BALNEO RESEARCH Balneo and PRM Research Journal
English Edition
e ISSN 2734 - 8458 p ISSN 2734 - 844X ROMANIAN ASSOCIATION OF BALNEOLOGY

Research article

Identification of Postural Deviations and Trunk Asymmetries in Physical Therapy Students Using an AI-Based Mobile Application

Liviu Moraru [1], Adela Badau [2,*,†], Florin Marin Litoi [3,†], Andrei Madalin Petrescu [4,†], Catalin Octavian Manescu [5,†], Neluta Smidu [5,†]

1 Faculty of Medicine, "George Emil Palade" University of Medicine, Pharmacy, Sciences and Technology, Targu Mures, Romania;
2 Faculty of Physical Education and Mountain Sports, Transilvania University, Brasov, Romania;
3 Department of Physical Education and Sports, University of Bucharest, Bucharest, Romania;
4 Faculty of Physical Education and Sport, Ovidius University of Constanta, Constanta, Romania;
5 Department of Physical Education and Sport, Academy of Economy Sciences, Bucharest, Romania.

* Correspondence: adela.badau@unitbv.ro
† The authors listed have made equal contributions to the paper, equal to that of the first author

Citation: Moraru L., Badau A., Litoi F.M., Petrescu A.M., Manescu C.O., Smidu N. - Identification of Postural Deviations and Trunk Asymmetries in Physical Therapy Students Using an AI-Based Mobile Application
Balneo and PRM Research Journal **2025**, *16(2): 802*

Academic Editor(s):
Constantin Munteanu

Reviewer Officer:
Viorela Bembea

Production Officer:
Camil Filimon

Received: 29.03.2025
Published: 25.06.2025

Reviewers:
Andrei Iordan
Alin Daniel Malaelea

Publisher's Note: Balneo and PRM Research Journal stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Abstract: The aim of the study was to identify postural deviations and trunk asymmetries by comparing the anterior and posterior body views in physical therapy students using a mobile application based on artificial intelligence. The study included 49 students, specializing in physical therapy, aged between 21-24 years. The evaluation was carried out with the mobile application AI Posture Evaluation and Correction System (APECS), which uses markers placed on the body photograph and photogrammetric algorithms for precise scanning of body symmetry. The analysis included 6 transversal parameters and 3 trunk symmetry indices. The analysis of the results of body posture differences highlights that in the anterior plane these were smaller than the posterior ones, except for Pelvic Tilt of 0.586° (p>012), falling within the limits of normality. The largest difference was found in Shoulder Alignment and Axillae Alignment of 0.655°. Regarding trunk asymmetry, it was found that the anterior values are higher than the posterior ones. Analyzing the posture for Body Alignment, most intended point of the trunk and Fontal Knee Angle, the correlations were weak ICC<0.4 and for Shoulder Alignment, Axillae Alignment, Pelvic Tilt, the correlations were good, ICC between 0.6 and 0.7. The ICC values for trunk asymmetry reflect a low correlation. Posture and body asymmetry assessment should be a periodic concern to allow timely corrections through the implementation and practice of effective and specialized prophylactic programs.

Keywords: body posture; trunk asymmetry; APECS app; physical therapy; frontal analysis; posterior analysis

1. Introduction

Postural deviations of physiotherapists can significantly influence their efficiency; regarding the physical abilities of patient care, through the possibility of musculoskeletal disorders. Master's students in the physical therapy specialization, in curricular practice, are actively involved in learning and practicing various postural corrective programs, however, a routine or periodic assessment of their posture is not a requirement at this level as a preventive measure in reducing specific risks.

A correct posture creates the osteokinetic support to accurately perform any motor task, in the diversity of social and professional activities. Posture is a complex process focused on the control mechanisms of the central nervous system, sensory integration and musculoskeletal responses, targeting two aspects: supporting tonic muscle activity for posture and making adjustments to maintain balance in various conditions [1,2]. Posture is defined as the position acquired by the human body in various situations, opposing the gravitational force and adapting to different environments [3], by maintaining body balance in static and dynamic conditions [4]. A correct posture is determined by the symmetrical positioning of the head in relation to the vertical axis, the slight arch of the chest, the same length of the upper and lower limbs and the correct arch of the feet [5,6]. Maintaining a correct body position influences and defines: the optimal functioning of internal organs, muscles and neuromuscular coordination [7].

