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Identifying Postural Dysfunction as a Common Phenotype in Flatfoot, Pronated Foot, and Genu Valgum: A Cross-Sectional Study in the Pediatric Population

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Abstract

Background: To investigate the association between symptomatic flexible flatfoot, pronated foot, and genu valgum and global postural alignment in children and adolescents, with particular focus on pelvic and spinal parameters and patterns of pain localization. **Methods**: A cross-sectional observational study was conducted on a cohort of 2,130 individuals evaluated for postural dysfunction. A paediatric subgroup (=126) between the ages of 6 and 10 years (M_{age} = 8.50, SD = 1.78), presenting with symptomatic lower-limb deformities was selected. Participants were classified into three groups: symptomatic flexible flatfoot (n = 64), pronated foot (n = 38), and genu valgum (n = 24), based on clinical and radiographic criteria including Foot Posture Index (FPI-6), Staheli Arch Index, Meary's angle, talo-calcaneal angle, and femoro-tibial angle. Global postural alignment was assessed using optoelectronic analysis and weight-bearing radiographs. **Results**: Neutral postural alignment was infrequently observed. Recurrent patterns included pelvic anteversion and mild variations in sagittal spinal curves, generally within paediatric reference ranges. Frontal-plane deviations were common but predominantly mild. Differences between groups were mainly related to distribution rather than magnitude of postural variations. Pain was described according to anatomical location. **Conclusions**: Lower-limb deformities in children appear to be associated with specific patterns of postural adaptation rather than isolated segmental alterations. However, findings should be interpreted cautiously due to the absence of a control group and the cross-sectional design. Further studies are required to determine clinical relevance.

Keywords: flatfoot; pronated foot; genu valgum; pain; posture

1. Introduction

Lower-limb alignment variations, including flatfoot, pronated foot, and genu valgum, are among the most commonly observed musculoskeletal conditions during growth and development and are generally considered part of physiological variability in pediatric populations [1–3]. In many cases, these conditions are asymptomatic and self-limiting. However, when associated with pain or functional complaints, their clinical relevance becomes more complex and may extend beyond the local anatomical region [4,5].

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Previous studies have reported that symptomatic flexible flatfoot is associated with altered plantar pressure distribution, reduced balance, impaired proprioception, and diminished shock absorption capacity of the medial longitudinal arch [6–8]. Similarly, pronated foot has been linked to kinematic alterations during gait, including increased internal rotation of the tibia and femur and changes in lower-limb alignment, potentially influencing mechanical loading at the knee and hip joints [9,10]. Genu valgum, particularly when persistent beyond physiological developmental stages, has been associated with altered patellofemoral mechanics and anterior knee pain [11].

From a biomechanical perspective, alterations at the level of the foot and knee may influence load transmission along the kinetic chain and be associated with adaptations in more proximal segments, including the pelvis and spine [12,13]. These adaptations may reflect compensatory strategies aimed at maintaining postural stability and locomotor efficiency. However, in growing individuals, such findings must be interpreted with caution, as many postural variations fall within normal developmental ranges and may not necessarily represent pathological conditions [14,15].

Commonly described postural patterns include pelvic anteversion, variations in lumbar lordosis and thoracic kyphosis, and frontal-plane spinal asymmetries. In pediatric populations, these features occur within the context of ongoing skeletal growth and neuromotor development, making it challenging to distinguish between physiological adaptation and clinically relevant dysfunction [16,17].

Despite increasing interest in the relationship between lower-limb alignment and global posture, most studies have examined flatfoot, pronated foot, and genu valgum individually [18,19]. Direct comparisons of these conditions within the same population remain limited, particularly in children and adolescents. Furthermore, the extent to which these deformities are associated with broader postural patterns, rather than isolated segmental alterations, is still not clearly defined.

