Revista Românească pentru Educație Multidimensională
ISSN: 2066-7329 | e-ISSN: 2067-9270
Abstracting & Indexing | Clarivate Analytics - Web of Science (WoS); EBSCO; Google Scholar; ICI Journals Master List - Index Copernicus; Ideas RePeC; Econpapers; Socionet; CEEOL; Philpapers; KVK; WorldCat; CrossRef; J-GATE

2025, Volume 17, Issue 1, pages: 454-468 | https://doi.org/10.18662/rrem/17.1/961
Submitted: December 19, 2024| *Accepted for publication:* February 5, 2025

The Impact of Flatfoot on Posture Alignment in Primary School Students – A Proposal for Educational Preventive Strategies

Elena Adelina PANAET [1]
Bogdan Alexandru ANTOHE [2,*]
Cristina Ioana ALEXE [3]
Vasile OŞEAN [4]
Julien Narcis HERLO [5]
Lucian Ovidiu BURCHEL [6]

[1] Assistant Professor, "Vasile Alecsandri" University of Bacau, Romania, panaet.adelina@ub.ro
[2] Assistant Professor, "Vasile Alecsandri" University of Bacau, Romania, antohe.bogdan@ub.ro
[3] Associate Professor, "Vasile Alecsandri" University of Bacau, Romania, alexe.cristina@ub.ro
[4] MD, Medy Sportline, Bucharest, Romania, www.medysportline.ro
[5] Lecturer PhD, "Aurel Vlaicu" University of Arad, Romania, nherlo@yahoo.com.
[6] Lecturer PhD, "Lucian Blaga" University of Sibiu, Romania, lucian.burchel@frf.ro
* corresponding author: antohe.bogdan@ub.ro

Abstract: *Flatfoot is considered a structural condition that can occur in either one foot (unilaterally) or both feet (bilaterally), manifested by the collapse of the medial plantar arch of the foot, rearfoot pronation, and forefoot abduction. The purpose of the study was to investigate the impact of flatfoot on postural alignment of the primary school students regarding early detection and prevention of postural deviation. Using a pre-test design, foot posture was assessed using Foot Posture Index-6 and postural alignment using Global Postural System 400. The study's findings showed that there are statistically significant correlations between flatfoot and postural alignment. Specifically, significant correlations were found both: between the left flatfoot and the frontal alignment of the pelvis on the left side ($r = -.504$, $p < .014$) and between the midfoot and the frontal alignment of the ipsilateral pelvis ($r = -.754$, $p < .001$). In addition, strong correlations were identified between the alignment of the pelvic girdle on the side of the pronated and hyperpronated foot and the shoulder girdle in the frontal plane ($r = .617$, $p < .002$; $r = .600$, $p < .002$). The findings of the study underscore the relevance of early detection and implementation of intervention strategies in school, considering the impact of flatfoot on primary school students' posture.*

Keywords: *flatfoot, posture, postural deviations, foot pronation, FPI-6.*

How to cite: Panaet, E. A., Antohe, B. A., Alexe, C. I., Oşean, V., Herlo, J. N., & Burchel, L. O. (2025). The impact of flatfoot on posture alignment in primary school students- a proposal for educational preventive strategies. *Revista Românească pentru Educație Multidimensională, 17*(1), 454-468. https://doi.org/10.18662/rrem/17.1/961

©2025 Published by In Manifest Network in partnership with LUMEN Publishing. This is an open access article under the CC BY-NC-ND license http://creativecommons.org/licenses/by-nc-nd/4.0/

Introduction

Flatfoot is considered a structural condition that can occur in either one foot (unilaterally) or both feet (bilaterally), manifested by the collapse of the medial plantar arch of the foot, rearfoot pronation, and forefoot abduction (Vergillos Luna et al., 2023).

Specialists in the field demonstrate that in the case of flatfoot, was observed several common clinical modifications that impact the structure of the foot. In connection with the tibia, the calcaneum is plantar flexed, the talus follows the calcaneum and realizes the plantar flexion, navicular is forced to abduct and dorsal flexed. At the same time, the forefoot is in an abduction and supination position. Furthermore, radiological investigations subjects with flatfoot exhibit a marked exacerbation of the articular space between the talus and navicular and contribute to the collapse of the plantar arch (Ezema et al., 2014; Peeters et al., 2013; Dare, 2014).

Flatfoot is not just a simple deformity. The excessive hindfoot pronation of the hindfoot, the collapse of the medial longitudinal arch, and the forefoot's abduction forced the medial edge of the foot to become convex. This phenomenon exerts additional stress on musculoskeletal structures, which try to compensate for the biomechanical deficit (Ghasemi et al., 2016; Cote et al., 2005).