Trunk asymmetry can be correlated with left and right imbalance in the trunk muscles, which have the role of supporting the spine [8]. The profession of physical therapist is based predominantly on active movement therapy, aiming to prevent, re-educate or recover from disabilities and motor deficiencies, customized for each patient. Specific professional demands in the healthcare environment, according to the World Health Organization (WHO), found that certain musculoskeletal disorders affect people aged between twenty and fifty years globally, characterized predominantly by pain in the cervical area [9], which requires additional energy consumption to achieve a balanced posture [10]. According to a previous study, approximately 50% of physiotherapists face such problems in the first five years of practice [11]. The main causes of occupational musculoskeletal problems are significantly associated with the following factors: work experience, poor posture, prolonged static positions, and workplace stress [12,13]. Previous studies have focused mainly on determining segmental body asymmetries in various population categories, but these are insufficiently analyzed in physiotherapists [6,7]. Comparisons between the anteroposterior planes require additional investigations, focused on the use of new generation AI-based devices, as part of the curricular aspects of somatic assessment and as a reliable tool in professional practice. Modern technological influences and the introduction of artificial intelligence (AI) in assessing posture and asymmetries of body segments have led to constant evolution, from physical tests that used a plumb line to modern 3D markers [4,14]. Artificial intelligence (AI) through the dynamics of development and expansion, predominantly in the healthcare field, is a modern alternative, a reliable, non-invasive tool that is easy to access and manipulate, replacing complex devices or expensive portable sensors, and can provide results in real-time [15,16]. APECS (Artificial Intelligence Posture Evaluation and Correction System) utilizes artificial intelligence to evaluate and correct static or dynamic posture, serving as a tool for professionals and posture experts. The APECS mobile application uses photogrammetric markers and algorithms positioned on the subject's body photograph, having high reliability and precision in assessing body symmetry. Static assessment from the standing position aims to analyze the position of the head, neck, and shoulders, as well as the posture of the spine, in the anterior, posterior, and sagittal planes, and the asymmetry of the trunk in the anterior and posterior planes [17-19]. This innovative tool is effective in evaluating physiotherapists and physical therapists regarding aspects of body mechanics, both their own and those of their patients. Based on the results, the prevalence of postural disorders can be anticipated and corrected in an optimal timeframe [20,6].

Despite the advancements in studying body and trunk posture, several research gaps remain. Firstly, much of the existing literature focuses on either the anterior or posterior segments individually, often neglecting a comprehensive comparison between the two. Additionally, while there are studies related to posture among various populations, there is a limited understanding of how these asymmetries specifically impact functional outcomes in master's students focusing on physical therapy. Moreover, the role of environmental factors, such as workspace ergonomics and physical activity levels, on postural dynamics has not been thoroughly explored. Another gap is the long-term effects of postural asymmetries on career longevity and health in physical therapy practitioners. Finally, while mobile applications and AI are emerging tools for postural analysis, empirical studies validating their efficacy and accuracy in real-world settings are still lacking. Filling these gaps could significantly enhance the understanding and management of postural issues in both clinical and educational settings within physical therapy.

This study aimed to uncover critical asymmetries in body and trunk posture by comparing the anterior and posterior segments among master's students specializing in physical therapy. Leveraging a cutting-edge mobile application powered by artificial intelligence, we sought to provide a thorough and insightful analysis, enhancing our understanding of postural dynamics in this vital field.

2. Materials and Methods

2.1. Participants

In this study, 49 female subjects, master's students specializing in physical therapy and prophylaxis, aged 21-24 years, with a mean age±SD of 22.586±0.779 years, were included. Body composition characteristics of the participants mean±SD: height 168.344±9.596, weight 68.551±10.864, and BMI 24.086±2.487. Inclusion criteria: master's students specializing in physical therapy, female, healthy, without a history of chronic osteoarticular diseases. The approval of the Ethics Committee of the Faculty of Physical Education and Mountain Sports, no. 35/04.02.2025. Participation in the study was voluntary, and the study adhered to the principles outlined in the Declaration of Helsinki. All authors contributed equally with the first author.

The required sample size for the present study was determined using G*Power software (version 3.1.9.4). A priori power analysis was conducted using a t-test for mean comparisons, with a one-tailed distribution. The analysis parameters included an assumed effect size (Cohen's d) of 0.5, a significance level (α) of 0.05, and a statistical power (1−β) of 0.95. The results indicated that a minimum of 45 participants would be required in the study group to achieve the desired power.