The aim of the present study was therefore to investigate the association between symptomatic flexible flatfoot, pronated foot, and genu valgum and patterns of global postural alignment in children and adolescents. Particular attention was given to pelvic orientation, sagittal and frontal spinal parameters, and the anatomical distribution of pain. This study does not aim to establish causal relationships, but rather to describe potential associations within a clinical population presenting with postural complaints.

2. Materials and Methods

2.1. Study Design

This cross-sectional observational study was conducted on a cohort of individuals referred for clinical evaluation of postural dysfunction. All participants underwent a standardized clinical examination, three-dimensional optoelectronic postural analysis in upright stance, and weight-bearing radiographic assessment, allowing an integrated evaluation of peripheral alignment and global posture.

The study was performed in accordance with the Declaration of Helsinki and approved by the local Ethics Committee (approval number: 587/2024/MEDF-12/11). Written informed consent was obtained from the parents or legal guardians of minors prior to inclusion. The use of radiographic imaging was clinically justified and performed according to standard paediatric safety protocols.

2.2. Participants

A total of 2,130 individuals (age range: 6–75 years) were initially evaluated for postural dysfunction. For the purposes of the present study, a paediatric subgroup aged 6–10 years presenting with symptomatic lower-limb deformities was selected for analysis.

Participants were classified into three groups:

1. symptomatic flexible flatfoot
2. pronated foot
3. genu valgum

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Inclusion and Exclusion Criteria

Inclusion criteria were:

- age between 6 and 10 years
- presence of lower-limb deformity associated with musculoskeletal pain

Exclusion criteria included:

- previous lower-limb surgery
- neuromuscular or congenital disorders
- recent lower-limb trauma

Other potential causes of pain and postural alteration in paediatric populations, such as spondylolysis, spondylolisthesis, or shortening of posterior muscular chains, were not systematically assessed and represent a limitation of the study.

2.3. Clinical Assessment

Foot posture was assessed using the Foot Posture Index (FPI-6) [20], acknowledging that its application in younger children may be associated with reduced reliability. The Staheli Arch Index [21] was used to quantify medial longitudinal arch morphology.

Postural evaluation in upright stance included:

- knee extension (normal or hyperextension)
- pelvic orientation (neutral, anteversion, retroversion, anterior shift)
- sagittal spinal curves (lumbar lordosis and thoracic kyphosis)
- frontal spinal alignment

Neutral postural alignment was defined as the absence of clinically evident deviations in both sagittal and frontal planes, according to standardized observational criteria.

All clinical assessments were performed by trained clinicians following standardized protocols. Inter-examiner consistency was supported through calibration sessions.

2.4. Radiographic Assessment

Weight-bearing radiographs were obtained with participants in a standardized upright position. The following parameters were measured:

- Meary's angle
- talo-calcaneal angle
- femoro-tibial angle (FTA)

Measurements were performed using standardized anatomical landmarks, and when necessary, repeated measurements were averaged to improve reliability.

2.5. Optoelectronic Postural Analysis

Global postural alignment was assessed using a three-dimensional optoelectronic motion analysis system. Passive reflective markers were placed on standardized anatomical landmarks of the trunk, pelvis, and lower limbs.

During quiet bipedal stance, three-dimensional positional data were recorded to quantify:

- pelvic tilt
- lumbar lordosis
- thoracic kyphosis
- frontal-plane spinal deviations

All acquisitions were performed by trained operators under standardized conditions, with system calibration conducted prior to each session.

2.6. Spinal Alignment Definitions

Sagittal and frontal spinal alignment were evaluated using both optoelectronic analysis and radiographic measurements. All parameters were interpreted with reference to paediatric normative ranges, considering age-related variability.

2.7. Thoracic Kyphosis

Thoracic kyphosis was measured in degrees and classified according to commonly reported pediatric reference values. Values between approximately 20° and 50° were considered within the physiological range, while values exceeding 50° were classified as hyper kyphosis. Mild increases within the upper physiological range were described as postural variations rather than structural deformities.