The postural deviations associated with biomechanical alterations affect the foot's walking function (Jouira et al., 2024) and significantly affect the entire body. Such changes, in combination with body morphology and composition, can compromise stability, balance, and coordination, negatively influencing physical activity (Calcaterra et al., 2022), especially in highly complex sports such as basketball or football (Čović et al., 2023; Čaušević et al., 2023). In this context, identifying and correcting postural deviations caused by flatfoot become critical for preventing injuries and optimizing performance.

In addition to the biomechanical explanations, we highlight the importance of the plantar surface in the postural tonic activity. The plantar surface, rich in somatosensory endings, provides information that facilitates the coordination and adjustment of the postural response (Shumway-Cook, 1986). Therefore, even minimal changes to the human support base can significantly impact postural control strategies (Alexe, 2013). In other words, changes in the foot's structure trigger several adaptive reactions, not only in the foot but also in the upper structures of the body.

Following the concept that the feet are considered a crucial sensory structure involved in postural control mechanisms, several researchers have

identified essential correlations between foot posture types and various changes in posture alignment (Van Boerum & Sangeorza, 2003; Buldt et al., 2013).

From a biomechanical point of view, bilateral feet hyperpronation creates tension forces that force the tibia, knees, and hips to rotate (Cornwall et al., 1991; Barton et al., 2009) internally. Therefore, the pelvis is anteriorized, and the lumbar spine is hyperlordosis through the conjugation connections of the pelvic-lumbar complex. Compensatory, to preserve the body's homeostasis, the thoracic and cervical spine change their posture (Yi, 2016). It can generate structural and functional deficits in the lower limbs (Khamis & Yizhar, 2007).

Some clinical trial results indicate that structural changes in flatfoot influence the pelvic and spine alignment (Khamis et al., 2015; Ghasemi et al., 2016). The authors consider that when the tibia, knee, and hip perform internal rotation, the femoral head is pushed posteriorly into the acetabular cavity and, therefore, will anteriorize the pelvis.

Due to the lumbar-pelvic complex's connective connections, this pelvis forward inclination can produce lumbar hyperlordosis. The iliopsoas muscle tenses, inhibiting the activity of the gluteal muscles, which makes them unable to provide maximum performance. Therefore, the hamstring muscles and extensor hamstrings take over their role. Thus, a muscular imbalance is created between the abdominal and back muscles, which also causes the exacerbation of the curvatures of the vertebral column (Dabholkar, 2012).

In contrast with bilateral pronation, unilateral pronation causes the pelvis to rotate forward (anterior pelvic tilt posture). In this case, the pelvis tilts on the side of the affected lower limb (Eldesoky & Abutaleb, 2015). Although this limb is shorter, this difference is a functional adaptation. When the difference exceeds 1-2 cm, imbalances occur in the pelvis, leading to dorso-lumbar scoliosis (Albu & Albu, 2000).

Following the statistical results, the researchers emphasize the importance of assessing the foot posture in vertebral column deviations, as the biomechanical alignment of the foot can directly influence the structure and posture of the entire body, including the spine (Coglianese, 2006; Negrini et al., 2016; Ionite et al., 2022). The Foot Posture Index (FPI-6) is a standard method for assessing and evaluating foot posture. It offers an objective and standardized assessment of the various components of foot alignment and valuable information in diagnosing and treating spinal deviations.

Even the clinical manifestation of the flexible flatfoot improves with age: the plantar arch develops and matures (Turner et al., 2020), and the valgus of the feet reduces (Valmassy et al., 1996; Sobel et al., 1999), the flatfoot still registers high prevalence in primary school students (Vergara-Amador et al., 2012). It was found that approximately 59% of 2083 children aged between 7- 12 years were diagnosed with flatfoot, with a preponderance among 8 years (Chang et al., 2010).

The premises of the study were based on the following training framework: (1) the foot is one of the pillars of the postural system and is regarded as a primary input of postural tonic activity with a role in providing sensory information, for the elaboration and adjustment of postural responses; (2) any change in the support base can disrupt the functional level of the foot structures and consequently can change the entire kinematic chain of the body.

Based on the scientific foundations mentioned above, this study aims to investigate the impact of flat feet on the postural alignment of primary school students, highlighting the need for early detection and implementation of preventive strategies for postural deviation.

Material and methods

Participants

The participants were selected based on eligibility criteria. The study included 23 subjects, eleven girls and twelve boys, primary school students (mean age 7.54±0.61 years). We applied the following inclusion criteria: primary school students aged 7 to 9 years, an FPI-6 score ≥ 6 points, and a flexible foot. On the other hand, the exclusion criteria concerned subjects with a history of trauma to the lower limbs or feet, surgeries in the same area, length discrepancies of the lower limbs, neuro-muscular pathologies, use of plantar supports, and obesity. To participate in this study, we obtained informed consent from their parents.