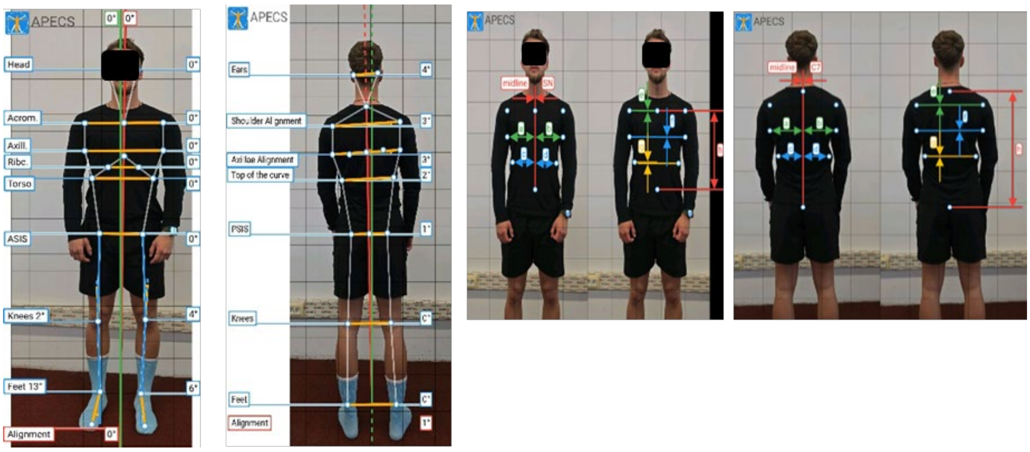
2.2. Study design

This study utilized a cross-sectional design to assess body posture and trunk asymmetry among master's students in physical therapy. Participants underwent testing in a controlled laboratory environment at the university's research center. To ensure accuracy and reduce distortions, students were encouraged to participate with minimal equipment, which helped maintain the correct positioning of landmark axes during photography. This approach aimed to enhance the reliability of the findings and contribute to a better understanding of these important factors in physical therapy.

2.3. Data Collection Tools

The mobile app Apecs-AI Posture Evaluation and Correction System (New Body Technologies SAS, Grenoble, France) was used to capture images of the participants in a standing position, with their shoulders shoulder-width apart. To determine postural alignment and trunk symmetry, four photographs were captured, specifically in the two planes: anterior and posterior, using two applications integrated into the design of the application. The application display features an image of a virtual body and a target in the form of a square sign, which turns green when the images are captured correctly and overlap. After taking a photograph, depending on the pre-selected plane, the image will be cropped, as close as possible to the subject's body, to avoid inconsistent proportions. The APECS application is based on standardized digital landmarks and anatomical angles. Expert evaluators placed markers on the participants’ bodies in correspondence with the app’s predetermined landmarks. After the cropping phase, the app guides the user to position the digital markers correctly through examples of their placement, reducing bias. The app is based on sophisticated machine learning algorithms, and the storage and processing of information produces predictive and reliable models.

For posture in the anterior and posterior planes, the present study targeted 12 indicators (Figure 1, a, b) following the following alignments: body alignment, shoulder alignment, axillae alignment, trunk inclination, pelvic tilt, and Knee angle. For trunk asymmetry, the 3 calculated indices were taken into analysis, namely: Frontal Asymmetry Index calculated as the medio-lateral length difference index at the axilla and the waist, and off balance index at jugular notch; Height Difference Index (HDI) which represents the height differences between the shoulders, axilla and waist level and Trunk Asymmetry Index (TAI) calculated as the sum of the anterior (ATSI) and posterior (POTSI) mentioned in the anterior plan (Figure 1, d, e). The calculation formulas for the indices were: ATSI = (FAI_SN + FAI_A + FAI_T) + (HDI_S + HDI_A + HDI_T) and POTSI = (FAI_C7 + FAI_A + FAI_T) + (HDI_S + HDI_A + HDI_T).



(a) (b) (c) (d)

Figure 1. Postural alignment in the anterior coronal plane (a), posterior coronal plane (b), and trunk asymmetry in the anterior (c) and posterior (d) planes.

2.4. Data analysis

The software IBM-SPSS 30 was used for the statistical analysis of the data, allowing for a rigorous and detailed assessment of the parameters included in the research: arithmetic mean (X) and standard deviation (SD). The mean difference between tests (ΔX), associated with the Student's t-test (t), was used to compare the average differences between groups or measurements, a standard statistical method for determining the significance of differences between two sets of data. The confidence interval (95% CI) values ensured a robust and precise estimate of the upper and lower limits of the values,

3. Results

In Tables 1 and 2, we present the descriptive statistics of full posture parameters and trunk parameters analyzed using APECS. In Tables 3 and 4, we present the differential analysis, highlighting the statistical significance of the paired t-test and the intraclass correlation coefficient (ICC). The results presented in Table 1 indicate that all full posture parameters were lower in the anterior analysis compared to the posterior analysis. The Kurtosis values ranged between -0.67 and 0.62, which reflects a normal distribution of the data.