2.8. Lumbar Lordosis

Lumbar lordosis was evaluated using angular measurements and interpreted according to paediatric reference ranges, typically between 30° and 60°, depending on age. Values exceeding these ranges were considered increased lordosis, while values within the upper limits of normal were interpreted cautiously as potential postural adaptations rather than pathological findings.

2.9. Frontal Spinal Alignment

Frontal-plane spinal alignment was assessed to identify lateral deviations. Given the absence of radiographic confirmation using Cobb angle measurements in all cases, the term "scoliosis" was not used diagnostically. Instead, deviations were classified descriptively as:

- within normal limits
- mild deviation (consistent with postural or functional asymmetry)
- marked deviation (requiring further clinical or radiographic evaluation)

Only deviations supported by radiographic assessment and meeting established diagnostic thresholds (Cobb angle ≥10°) would be consistent with scoliosis; however, such differentiation was not the primary aim of this study.

2.10. Diagnostic Criteria

Diagnostic classification was based on a combination of clinical findings and radiographic parameters, interpreted in relation to age-specific reference values.

Symptomatic flexible flatfoot was defined by an FPI-6 score between 6 and 10, Meary's angle greater than 15°, talo-calcaneal angle exceeding 40°, and a Staheli Arch Index above age-related normative values, in association with reported symptoms.Pronated foot was defined by an FPI-6 score between 6 and 9 in combination with Meary's angle greater than 15°, without complete collapse of the medial longitudinal arch as observed in flexible flatfoot. Genu valgum was defined by a reduced femoro-tibial angle (FTA). Given the known variability during growth, values between approximately 170° and 175° were interpreted with caution and considered in relation to age, to minimize potential overdiagnosis. Only participants fulfilling the diagnostic criteria and reporting pain associated with posture or physical activity were included in the analyses.

2.11. Outcome Measures

Primary outcomes included patterns of postural alignment and their association with lower-limb deformities.

Variables analyzed included:

- pelvic configuration
- lumbar lordosis
- thoracic kyphosis

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- frontal spinal alignment
- knee extension

Pain was recorded according to anatomical location (e.g., lumbar, femoro-patellar, hip), without quantitative assessment of intensity, duration, or functional impact.

2.12. Statistical Analysis

Descriptive statistics were calculated for all variables. Categorical variables were analysed using chi-square tests, while continuous variables were expressed as means and standard deviations. Statistical significance was set at $p < 0.05$.

Analyses focused on identifying associations between deformity type, postural parameters, and pain localization within the paediatric subgroup.

3. Results

3.1. Study Sample

A total of 2,130 individuals were initially evaluated for postural dysfunction. Among these, a paediatric subgroup (=126; 61 male, 65 female) between the ages of 6 and 10 years (Mage = 8.50, SD = 1.78), presenting with symptomatic lower-limb deformities was selected for analysis.

Within this subgroup:

- symptomatic flexible flatfoot: n = 64
- pronated foot: n = 38
- genu valgum: n = 24

Anthropometric characteristics were included in the Table 1.

Table 1. Participants' anthropometric characteristics (Mean ± standard deviation).

Group	Age	Height (cm)	Weight (kg)	BMI (kg/m²)
Symptomatic flexible flatfoot = 64	8.1±1.4	113.3 ± 4.3	34.3 ± 2.3	26.7
Pronated foot = 38	8.8±1.7	114.1 ± 4.1	31.1 ± 2.8	23.9
Genu valgum = 24	8.5±1.8	110.1 ± 4.8	33.1 ± 2.6	27.3

3.2. Distribution Across Age Groups

All examined deformities were observed within the paediatric age range included in the study (6–10 years). No comparisons with other age groups were performed, and therefore no conclusions regarding age-related prevalence can be drawn.

3.3. Postural Alignment

Across all groups, a fully neutral global postural alignment was infrequently observed.