Instruments

Foot Posture Index 6 (FPI-6) is a valid assessment tool for foot posture in various clinical settings. Based on visual and palpation evaluation methods, it frames foot posture regarding supination, neutrality, or pronation. Following a standard procedure of evaluation, this tool can evaluate the foot in a static position in orthostatic, assessing six criteria: palpation of the head of the talus to establish its position, visual evaluation of curve formed by the edge above and below the lateral malleolus, visual

evaluation of inversion or eversion of the calcaneum, navicular position and the height of the medial longitudinal arch, adduction or abduction of the forefoot.

The Rasch statistical model confirms the validity of the construct of the six-item instrument and the consistency of the PSI=0.88 metric results (Keenan et al., 2007). This tool is handy in paediatric populations, where early detection of foot position abnormalities can guide interventions for conditions such as flatfoot. The instrument uses a scoring system based on the Likert scale, where the subjects that register a lower score indicate a very supinated foot. In contrast, higher scores indicate a very pronated foot (Figure 1).

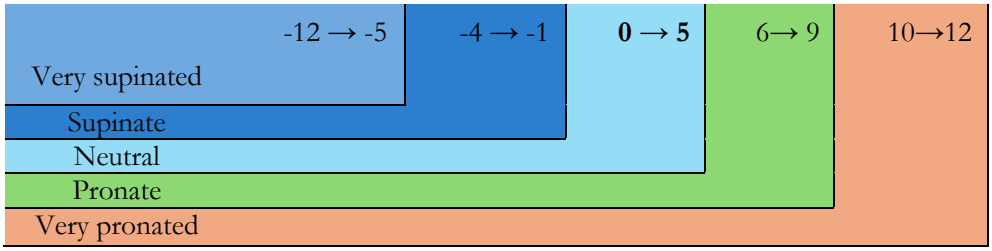


Figure 1. Interpretation of the FPI-6 score according to Redmond et al. (2006) (author's creation)

The Global Postural System 400 (GPS 400) is a postural analysis device that captures digital information about the position of segments of the body in different anatomical planes. It comprises several items accompanied by software that registers, processes, and calculates the variables related to body morphology. The hardware component of the GPS 400 includes a platform, a digital camera that captures the posture in real-time, and a frame ruler with sensors vertically defined by two bars. The markers used for the assessment include horizontal alignment of the eyes, nose-ear plane, head position, shoulder alignment, the line formed between the scapulae, and alignment of the pelvis, knees, and ankles. The GPS 400 is considered a reliable system due to its ability to produce consistent and accurate measurements of postural parameters. Included in the system is the PodataTM, a plantar pressure and weight distribution analysis device used in the biomechanical evaluation of the feet. This device is part of a complex diagnostic system that analyzes posture and gait problems by capturing the plantar footprint and estimating the distribution of forces applied to the plantar surface.

Evaluation procedure

a) Identifying the type of foot

The subjects were informed and instructed about the testing procedure. After this step, they were asked to stay relaxed and barefoot on the testing surface. For this step, we used a wooden base with the following characteristics: 40 cm x 44 cm x 20 cm. Throughout the testing procedure, the subjects stayed still but relaxed and tried to keep a visual target placed 10 m away. For data interpretation and subject selection, the following reference values were applied: a neutral foot was defined by a score ranging from 0 to 5; a pronated foot corresponds to scores between 6 to 9; a very pronated foot was characterized by scores above 10; a supinated foot identified with scores between -1 and -4; and a very supinated foot indicated by scores below -5 (Figure 1).

b) Assessment of posture and footprint

The assessment of posture and the plantar footprint was performed by postural analysis and 2D podometry. First, the subjects were asked to place their feet on marks indicated on the platform. The entire body was scanned, and the reference points were captured using the sensors from sliding wires. In step 2, the subjects did two steps on the spot, after which they were positioned on the PodataTM platform to assess body weight distribution on the plantar surface. Then, they were asked to remain still and relaxed for 30 seconds while data on plantar surfaces were recorded. The system generated the image of the plantar surface, highlighting the footprint of the sole. Subsequently, the loading areas on each foot were estimated in pixels by measuring the anterior plantar surface (metatarsal area) and the medial longitudinal arch (the narrowest region of the sole).

Statistical analysis

Statistical analysis was performed by applying the Pearson correlation using the IBM SPSS software package (Version 25), with a significance level set to $p \leq 0.05$ (two-tailed).

Results

The analysis of the results obtained through FPI-6 highlighted the following findings: a) 6 subjects (26.08% of the total subjects evaluated) were classified with both feet in the reference category very pronate; b) 7 subjects, representing 30.43% of the total number of participants, had a right very pronated foot and a left pronated foot; c) 10 subjects (43.47%) had a pronated right foot and a very pronated left foot (Figure 2).