Table 1. Descriptive statistical analysis of full-body posture parameters obtained through the APECS assessment tool

Parameters	Side	Mean	SD	Min	Max	Kurtosis
Body Alignment	Anterior	.69	.81	.00	2.00	-.64
	Posterior	.52	.63	.00	2.00	-.22
Shoulder Alignment	Anterior	2.07	1.46	.00	.,00	-63
	Posterior	1.41	1.18	.00	4.00	-.17
Axillae Alignment	Anterior	2.07	1.46	.00	5.00	-.63
	Posterior	1.41	1.18	.00	4.00	-.17
Most intended point of the trunk	Anterior	1.31	.93	.00	3.00	-.46
	Posterior	1.17	1.41	.00	4.00	-.21
Pelvic Tilt	Anterior	.72	.88	.00	3.00	.24
	Posterior	1.31	1.23	.00	4.00	-.38
Frontal Knee Angle	Right	1.96	1.97	.00	6.00	-.61
	Left	1.90	1.68	.00	6.00	.62

SD – standard deviation

Analyzing the results in Table 2, we find that the Kurtosis values ranged between -0.90 and 1.35, highlighting that the results fall within the limits of a normal distribution. The mean values of Frontal Asymmetry Index, Height Difference and Trunk Symmetry Index in the anterior plane were higher than the values in the posterior plane.

Table 2. Descriptive statistical analysis of trunk parameters obtained through the APECS assessment tool

Parameters	Side	Mean	SD	Min	Max	Kurtosis
Frontal Asymmetry Index	Anterior	2.59	1.82	.00	4.00	-.52
	Posterior	2.48	1.12	.00	5.00	1.35
Height Difference	Anterior	4.93	4.15	.00	13.00	-.49
	Posterior	4.62	3.06	.00	10.00	-.75
Trunk Symmetry Index	Anterior	7.96	5.16	.00	5.00	.25
	Posterior	7.90	3.58	2.00	14.00	-.90

The comparative analysis of the results from the anterior and posterior planes (Table 3) highlights a difference of 0.17º for Body Alignment; for Shoulder Alignment and Axillae Alignment of 0.65º; for the Most intended point of the trunk of 0.14º, and a mean difference of -0.59º for Pelvic Tilt. The smallest difference in full-body posture in the present study was recorded between the right and left frontal parts of the Knee Angle parameter, at 0.07º. The mean differences recorded for all parameters of full body posture were not statistically significant, $p>0.05$, except for Pelvic Tilt, where $p>0.012$. Analyzing the values of the intraclass correlation coefficient, we find that for Body Alignment, most intended point of the trunk, and Fontal Knee Angle, the correlations were weak, ICC<0.4; for Shoulder Alignment, Axillae Alignment, and Pelvic Tilt, the correlations were good, with ICC between 0.6 and 0.7.

Table 3. Descriptive analysis of full-body posture parameters obtained through the APECS assessment

Parameters	ΔX	SD	95%CI		t	p	ICC
			Lower	Upper			
Body Alignment	.17	.97	-.19	.54	.96	.34	.11
Shoulder Alignment	.65	2.40	-.25	1.57	1.47	.15	.62
Axillae Alignment	.65	2.39	-.25	1.56	1.47	.15	.62
Most intended point of the trunk	.14	1.98	-.61	.89	.38	.71	.36
Pelvic Tilt	-.59	1.18	-1.03	-.14	-2.67	.01	.66
Fontal Knee Angle	.07	2.55	-.90	1.04	.15	.88	.06

DX – difference of arithmetic means; SD – standard deviation; 95%CI- interval of confidence; t-Student's t-test; ICC- the intraclass correlation coefficient

In Table 4, the analysis of the average results between the anterior and posterior planes shows statistically insignificant differences, where $p<0.05$. The smallest difference between the anterior and posterior parts of the trunk was recorded at the Asymmetry Index parameter of 0.10, and the largest average difference at the Height Difference Index of trunk with .31. The ICC values were lower than 0.6, which reflects a low correlation between the two trunk planes.

Table 4. Descriptive analysis of trunk parameters obtained through the APECS assessment tool

Parameters	ΔX	SD	95%CI		t	p	ICC
			Lower	Upper			
Frontal Asymmetry Index	.10	1.90	-.62	.82	.29	.77	.35
Height Difference Index	.31	5.71	-1.86	2.48	.29	.77	.59
Trunk Symmetry Index	.07	6.65	-2.46	2.60	.06	.96	.28

Authors should discuss the results and explain how they can be interpreted in light of previous studies and the working hypotheses. The findings and their implications should be discussed in the broadest context possible. Future research directions may also be highlighted.

4. Discussion

The aim of this study was to identify body and trunk postural asymmetries, comparing the anterior and posterior parts, in master's students specializing in physiotherapy, using a mobile application based on artificial intelligence. The results revealed that predominantly postural deviations in the anterior plane are greater compared to the posterior one, a finding also highlighted in trunk asymmetry.