Pelvic anteversion was the most common finding, present in approximately:

- 61% of symptomatic flexible flatfoot
- 67% of genu valgum

Lumbar lordosis and thoracic kyphosis frequently showed mild increases across all groups. However, the majority of values remained within reported paediatric reference ranges, suggesting that these findings may reflect postural adaptations rather than structural abnormalities.

Frontal-plane spinal deviations were also observed in all groups. These were predominantly mild and compatible with postural asymmetry. Marked deviations were more frequently observed in the flatfoot group, although no definitive diagnosis of scoliosis was established based on radiographic criteria.

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3.4. Quantitative Parameters

Meary's angle (Figure 1) was significantly higher in the flatfoot and pronated foot groups compared to genu valgum ($p < 0.001$), reflecting differences in medial arch configuration.

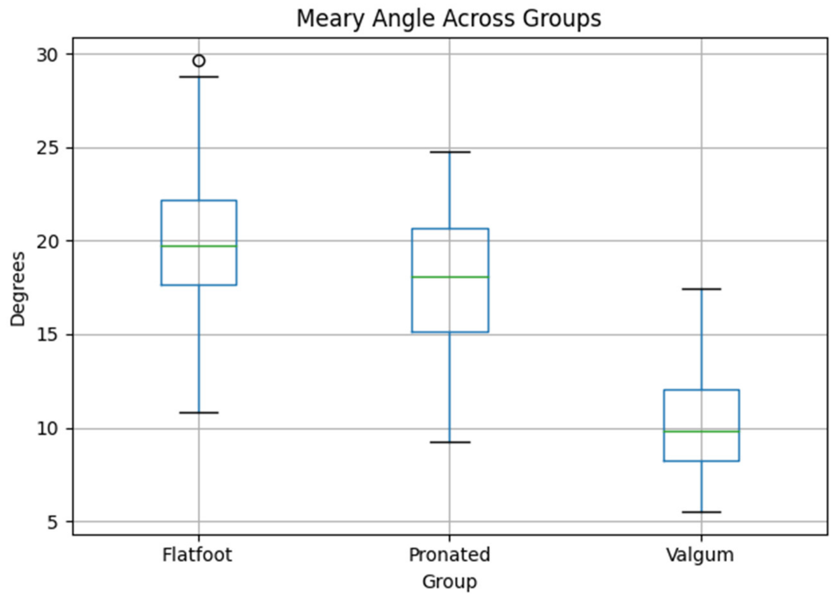

Figure 1. Meary's angle.

The femoro-tibial angle (Figure 2) was significantly reduced in the genu valgum group ($p < 0.001$), consistent with frontal-plane knee alignment.