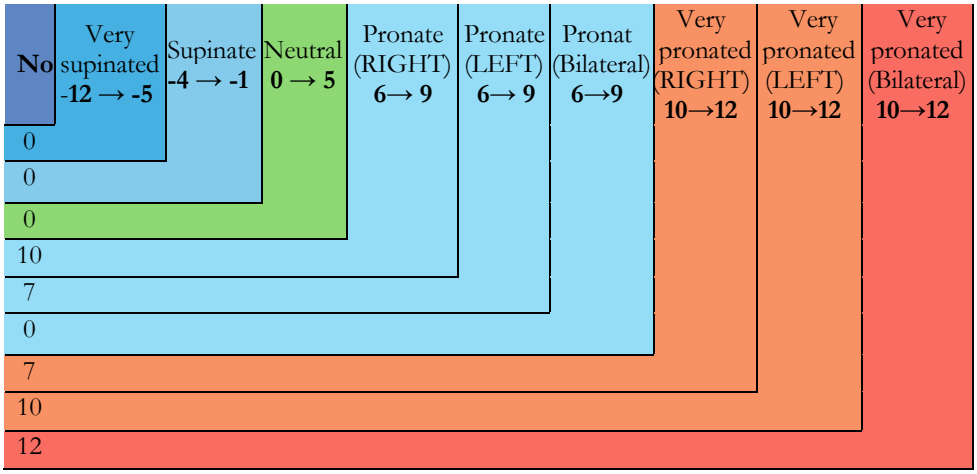


Figure 2. The number of feet analyzed and the ir interpretation according to according to Redmond et al. (2006)- (author's creation)

The distribution of flatfoot children, based on FPI-6 scores for the right and left feet, have an asymmetry that tends to agglomerate towards high values. For both FPI 6 scores, the median of data collected for right and left foot was 10, suggesting more than half of the sample recorded lower or higher scores than this reference point. We highlight that at the top of the graph (Q3-max range), there is a higher concentration of FPI 6-lf scores. This could express that more subjects recorded higher scores for the left foot than the right foot.

Pearson correlation analysis

The Pearson correlation coefficient was used to evaluate the relationships between the variables, which measures the strength of the relationship between them. We investigated the relationship between the FPI-6 right foot score (independent variable) and FPI-6 the left foot score (independent variable), and the following dependent variables: the distance between the upper sensor and the acromion homolateral to the very pronated foot, the distance between the upper sensor and the acromion homolateral to the pronated foot, the distance between the upper sensor and the acromion on the right foot, the distance between the upper sensor and the acromion on the left foot, the distance between the lateral sensor and the iliac crest both feet, calcaneus angles, tibiae angles, pelvis tilt angle, the distances between posterior sensors and the lumbar and dorsal spinous process, the distances between the anterior sensor and the acromion for the right and left foot, the plantar pressure distribution in the forefoot and

midfoot area for both feet. We mention that, in Table no. 1 and Table no. 2, we highlight the results of the Pearson correlations analysis relevant to our study, which were selected from a large volume of data. Therefore, the statistical analysis highlighted the following relationships:

- Significant negative, medium-to-strong correlation between left flatfoot and frontal pelvis alignment: FPI-6 Lf score and distance between the iliac crest and lateral sensor left foot ($r = -.504$, $p < .014$), Table 1;
- Highly significant negative correlation of strong intensity between the left midfoot area and the pelvis alignment in the frontal plane, homolateral: left midfoot area, and the distance between the lateral sensor and iliac crest homolateral to Lf ($r = -.754$, $p < .00$), Table 2;
- Significant positive correlation of medium to strong intensity was established between the pelvis alignment and alignment of the shoulder girdle in the frontal plane (distance of the iliac crest Lf -lateral sensor and distance of the acromion- superior sensor on homolateral to the pronated feet and also homolateral to very pronated feet ($r= .617$; $p < .002$; $r= .600$; $p < .002$), table 2;
- A significant positive correlation of strong intensity was established in the frontal plane, between the pelvis alignment and the shoulder girdle in the frontal plane (distance from the lateral sensor Lf and the distance from the superior sensor and acromion Rf ($r= .575$; $p < .004$), table 2;
- Between the pelvis alignment and the alignment of the scapular girdle has established a strong, significant, positive, high-intensity correlation in the frontal plane: iliac crest distance Rf- lateral sensor and acromion distance Lf - upper sensor ($r= .637$; $p < .001$), table 2;
- No correlations were found between the left flatfoot and pelvis alignment in the sagittal plane: FPI-6 Rf respectively Lf and pelvic tilt angle ($r = -.035$, $p < 0.874$; $r = 0.069$ $p < .753$), Table 1;
- No correlations were found between flatfoot and lumbar spine alignment: FPI-6 Rf and Lf score Rf, and lumbar spinous process distance-posterior sensor ($r = -.154$, $p < .482$; $r = -.099p < .652$), Table 1;
- No correlations were found between flatfoot and dorsal spine alignment: FPI-6 score PD respectively PS and dorsal spinous process - posterior sensor ($r = -.318$, $p < .139$; $r = 0.081$ $p < .714$), Table 1.