Analyzing the postural indicators, it was found that pelvic asymmetry was greater in the posterior plane compared to the anterior plane, with a statistically significant difference in means of 0.59 °. This finding has a higher incidence [21-23], which is justified by the mechanical load on the pelvis, as it transmits mechanical loads asymmetrically to facilitate adaptation of the locomotor system, thereby favoring physiological alteration. Body Alignment recorded values below 1°, which reflects a correct and normal development of the body, for the age of our subjects. A previous study, conducted on 50 healthy women of a certain age, found an average deviation of 1°, which aligns with our findings [4]. Regarding Shoulder Alignment and Axillae Alignment, the postural deviation in the anterior plane was greater than

2°, and in the posterior plane of 1.41°, the two indicators presented the same deviation. These results are in agreement with previous studies where deviations equal to 1.4° were recorded [4]. Correlating the three indicators of the pelvis, mentioned above, where the most significant deviations were found, these may be associated with certain inappropriate postural habits, slight muscle imbalances, a deficient lateral spinal inclination due to the long duration of maintaining a vicious position, the habit of carrying weights on one side, the lack of constant physical activity, etc. [24-28]. The Frontal Knee Angle analysis found an alignment of approximately 2° between the legs, results that align with the findings of previous studies conducted on young women [29,30].

The asymmetry of the trunk revealed that there are no significant differences in the arithmetic means between the anterior and posterior parts, which aligns with the results of previous studies [16]. Referring to the two indices, the frontal one and the one that targets height differences, the values of the latter are approximately double, also reflected in the total asymmetry of the trunk. In a study conducted on healthy subjects, a link was found between pelvic asymmetry and altered trunk movement in the sitting position, which is explained by the compensatory mechanism of pelvic alignment that requires greater stress on the dorsal spine [31]. Trunk asymmetry is mainly conditioned by spinal deformities [5-7]. Previous studies have shown that the incidence of spinal deviations is more frequent in women compared to men, during the bone maturation process [32-34]. Regular exercise contributes to improving posture and physical fitness, provided that these exercises are adapted to the age characteristics and preferences of the subjects [35-37]. Experts in the field of physical activities and physiotherapists recommend adapting exercise programs so as to achieve correct prevention of postural problems or deviations [38-40].

Technological innovations based on machine learning offer intelligent options for assessment and personalized interventions in various health conditions used by different professional categories in the healthcare environment [41]. The use of modern intelligent technologies compared to traditional methods (plumb line, etc.) of postural assessment, presents the same increased reliability, offering real-time information, very low costs, accessibility and efficiency and effectiveness in the professional act.

Based on the results of our study, we believe that anticipatory physical exercise programs, which target postural adjustments, can be considered an effective prophylactic method tailored to individual needs. Master's students in the physical therapy specialization, through the knowledge and skills acquired in their professional training, possess the skills of timely intervention, both for their patients and for themselves personally, selecting the most effective specific toning and postural reeducation exercises.

Limits of the study

Among the limitations of this study, we highlight the most relevant ones, namely the lack of an intervention program based on the tested results and the female gender of the subjects included in the study, which was also influenced by the low number of male subjects choosing this professional specialization.

Practical implication of the study

The findings of this study carry important practical implications for the training and practice of future physical therapy professionals. A practical implication, taking into account the characteristics of the subjects of the present study, consists in knowing the advantages offered by devices based on artificial intelligence, as part of the knowledge regarding somatic assessment specific to the university curriculum. The expansion of the knowledge to be assessed from traditional to advanced, modern and current ones, with increased accessibility and reliability, offers new opportunities for the professional development of future physiotherapists. Emphasizing the early identification of postural deviations and trunk asymmetries will empower these practitioners to recognize potential issues before they evolve into more significant problems. This proactive approach allows for the development of tailored corrective and preventive programs that address the unique needs of each patient, ensuring a more personalized rehabilitation process. In addition, the integration of a reliable mobile application designed for continuous monitoring of postural changes represents a significant innovation in the field. Such an application could provide real-time feedback to both patients and therapists, enhancing the overall quality of physical therapy evaluations. By enabling consistent tracking of patient progress and facilitating the identification of emerging postural issues, the app would support timely adjustments to treatment plans. These advancements not only enhance the therapeutic experience but also hold the promise of improving patient outcomes. By fostering a deeper understanding of posture and encouraging ongoing engagement with therapeutic exercises, future physical therapists will be better equipped to help their patients achieve optimal health and mobility. This approach aligns with the evolving landscape of physical therapy, wherein technology plays a key role in delivering effective care.

5. Conclusions

The comprehensive analysis of postural and trunk asymmetry indicators in high school students specializing in physical therapy underscores the importance of normal body development. Our findings reveal that deviations between the anterior and posterior planes are statistically insignificant overall, with the notable exception of pelvic alignment. Specifically, the most pronounced differences, as determined by the arithmetic mean difference, were observed at the upper body level. Key areas of concern included Shoulder Alignment, Axillary Alignment, and Pelvic Tilt, where discrepancies indicate potential postural imbalances that could impact physical function. In terms of trunk asymmetry, our investigation did not uncover significant differences between the evaluated anterior and posterior planes; however, the Height Difference Index emerged as the most critical indicator, reflecting variations that warrant further attention. This analysis underscores the need for periodic and systematic postural evaluations, which can be enhanced through the integration of advanced technological innovations. These tools provide high reliability, can be conducted within a short time frame, are cost-effective, and enable real-time assessment of results. Given these insights, we strongly advocate for the implementation of postural investigations not only as adjuncts for individuals presenting with musculoskeletal disorders, but also as routine components of health monitoring. Incorporating these evaluations into regular check-ups can ensure a proactive approach to body development, enabling early detection and intervention for potential postural issues among students.

