with postural deviations also reflect an important fact: some minor postural deviations may be compensatory rather than pathological. In many cases, the body shows remarkable ability to redistribute muscular efforts and achieve dynamic functional balance, especially in non-athletes or those who have not been exposed to injuries or medical conditions affecting the musculoskeletal system. Therefore, muscle efficiency can be maintained even with minor differences in body posture.

Additionally, these results indicate that deviations in shoulder angle or pelvis, even if visible at the anatomical level, do not automatically lead to functional disturbances in muscles.

This result is supported and confirmed by the study of Murta et al. (2020), which found that reducing anterior pelvic tilt led to reduced trunk extension and increased lower trapezius muscle activity, without noticeable effect on forward shoulder position, which agrees with the results of this study.

Kostyukov et al. (2021) reached similar results, where they found no relationship between posture (including shoulder and pelvic angles) and maximum strength in young athletes, confirming that minor deviations in posture do not affect strength or acceleration.

4. CONCLUSIONS

In light of what the researchers found from the data and after statistical processing, they reached several conclusions which they presented by linking these results together, where the following extractions were made:

There are statistically significant differences between groups of healthy students and students with postural deviations regarding shoulder alignment angles and pelvic tilt, indicating that postural deviations clearly affect physical posture indicators related to these angles.

At the same time, the results did not show statistically significant differences between groups in grip strength and maximum leg strength, suggesting that these muscular capabilities are not affected by the studied postural deviations.

On the other hand, no statistically significant correlations were found between postural angles (shoulder angle and pelvic tilt) and both grip strength and maximum leg strength in both healthy students and students with postural deviations, indicating the independence of these postural angles from muscular performance in the studied sample.

It was also shown that this age group exhibits unhealthy body postures according to biomechanical theories, and perhaps we can generalize this result to all students in schools. The researchers consider this result dangerous for the Kurdish and Iraqi society as a whole.

The researchers also concluded from the study results that postural deviations in shoulder and hip areas among a group of students aged 12-15 years indicates

unbalanced movement patterns reflecting postural differences. These deviations are interpreted as resulting from acquired muscular adaptations or postural incompatibility related to improper movement habits, necessitating the development and improvement of early postural screening programs for this critical age group.

On the other hand, muscle strength indicators (grip strength and maximum leg strength) showed stability and consistency across all studied groups. This supports the main hypothesis that postural deviations are not necessarily related to muscle strength deficiency. but may result from more complex factors related to neuromuscular control or structural imbalance.

These results have significant scientific and practical importance, directing future research toward studying neuromuscular mechanisms and precise motor factors instead of focusing exclusively on muscle strength levels. They also highlight the need to develop early diagnostic and therapeutic strategies aimed at improving motor control and structural balance, opening new horizons for preventive and therapeutic intervention programs in the field of postural health among adolescents.

RECOMMENDATIONS:

In light of the results reached by the researchers, the following is recommended:

Conducting regular examinations to assess posture among middle school students with the aim of early detection of postural deviations, especially those related to shoulder alignment and pelvic tilt, and working to correct them through rehabilitation programs and therapeutic exercises.

Implementing posture awareness programs in schools and educational activities to teach students the importance of correct posture and its impact on general health and motor skills.

The necessity of conducting additional studies that examine the relationship between postural characteristics and muscular capabilities using diverse measurements and tests covering different age groups and educational environments to deepen comprehensive scientific understanding of these relationships.

Not relying solely on muscular capabilities, such as grip strength and maximum strength, as criteria for evaluating postural deviations, as the results showed no significant correlation between them.

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