Table 1. Pearson's correlation coefficient between flatfoot and postural references (author's analysis)

		Lateral sensor-Iliac crest distance Right foot	Lateral sensor-Iliac crest distance Left foot	Tilt angle - pelvis	Posterior sensor-Lumbar spinous process	Posterior sensor-Dorsal spinous process
FPI-6 Right foot	Pearson Correlation	-0,179	0,396	-0,035	-0,154	-0,318
	Sig. (2-tailed)	0,414	0,061	0,874	0,482	0,139
	N	23	23	23	23	23
FPI-6 Left foot	Pearson Correlation	0,224	-,504*	0,069	0,099	0,081
	Sig. (2-tailed)	0,303	0,014	0,753	0,652	0,714
	N	23	23	23	23	23

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Table 2. Pearson's correlation coefficient between dependent variables (author's analysis)

		Left midfoot area	Upper sensor and acromion-pronated foot	Upper sensor-acromion-very pronated foot	Upper sensor-acromion-Right foot	Upper sensor-acromion-Left foot
Lateral sensor-Iliac crest distance Left foot	Pearson Correlation	-,754**	,617**	,600**	,575**	,637**
	Sig. (2-tailed)	0,000	0,002	0,002	0,004	0,001
	N	23	23	23	23	23

Discussions

The results of this study confirm that primary school students aged 7-9 with flatfeet show changes in body posture, especially in the alignment of the pelvis and the shoulder girdle.

Our results emphasize the international literature, which indicates that structural deviations in the foot can influence the ascending kinematic chain, leading to compensatory changes superiorly (Molina-Rueda et al., 2014; Kothari

et al., 2016). Results of experimental studies demonstrated that a minimal deviation in the alignment of the subtalar joint forces the talus to slide medially, which induces, through the biomechanical links, an internal rotation at the level of the tibia (Metcalfe et al., 2011). In a previous study, it was confirmed that in subjects aged 7-9 years, there is a statistically supported link between flatfoot and calcaneal and tibial alignment, ipsilateral (Panaet et al., 2022).

Flatfoot and pelvic alignment

The results of our study suggest changes in the pelvic alignment in the frontal plane, ipsilateral with the left flatfoot.

Both feet registered higher FPI-6 scores. The left midfoot expresses strong statistical links with the pelvic alignment in the frontal plane. From a clinical point of view, these variables highlight the fact that the left flatfoot has a more significant pronation component, and together with the collapsed plantar arch, they are related to the lateral translation of the pelvis. Similarly, Resende et al. (2016), demonstrated that foot pronation causes biomechanical changes in both the lower limbs and the trunk, exacerbating knee adduction, calf rotation, and lateral trunk translation.

No statistically supported results were recorded for landmarks measured in the sagittal plane at the pelvis level. Based on biomechanical reasoning, Khamis et al., 2007, proved that the coupling movement between the ankle and the tibia generates the knee's internal rotation, which is closely related to the internal rotation movement of the femur. As a result, the femur pushes into the posterior acetabular region, causing the pelvis to anteriorize (Duval et al., 2010). Similar results were found in the study of Wyndow et al. (2016) which confirmed that a pronounced forward inclination of the pelvis was observed in subjects with foot pronation.

Flatfoot and dorso-lumbar spine

Our results cannot confirm the link between flatfoot and the spine because no statistical evidence was found at the lumbar and dorsal level of children with flatfoot. Contrary to the results of the current study, Kim et al., 2017), obtained by inducing calcaneal hyperpronation, the forward inclination of the pelvis, suggesting that the body tries to reduce the disturbances caused by the initial imbalance through different adjustments of the postures of the upper structures. Moreover, it was observed that increasing the curvature of the lumbar spine by one degree will exacerbate the vertebral flexion of the dorsal spine. Through a comprehensive analysis of the structure and function of joints, Levangie et al. (2005, 495-496) explain the mechanism by which the posterior convexity of the dorsal spine enlarges and compensates for lumbar hyperlordosis to keep the head in alignment with the sacrum.

Flatfoot and shoulder girdle

In the context of postural changes at the pelvic level, the forward inclination of the pelvis often causes a compensatory reaction in the spine in the form of lumbar lordosis and thoracic kyphosis, which can lead to anteriorization of the shoulders and an anterior position of the head (Lim, 2012; Neumann, 2016).