Author Contributions: Conceptualization: L.M.; A.B.; F.M.L.; A.M.P.; C.O.M. and N.S.; methodology: L.M.; A.B.; F.M.L.; A.M.P.; C.O.M. and N.S; software: L.M.; A.B.; F.M.L.; A.M.P.; C.O.M. and N.S; validation: L.M.; A.B.; F.M.L.; A.M.P.; C.O.M. and N.S.; investigation, L.M.; A.B.; F.M.L.; A.M.P.; C.O.M. and N.S.; writing—original draft preparation, X.X.; writing—review and editing: L.M.; A.B.; F.M.L.; A.M.P.; C.O.M. and N.S. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki, and approved by the Ethics Committee of the Faculty of Physical Education and Mountain Sports no. 35/04.02.2025.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Acknowledgments: Nothing to declare.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. 1. Gherghel, C.L.; Teodorescu, V.; Iordan, D.A.; Sardaru, D.P.; Onu, I. Analysis of oscillations of the center of pressure in postural control. Balneo and PRM Research Journal, 2024, 15(2), pp: 698, https://doi.org/10.12680/balneo.2024.698;
2. Călin, G.; Costescu, E.; Damir, D.L.; Mihai, C.; Grierosu, C.; Ciuhodaru, T. Pluridisciplinary approaches in global postural rehabilitation. Balneo and PRM Research Journal. 2024, 15(2), pp: 711, https://doi.org/10.12680/balneo.2024.711
3. Carini, F.; Mazzola, M.; Fici, C.; Palmeri, S.; Messina, M.; Damiani, P.; Tomasello, G. Posture and posturology, anatomical and physiological profiles: Overview and current state of art. Acta Biomed. 2017, 88, 11–16. https://doi.org/10.23750/abm.v88i1.5309
4. Trovato, B.; Roggio, F.; Sortino, M.; Zanghì, M.; Petrigna, L.; Giuffrida, R.; Musumeci, G. Postural Evaluation in Young Healthy Adults Through a Digital and Reproducible Method. J. Funct. Morphol. Kinesiol. 2022, 7, 98. https://doi.org/10.3390/jfmk7040098
5. Ezzatvar, Y.; Calatayud, J.; Andersen, L.L.; Aiguadé, R.; Benítez, J.; Casaña, J. Professional experience, work setting, work posture and workload influence the risk for musculoskeletal pain among physical therapists: a cross-sectional study. Int Arch Occup Environ Health. 2020, 93(2), 189-196. https://doi.org/10.1007/s00420-019-01468-7
6. Irfan, U.; Asif, S.; Mumtaz, M.; Jamal, S.; Khalid, F.; Fatima, K.; Nawaz, I.; Sheikh, N.; Rafique, H.; Aslam, I. Prevalence of Poor Body Posture among Physiotherapists Using APECS. Journal of Health and Rehabilitation Research. 2024, 4(1), 1323–1327. https://doi.org/10.61919/jhrr.v4i1.602
7. Vieira, E.R.; Schneider, P.; Guidera, C.; Gadotti, I.C.; Brunt, D. Work-related musculoskeletal disorders among physical therapists: A systematic review. J Back Musculoskelet Rehabil. 2016, 29(3), pp. 417-428. https://doi.org/10.3233/bmr-150649
8. Lim, J.H. Correlations of Symmetry of the Trunk Muscle Thickness by Gender with the Spinal Alignment in Healthy Adults. The Journal of Korean Physical Therapy, 2013, 25(6), 405-410.
9. Ramanndi, V.; Desai, A. Prevalence and Risk Factors of work-related Musculoskeletal Disorders among Indian Physiotherapists: A Narrative Review of Literature. Archives of Occupational Health. 2021, 5(2), 961-8. https://doi.org/10.18502/aoh.v5i2.6190