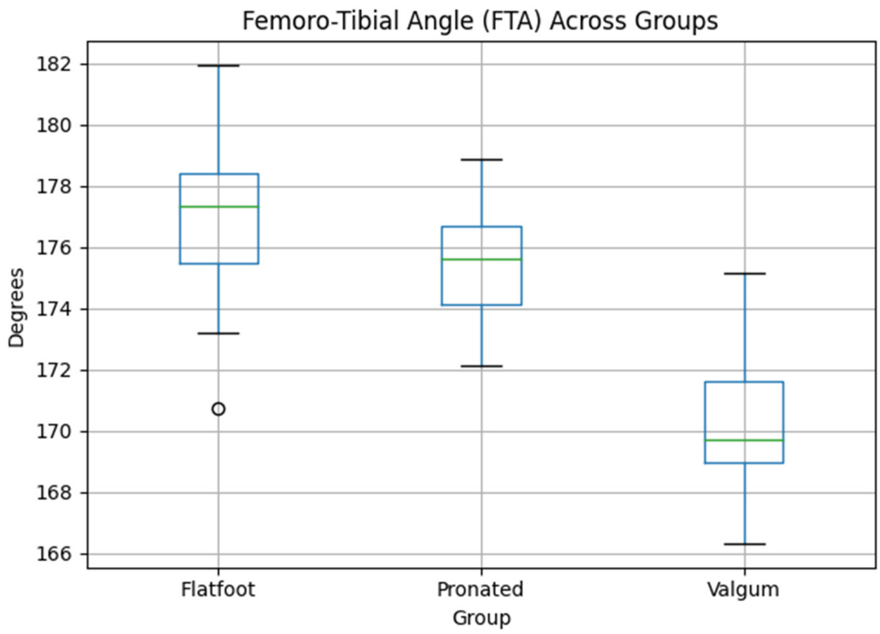

Figure 2. Femoro-tibial angle.

Differences in lumbar lordosis (Figure 3) reached statistical significance ($p = 0.028$), although absolute values remained within physiological ranges. No significant differences were observed for thoracic kyphosis.

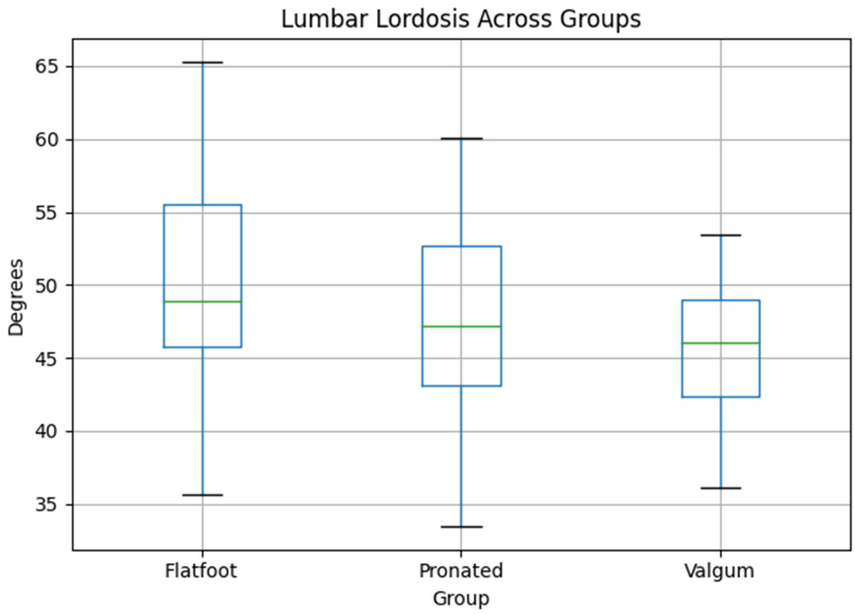

Figure 3. Lumbar lordosis.

3.5. Sagittal Spinal Alignment

Variations in sagittal spinal alignment were observed across all deformity groups. These findings were interpreted as potential postural adaptations within the kinetic chain, although causality cannot be established.

Mild increases in lumbar lordosis were observed in:

- 30 of 46 children with symptomatic flexible flatfoot (65%)
- 22 of 36 with pronated foot (61%)
- 16 of 24 with genu valgum (67%).

Marked increases in lumbar lordosis were less frequent and were most commonly observed in the pronated foot group (10/36; 28%), compared with symptomatic flexible flatfoot (8/46; 17%) and genu valgum (4/24; 17%).

Overall, most values remained within paediatric reference ranges, suggesting adaptive rather than structural changes.

Thoracic kyphosis showed a comparable distribution. Mild increases were observed in:

- 65% of children with symptomatic flexible flatfoot
- 83% of those with pronated foot
- 67% of those with genu valgum

Marked increases in thoracic kyphosis were less frequent, occurring in:

- 17% of symptomatic flexible flatfoot
- 11% of pronated foot
- 17% of genu valgum

3.6. Frontal Spinal Alignment

Variations in frontal-plane spinal alignment were also observed across all groups. These findings were described in terms of postural deviations rather than structural deformities.