Our study results indicated that the pelvis' alignment did not change in the sagittal plane. A lateral translational movement was found in the opposite direction in the frontal plane.

In unilateral flatfoot, authors highlight an ipsilateral forward inclination of the pelvis that creates a lateral translation. These functional adjustments make the length of the lower limb appear smaller. When the difference is more significant than 1-2 cm, it causes imbalances in the pelvis and leads to lumbar scoliosis.

Since the selected age group is in a critical development stage, our study significantly contributes to understanding the link between the feet and postural alignment of the children regarding early detection and prevention of postural deviation. Additionally, our study provides a comprehensive framework for guiding other specialists in the assessment of pediatric flatfoot. In this regard, our findings suggest that it is essential to effectuate a complete evaluation of a child with flatfoot rather than focusing just on the foot.

These strategies align with global health and education initiatives promoting holistic child development.

Another perspective that our study proposes focuses on the interdisciplinary approach. Incorporating FPI-6 and GPS could be an assessment tool used in schools, encouraging multidisciplinary approaches that help create internationally applicable preventive and corrective strategies.

Limitations of the study are represented by the small and demographically homogeneous sample, which may limit the generalization of the results compared to a broader population. Secondly, this study has not explored in detail whether these correlations differ depending on the severity of the flatfoot.

Starting from the idea that prophylactic education is essential in an actual societal context, the prevention of posture disorders generated by lack of activity, genetic factors, obesity, demographic-geological factors, and sociological contexts, we consider it necessary for other future studies to develop our idea as a scientific approach to establishing prophylactic educational strategies in different age categories.

Author contributions

PEA and ABA contributed to the design and implementation of the research, ACI and OV were used to analyze the results, and HJN and BLO were used to write the manuscript. All authors have read and agreed to the published version of the manuscript.

References

Albu, A, Albu, C. (2000). *Asistenta psihopedagogica si medicala a copilului deficient fizic [Psycho-pedagogical and medical assistance for the physically deficient child]*. Polirom

Alexe, D. I. (2013). *Echilibrul la pubertate. Relația dominanță emisferică - performanță.* [*Balance at puberty. Hemispheric dominance-performance relationship]*. Performantica

Barton, C. J., Bonanno, D., & Menz, H. B. (2009). Development and evaluation of a tool for the assessment of footwear characteristics. *Journal of foot and ankle research*, *2*(1), 10. https://doi.org/10.1186/1757-1146-2-10

Buldt, A. K., Murley, G. S., Butterworth, P., Levinger, P., Menz, H. B., & Landorf, K. B. (2013). The relationship between foot posture and lower limb kinematics during walking: A systematic review. *Gait & posture*, *38*(3), 363–372. https://doi.org/10.1016/j.gaitpost.2013.01.010

Calcaterra, V., Marin, L., Vandoni, M., Rossi, V., Pirazzi, A., Grazi, R., Patané, P., Silvestro, G. S., Carnevale Pellino, V., Albanese, I., Fabiano, V., Febbi, M., Silvestri, D., & Zuccotti, G. (2022). Childhood obesity and incorrect body posture: Impact on physical activity and the therapeutic role of exercise. *International Journal of Environmental Research and Public Health*, *19*(24), 16728. https://doi.org/10.3390/ijerph192416728

Čaušević, D., Rani, B., Gasibat, Q., Čović, N., Alexe, C. I., Pavel, S. I., Burchel, L. O., & Alexe, D. I. (2023). Maturity-related variations in morphology, body composition, and somatotype features among young male football players. *Children (Basel, Switzerland)*, *10*(4), 721. https://doi.org/10.3390/children10040721

Chang, J. H., Wang, S. H., Kuo, C. L., Shen, H. C., Hong, Y. W., & Lin, L. C. (2010). Prevalence of flexible flatfoot in Taiwanese school-aged children about obesity, gender, and age. *European Journal of Pediatrics*, *169*(4), 447–452. https://doi.org/10.1007/s00431-009-1050-9

Coglianese, D. (2006). Muscles: testing and function with posture and pain, ed 5 (with Primal Anatomy CD-ROM). *Physical Therapy*, *86*(2), 304-305. https://doi.org/10.1093/ptj/86.2.304

Cornwall, M. W., & Murrell, P. (1991). Postural sway following inversion sprain of the ankle. *Journal of the American Podiatric Medical Association*, *81*(5), 243–247. https://doi.org/10.7547/87507315-81-5-243

Cote, K. P., Brunet, M. E., Gansneder, B. M., & Shultz, S. J. (2005). Effects of pronated and supinated foot postures on static and dynamic postural stability. *Journal of Athletic Training*, *40*(1), 41–46.