10. Cioroiu, S.G. Kynetoterapy of physical deficience – head and neck tilted forward. Bulletin of the Transilvania University of Brasov, Series IX, Sciences of Human Kinetics, 2016, 9(58), 2, 41-46.
11. Hämmig, O. Work-and stress-related musculoskeletal and sleep disorders among health professionals: a cross sectional study in a hospital setting in Switzerland. BMC Musculoskelet Disord. 2020, 21(1), 319, https://doi.org/10.1186/s12891-020-03327-w
12. Gorce, P.; Jacquier-Bret, P. A systematic review of work related musculoskeletal disorders among physical therapists and physiotherapists. Journal of Bodywork and Movement Therapies. 2024, 38, 350-367, https://doi.org/10.1016/j.jbmt.2024.01.025
13. Al Hussein, H.; Al Hussein, H.; Stroe, V.; Harpa, M.; Ghiragosian, C.; Goia, C.M.; Opris, C.E.; Suciu, H. Different Manifestations in Familial Isolated Left Ventricular Non-compaction: Two Case Reports and Literature Review. Front Pediatr. 2020, 8, 370. https://doi.org/10.3389/fped.2020.00370
14. Welling. A.; Gurudut, P.; Shirodkar, G.; Shetye, N.; Khan, S. Validation of non-radiographic APECS software in comparison with standard radiographic measurement of full-length lower limb hip-knee-ankle angle in elderly obese women. Physiotherapy Quarterly. 2023, 31(1), 90-94. https://doi.org/10.5114/pq.2023.119865
15. Luna, A.; Casertano, L.; Timmerberg, J. et al. Artificial intelligence application versus physical therapist for squat evaluation: a randomized controlled trial. Sci Rep. 2021, 11, 18109, https://doi.org/10.1038/s41598-021-97343-y,
16. Çankaya, M.; Takı, F.N. Comparison of postural assessment and awareness in individuals receiving posture training using the digital AI posture assessment and correction system. International Journal of Occupational Safety and Ergonomics. 2024, 30(4), 1311–1317. https://doi.org/10.1080/10803548.2024.2397836
17. Timurtaş, E.; Avcı, E.E.; Mate, K.; Karabacak, N.; Polat, M.G.; Demirbüken, İ. A mobile application tool for standing posture analysis: Development, validity, and reliability. Ir. J. Med. Sci. 2021, 191, 2123–2131. https://doi.org/10.1007/s11845-021-02827-5. 14.
18. Szucs, K.A.; Brown, E.V.D. Rater reliability and construct validity of a mobile application for posture analysis. J. Phys. Ther. Sci. 2018, 30, 31–36. https://doi.org/10.1589/jpts.30.31
19. Moreira, R.; Fialho, R.; Teles, A.S.; Bordalo, V.; Vasconcelos, S.S.; Gouveia, G.P.M.; Bastos, V.H.; Teixeira, S. A computer vision based mobile tool for assessing human posture: A validation study. Comput. Methods Programs Biomed. 2022, 214, 106565 https://doi.org/10.1016/j.cmpb.2021.106565.).
20. Hopkins, B.B.; Vehrs, P.R.; Fellingham, G.W.; George, J.D.; Hager, R.; Ridge, S.T. Validity and Reliability of Standing Posture Measurements Using a Mobile Application. J. Manip. Physiol. Ther. 2019, 42, 132–140, https://doi.org/10.1016/j.jmpt.2019.02.003