Mild deviations of the primary frontal spinal curve were common:

- 61% in symptomatic flexible flatfoot
- 56% in pronated foot
- 50% in genu valgum

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More pronounced deviations were observed more frequently in the flatfoot group (39%), followed by pronated foot and genu valgum (approximately 33% each).

Secondary frontal deviations were present in:

- 61% of symptomatic flexible flatfoot
- 50% of pronated foot

More marked secondary deviations were observed only in symptomatic flexible flatfoot (13%) and pronated foot (6%), and were not detected in the genu valgum group. These findings represent postural asymmetries rather than scoliosis, as no systematic Cobb angle assessment was performed.

3.7. Pain Localization

Pain was described according to anatomical location.

- Symptomatic flexible flatfoot was more frequently associated with low-back pain
- Pronated foot was associated with knee and hip overload-related pain
- Genu valgum was predominantly associated with femoro-patellar pain.

Overall patterns of postural alignment and pain localization across the three groups are summarized in Table 2, providing a comparative overview of the main clinical findings.

Table 2. Postural characteristics and pain distribution.

Variable	Flatfoot	Pronated foot	Genu valgum
Knee hyperextension (%)	30%	28%	12%
Pelvic anteversion (%)	61%	-	67%
Lumbar lordosis (mild ↑)	65%	61%	67%
Thoracic kyphosis (mild ↑)	65%	83%	67%
Primary frontal deviation (mild)	61%	56%	50%
Secondary deviation (%)	61%	50%	0%
Main pain location	Low back	Knee/Hip	Femoro-patellar

Note. Values expressed as percentages. Pain reported by anatomical location.

4. Discussion

The present study explored the association between common lower-limb deformities and global postural alignment in a paediatric population presenting with musculoskeletal pain. The findings suggest that symptomatic flexible flatfoot, pronated foot, and genu valgum are associated with recurrent patterns of postural variation involving the pelvis and spine [6,10,22]. However, these findings should be interpreted as associations rather than causal relationships.

Across all groups, pelvic anteversion and mild variations in sagittal spinal alignment were frequently observed [23,24]. In particular, increases in lumbar lordosis and thoracic kyphosis were common, although most values remained within reported paediatric reference ranges. This suggests that the observed patterns may reflect adaptive or developmental postural variations rather than clear structural abnormalities. These observations are consistent with previous literature indicating that lower-limb alignment may be associated with proximal biomechanical adaptations along the kinetic chain [25].

Despite these common features, differences between groups were primarily related to the distribution rather than the magnitude of postural variations. Symptomatic flexible flatfoot was associated with a broader pattern of postural involvement, including both sagittal and frontal adaptations, whereas pronated foot and genu valgum appeared to show more localized patterns. These findings may reflect differences in load distribution and biomechanical demands, as previously suggested in studies examining plantar pressure, gait kinematics, and joint loading [26–29].

Pain localization also differed across groups, with low-back pain more frequently observed in symptomatic flexible flatfoot and more localized symptoms in pronated foot and genu valgum.

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However, pain was assessed only in terms of anatomical location and not quantified in terms of intensity, duration, or functional impact. Therefore, its clinical interpretation remains limited.

The present findings should be interpreted in light of several methodological limitations. First, the absence of an asymptomatic control group prevents differentiation between physiological postural variability and clinically relevant alterations. Second, the cross-sectional design does not allow conclusions regarding causality or the temporal evolution of postural patterns. Third, potentially relevant factors such as muscle flexibility, physical activity levels, and other causes of paediatric pain (e.g., spondylolysis or muscular imbalances) were not systematically assessed. Additionally, the broad age range without stratification may have contributed to variability in the findings.

Despite these limitations, the study provides a descriptive overview of postural patterns associated with symptomatic lower-limb deformities in children and adolescents. By analyzing flatfoot, pronated foot, and genu valgum within the same cohort, this study contributes to a more integrated interpretation of lower-limb alignment in relation to global posture, an area that has been relatively underexplored in paediatric populations [30–34].