Čović, N., Čaušević, D., Alexe, C. I., Rani, B., Dulceanu, C. R., Abazović, E., Lupu, G. S., & Alexe, D. I. (2023). Relations between specific athleticism and morphology in young basketball players. *Frontiers in sports and active living*, *5*, 1276953. https://doi.org/10.3389/fspor.2023.1276953

Dabholkar, A., Shah, A., & Yardi, S.S. (2012). Comparison of dynamic balance between flat feet and normal individuals using star excursion balance test. *Indian Journal of Physiotherapy and Occupational Therapy—An International Journal, 6*, 27-31.

Dare, D. M., & Dodwell, E. R. (2014). Pediatric flatfoot: cause, epidemiology, assessment, and treatment. *Current Opinion in Pediatrics*, *26*(1), 93–100. https://doi.org/10.1097/MOP.0000000000000039

Duval, K., Lam, T., & Sanderson, D. (2010). The mechanical relationship between the rearfoot, pelvis, and low-back. *Gait & posture*, *32*(4), 637–640. https://doi.org/10.1016/j.gaitpost.2010.09.007

Eldesoky, M.T., & Abutaleb, E.E. (2015). Influence of bilateral and unilateral flatfoot on pelvic alignment. *World Academy of Science, Engineering and Technology, International Journal of Medical and Health Sciences, 9*(8), 641-645. https://doi.org/10.5281/zenodo.1107806

Ezema, C. I., Abaraogu, U. O., & Okafor, G. O. (2014). Flat foot and associated factors among primary school children: A cross-sectional study. *Hong Kong Physiotherapy Journal*, *32*(1), 13-20. https://doi.org/10.1016/j.hkpj.2013.05.001

Ghasemi, M. S., Koohpayehzadeh, J., Kadkhodaei, H., & Ehsani, A. A. (2016). The effect of foot hyperpronation on spine alignment in standing position. *Medical Journal of the Islamic Republic of Iran*, *30*, 466.

Ionite, C., Rotariu, M., Osean, V., Mitran, C.I., & Condurache, I. (2022). Scoliosis incidence and treatment methods. *Balneo and PRM Research Journal, 13(2): 504*. https://bioclima.ro/Balneo504.pdf

Jouira, G., Rebai, H., Alexe, D. I., Sahli, S. (2024). Postural balance in boys with intellectual disabilities who participate in soccer training. *Pediatric Exercise Science*, *37*(1) 37-45. https://doi.org/10.1123/pes.2023-0098

Keenan, A. M., Redmond, A. C., Horton, M., Conaghan, P. G., & Tennant, A. (2007). The Foot Posture Index: Rasch analysis of a novel, foot-specific outcome measure. *Archives of Physical Medicine and Rehabilitation*, *88*(1), 88–93. https://doi.org/10.1016/j.apmr.2006.10.005

Khamis, S., & Yizhar, Z. (2007). Effect of feet hyperpronation on pelvic alignment in a standing position. *Gait & posture*, *25*(1), 127–134. https://doi.org/10.1016/j.gaitpost.2006.02.005

Khamis, S., Dar, G., Peretz, C., & Yizhar, Z. (2015). The Relationship Between Foot and Pelvic Alignment While Standing. *Journal of human kinetics*, *46*, 85–97. https://doi.org/10.1515/hukin-2015-0037

Kim, S. C., Yi, J. H., Jung, S. W., & Seo, D. K. (2017). The effects of calcaneal posture on thoracolumbar alignment in a standing position. *Journal of Physical Therapy Science, 29*(11), 1993–1995. https://doi.org/10.1589/jpts.29.1993

Kothari, A., Dixon, P. C., Stebbins, J., Zavatsky, A. B., & Theologis, T. (2016). Are flexible flat feet associated with proximal joint problems in children? *Gait & posture*, *45*, 204–210. https://doi.org/10.1016/j.gaitpost.2016.02.008

Levangie, P. K., Norkin, C.C. (2005). *Joint structure & function. A comprehensive analysis*. F. A. Davis Company.

Lim, B. W., Hinman, R. S., Wrigley, T. V., Sharma, L., & Bennell, K. L. (2008). Does knee malalignment mediate the effects of quadriceps strengthening on knee adduction moment, pain, and function in medial knee osteoarthritis? A randomized controlled trial. *Arthritis and rheumatism*, *59*(7), 943–951. https://doi.org/10.1002/art.23823

Metcalfe, S. A., Bowling, F. L., & Reeves, N. D. (2011). Subtalar joint arthroereisis in the management of pediatric flexible flatfoot: a critical review of the literature. *Foot & Ankle International*, *32*(12), 1127–1139. https://doi.org/10.3113/FAI.2011.1127