21. Gnat, R.; Saulicz, E.; Biały, M.; Kłaptocz, P. Does Pelvic Asymmetry always Mean Pathology? Analysis of Mechanical Factors Leading to the Asymmetry. Journal of Human Kinetics. 2009, 21, 23 - 35, DOI: 10.2478/v10078 - 09 - 0003 - 8
22. Fugiel, J.; Krynicka, J. The use of Moiré phenomenon in assessing the shape of the spine in the frontal plane. Physiotherapy 2010, 18, 26–31.
23. Çankaya, M., & Pouriyamanesh, P. Examination of Smartphone Applications for Assessment in Physiotherapy and Rehabilitation. In F. Nur Takı, S. Koçer & R. Bütüner (Eds.), 2024, New Generation Technologies and Sustainability in Health Current Studies (pp. 194-210). ISRES Publishing
24. Sarro, K.J.; Resende Lara, J.P.; Martins, L.; Silva, A.; Souza, S.; Momesso, I.; Miana, A. Seasonal variation of strength and power magnitude and asymmetry, and injury profile of Brazilian jiu-jitsu athletes. Journal of Physical Education and Sport. 2022, 22(6), 1346 –1355 https://doi.org/10.7752/jpes.202206169;
25. Radu, L.E.; Petrea, R.-G. Upper Body Posture Investigation in Young Track and Field Athletes. Revista Românească pentru Educaţie Multidimensională, 2022, 14(4Sup1), 314-329. https://doi.org/10.18662/rrem/14.4Sup1/675.;
26. Ene-Voiculescu, V.; Ene-Voiculescu, C.; Abramiuc, A. Professional Reconversion-Study and Perspectives on Sports Agents. Scientific Bulletin" Mircea cel Batran" Naval Academy, 2015, 18(2), 248.
27. Abramiuc, A.; Ene-Voiculescu, C.; Ene-Voiculescu, V.; Croitoru, H.; Melenco I. Method of diagnostic and SWOT analysis in the Naval pentathlon. Ovidius University Annals, Series Physical Education & Sport/Science, Movement & Health, 2023, 23(2), 103-109.
28. Stoica, A.I.; Harpa, M.M.; Banceu, C.M.; Ghiragosian, C.; Opris, C.E.; Al-Hussein, H.; Al-Hussein, H.; Flamind Oltean, S.; Mezei.; Mares, R.G.; Suciu, H. A Rare Case of Undifferentiated Pleomorphic Cardiac Sarcoma with Inflammatory Pattern. Medicina. 2022, 58(8), 1009. https://doi.org/10.3390/medicina58081009
29. Belli, G.; Maietta Latessa, P.; Rigliaco,F.; Mauro, M.; Toselli, S. Postural Assessment in Adolescent Idiopathic Scoliosis: relations between trunk and spine morphology, static balance and self-perceived body image. Sport Sciences for health, 2021, https://dx.doi.org/10.1007/s11332-021-00838-4
30. Glaner, M.F.; Mota, Y.L.; Viana, A.C R.; Santos, M.C. Fotogrametria: Fidedignidade e falta de objetividade na avaliação postural. Motricidade. 2012, 8(1), 78-85.
31. Al-Eisa, E.; Egan, D.; Deluzio, K.; Wassersug, R. Effects of Pelvic Asymmetry and Low Back Pain on Trunk Kinematics During Sitting: A Comparison With Standing. Spine. 2006, 31(5), E135-E143, https://doi.org/10.1097/01.brs.0000201325.89493.5f
32. Han, J.; Xu, Q.; Yang, Y.; Yao, Z.; Zhang. C. Evaluation of quality of life and risk factors affecting quality of life in adolescent idiopathic scoliosis. Intractable Rare Dis. Res., 2015, 4, 12-16. https://doi.org/10.5582/irdr.2014.01032
33. Brink, Y.; Louw, Q.; Somers, K.G. The quality of evidence of psychometric properties of three-dimensional spinal posture-measuring instruments. BMC Musculoskelet. Disord. 2011, 12, 93, https://doi.org/10.1186/1471-2474-12-93
34. Aroeira, R.M.; de Las Casas, E.B.; Pertence, A.E.; Greco, M.; Tavares, J.M. Non-invasive methods of computer vision in the posture evaluation of adolescent idiopathic scoliosis. J Bodyw Mov Ther. 2016, 20(4), 832-843. https://doi.org/10.1016/j.jbmt.2016.02.004
35. Gurses, V.V.; Ceylan, B.; Sakir, M.; Baydil, B.; Hussein, H.A.; Badau, D. Dehydration and Acute Weight Gain of Athletes Before Sport Competitions. Revista de Chimie, 2018, 69(11), 3196-3198. https://doi.org/10.37358/RC.18.11.6710
36. Kryeziu, A.R.; Iseni, A.; Teodor, D.F.; Croitoru, H.; Badau, D. Effect of 12 Weeks of the Plyometric Training Program Model on Speed and Explosive Strength Abilities in Adolescents. Appl. Sci. 2023, 13, 2776. https://doi.org/10.3390/app13052776
37. Kryeziu, A.R.; Begu, B.; Badau, D.; Iseni, A. Relative Age Effect (RAE) According to Norm Values on Anthropometric Performance and Physical Fitness in 9–11-Year-Old Children. J. Funct. Morphol. Kinesiol. 2025, 10, 32. https://doi.org/10.3390/jfmk10010032
38. Morina, B.; Miftari, F.; Badau, D. Fitness Level Differences between Students in Kosovo and Montenegro. Educ. Sci. 2021, 11, 140. https://doi.org/10.3390/educsci11030140
39. Pavlović, R.; Kozina, Z.: Badau, D.; Alexe C.I.; Radulović, N.; Joksimović, M. Overweight and Obesity in High School Students of 15-18 ages. A Cross-Sectional Study. Balneo and PRM Research Journal 2024, 15(2): 689, https://doi.org/10.12680/balneo.2024.689
40. Alecu, S.; Onea, G.A.; Badau, D. The Relationship Between Motivation for Physical Activity, Physical Activity Level, and Body Mass Index for University Students. Sports 2025, 13, 96. https://doi.org/10.3390/sports13040096
41. Kumar, P.; Jain, R.; Chawla, J.K. Machine Learning Innovations for Neck Health Among College Students. In: Hasteer, N., McLoone, S., Sharma, P., Nallamalli, R. (eds) Adaptive Intelligence. 2025, InCITe 2024. Lecture Notes in Electrical Engineer-ing, vol 1280. Springer, Singapore. https://doi.org/10.1007/978-981-97-9045-6_44