From a clinical perspective, these findings support the importance of evaluating children with lower-limb deformities within a broader biomechanical context rather than focusing exclusively on the affected segment. However, given that many of the observed variations fall within physiological ranges, caution is required to avoid overinterpretation and overdiagnosis.

Future research should include longitudinal designs, age-stratified analyses, and asymptomatic control groups to clarify whether these postural patterns represent transient developmental adaptations or clinically relevant dysfunctions. The inclusion of functional assessments and patient-reported outcome measures would further enhance the clinical interpretation of these findings.

In summary, symptomatic flexible flatfoot, pronated foot, and genu valgum in children appear to be associated with recurring patterns of postural variation involving the pelvis and spine. However, these patterns should be interpreted cautiously within the context of normal growth and development, and do not necessarily indicate a unified pathological condition.

5. Conclusions

The present study suggests that symptomatic flexible flatfoot, pronated foot, and genu valgum in children and adolescents are associated with recurring patterns of postural adaptation involving the pelvis and spine. These patterns differ in distribution, with flatfoot showing more widespread adaptations and pronated foot and genu valgum presenting more localized features.

However, these findings should be interpreted with caution. The absence of an asymptomatic control group, the lack of detailed pain characterization, and the cross-sectional design limit the ability to establish causal relationships or determine clinical significance. Furthermore, many of the observed postural variations fall within reported paediatric reference ranges and may reflect physiological variability rather than pathological conditions.

Future studies incorporating control groups, age stratification, and longitudinal follow-up are needed to clarify whether these postural patterns represent transient developmental adaptations or clinically relevant dysfunctions requiring intervention.

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Institutional Review Board Statement: The study was conducted according to the recommendations of the Ethical Code of the University of Palermo and of the Code of Ethics approved by the General Assembly of the Italian Association of Psychology held on 27 March 2015. All participants were informed about the procedures

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of the study and the anonymity of their answers before providing their written consent to participate, in accordance with the Declaration of Helsinki. The study design was approved by the Departmental Research Committee (approval number: 587/2024/MEDF-12/11).

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

Data Availability Statement: The data that support the findings of this study are available from the corresponding author (D.D.C.), upon reasonable request.