Molina-Rueda, F., Alguacil-Diego, I. M., Cuesta-Gómez, A., Iglesias-Giménez, J., Martín-Vivaldi, A., & Miangolarra-Page, J. C. (2014). Thorax, pelvis and hip pattern in the frontal plane during walking in unilateral transtibial amputees: biomechanical analysis. *Brazilian journal of physical therapy*, *18*(3), 252–258. https://doi.org/10.1590/bjpt-rbf.2014.0032

Negrini, S., Donzelli, S., Aulisa, A. G., Czaprowski, D., Schreiber, S., de Mauroy, J. C., ... & Zaina, F. (2018). 2016 SOSORT guidelines: Orthopaedic and rehabilitation treatment of idiopathic scoliosis during growth. *Scoliosis and spinal disorders*, *13*, 3, 1-48. https://doi.org/10.1186/s13013-017-0145-8

Neumann, D. A. (2016). *Kinesiology of the musculoskeletal system: Foundations for rehabilitation*. 3rd ed., Elsevier

Panaet, A. E., Alexe, C. I., Stângaciu, O. A., Hazar, F., Rată, G. Alexe, D. I., Hofmeister, M. (2022). The effects of pediatric flat foot on the frontal alignment of proximal segment. *Balneo and PRM Research Journal*, *13*(2), 499, 1-10. https://bioclima.ro/Balneo499.pdf

Peeters, K., Schreuer, J., Burg, F., Behets, C., Van Bouwel, S., Dereymaeker, G., Sloten, J. V., & Jonkers, I. (2013). Altered talar and navicular bone morphology is associated with pes planus deformity: a CT-scan study. *Journal of Orthopaedic Research: Official Publication of the Orthopaedic Research Society*, *31*(2), 282–287. https://doi.org/10.1002/jor.22225

Redmond, A, C., Crosbie, J., & Ouvrier, R. A. (2006). Development and validation of a novel rating system for scoring standing foot posture: The foot posture index. *Clinical biomechanics (Bristol, Avon), 21*(1), 89–98. https://doi.org/10.1016/j.clinbiomech.2005.08.002

Resende, R. A., Deluzio, K. J., Kirkwood, R. N., Hassan, E. A., & Fonseca, S. T. (2015). Increased unilateral foot pronation affects lower limbs and pelvic biomechanics during walking. *Gait & posture*, *41*(2), 395–401. https://doi.org/10.1016/j.gaitpost.2014.10.025

Shumway-Cook, A., & Horak, F. B. (1986). Assessing the influence of sensory interaction of balance. Suggestion from the field. *Physical therapy*, *66*(10), 1548–1550. https://doi.org/10.1093/ptj/66.10.1548

Sobel, E., Levitz, S., Caselli, M., Brentnall, Z., & Tran, M. Q. (1999). Natural history of the rearfoot angle: preliminary values in 150 children. *Foot & ankle international, 20*(2), 119–125. https://doi.org/10.1177/107110079902000209

Turner, C., Gardiner, M. D., Midgley, A., & Stefanis, A. (2020). A guide to the management of pediatric pes planus. *Australian journal of general practice*, *49*(5), 245–249. https://doi.org/10.31128/AJGP-09-19-5089

Valmassy, R. L. (1996). *Clinical biomechanics of the lower extremities.* 1st ed. Mosby

Van Boerum, D. H., & Sangeorzan, B. J. (2003). Biomechanics and pathophysiology of flat foot. *Foot and ankle clinics*, *8*(3), 419–430. https://doi.org/10.1016/s1083-7515(03)00084-6

Vergara-Amador, E., Serrano Sánchez, R. F., Correa Posada, J. R., Molano, A. C., & Guevara, O. A. (2012). Prevalence of flatfoot in school between 3 and 10 years. Study of two different populations geographically and socially. *Colombia medica (Cali, Colombia)*, *43*(2), 141–146. https://doi.org/10.25100/cm.v43i2.785

Vergillos Luna, M., Khal, A. A., Milliken, K. A., Solla, F., & Rampal, V. (2023). Pediatric flatfoot: Is there a need for surgical referral?. *Journal of Clinical Medicine*, *12*(11), 3809. https://doi.org/10.3390/jcm12113809

Wyndow, N., Collins, N. J., Vicenzino, B., Tucker, K., & Crossley, K. M. (2018). Foot and ankle characteristics and dynamic knee valgus in individuals with patellofemoral osteoarthritis. *Journal of foot and ankle research*, *11*, 65. https://doi.org/10.1186/s13047-018-0310-1

Yi, J. (2016). The effects of increased unilateral and bilateral calcaneal eversion on pelvic and trunk alignment in standing position. *Physical Therapy Rehabilitation Science*, *5*(2), 84-88. https://doi.org/10.14474/ptrs.2016.5.2.84