References

1. Cömert, G.M.; Gruber, M. Exercise modalities for improving frontal plane knee and foot posture in healthy adults: A systematic review. *Sports* **2025**, *13*, 52. https://doi.org/10.3390/sports13020052
2. Ghorbani, M.; Yaali, R.; Sadeghi, H.; Luczak, T. The effect of foot posture on static balance, ankle and knee proprioception in 18-to-25-year-old female students: A cross-sectional study. *BMC Musculoskelet. Disord.* **2023**, *24*, 547. https://doi.org/10.1186/s12891-023-06678-2
3. Ghorbani, M.; Norasteh, A.A.; Tabatabaei, S.; Akbarzadeh, A. The impact of flatfeet on functional movement, balance, agility, and core muscle strength in young females. *Sci. Rep.* **2025**, *15*, 5077. https://doi.org/10.1038/s41598-025-89364-8
4. Sabouri, L.; Ebrahimi Takamjani, I.; Salavati, M.; Akhbari, B.; Mazaheri, M. Biomechanics of transitional movements in individuals with pronated feet: A review. *J. Sport Biomech.* **2025**, *11*, 270–287. https://doi.org/10.61882/JSportBiomech.11.3.270
5. Harris, E.J. The natural history and pathophysiology of flexible flatfoot. *Clin. Pediatr. Med. Surg.* **2010**, *27*, 1–23. https://doi.org/10.1016/j.cpm.2009.09.002
6. Nourbakhsh, S.A.; Sheikhhoseini, R.; Piri, H.; et al. Spatiotemporal and kinematic gait changes in flexible flatfoot: A systematic review and meta-analysis. *J. Orthop. Surg. Res.* **2025**, *20*, 223. https://doi.org/10.1186/s13018-025-05649-8
7. Pfeiffer, M.; Kotz, R.; Ledl, T.; Hauser, G.; Sluga, M. Prevalence of flatfoot in preschool-aged children. *Pediatrics* **2019**, *144*, e20191530. https://doi.org/10.1542/peds.2019-1530
8. Willy, R.W.; Hoglund, L.T.; Barton, C.J.; Bolgla, L.A.; Scalzitti, D.A.; Logerstedt, D.S.; et al. Patellofemoral pain: Clinical practice guidelines. *J. Orthop. Sports Phys. Ther.* **2020**, *50*, CPG1–CPG70. https://doi.org/10.2519/jospt.2019.0302
9. Dodelin, D.; Tourny, C.; L'Hermette, M. The biomechanical effects of pronated foot function on gait: An experimental study. *Scand. J. Med. Sci. Sports* **2020**, *30*, 2167–2177. https://doi.org/10.1111/sms.13785
10. Abbasi, S.; Mousavi, S.H.; Khorramroo, F. Association between lower limb alignment and low back pain: A systematic review with meta-analysis. *PLoS ONE* **2024**, *19*, e0311480. https://doi.org/10.1371/journal.pone.0311480
11. Peoples, B.M.; Harrison, K.D.; Samaan, M.A.; Mobley, C.B.; Redden, D.T.; Roper, J.A. Knee health is a major determinant of mobility across the healthspan. *J. Funct. Morphol. Kinesiol.* **2025**, *10*, 454. https://doi.org/10.3390/jfmk10040454
12. Micheo, W.; Rodríguez-Santiago, B.; Sepulveda-Irizarry, F.; Castillo, B. Knee injuries. In *Essential Sports Medicine: A Clinical Guide for Students and Residents*; Springer: Cham, Switzerland, 2021; pp. 315–340. https://doi.org/10.1007/978-3-030-64316-4_16
13. Thabit, G.; Micheli, L.J. Patellofemoral pain in the pediatric patient. *Orthop. Clin. N. Am.* **1992**, *23*, 567–585. https://doi.org/10.1016/S0030-5898(20)31772-7
14. Rodgers, M.M. Dynamic foot biomechanics. *J. Orthop. Sports Phys. Ther.* **1995**, *21*, 306–316. https://doi.org/10.2519/jospt.1995.21.6.306
15. Yiou, E.; Hamaoui, A.; Allali, G. The contribution of postural adjustments to body balance and motor performance. *Front. Hum. Neurosci.* **2018**, *12*, 487. https://doi.org/10.3389/fnhum.2018.00487
16. Azevedo, N.; Ribeiro, J.C.; Machado, L. Balance and posture in children and adolescents: A cross-sectional study. *Sensors* **2022**, *22*, 4973. https://doi.org/10.3390/s22134973
17. Asaka, T.; Okubo, Y.; Hasegawa, N. Postural control priorities and effective motor learning. *Front. Hum. Neurosci.* **2025**, *18*, 1542432. https://doi.org/10.3389/fnhum.2024.1542432

18. Patil, M.; Kulkarni, M.S.; Sinha, A.; Ghorpade, R.R. Biomechanical variations in patients with flatfoot deformity: Impact of gender, age, and BMI on foot kinetics and kinematics. *J. Orthop.* **2024**, *57*, 90–97. https://doi.org/10.1016/j.jor.2024.06.018
19. Hira, K.; Nagata, K.; Hashizume, H.; et al. Relationship of sagittal spinal alignment with low back pain and physical performance in the general population. *Sci. Rep.* **2021**, *11*, 20604. https://doi.org/10.1038/s41598-021-00116-w
20. Redmond, A.C.; Crosbie, J.; Ouvrier, R.A. Development and validation of a novel rating system for scoring standing foot posture: The foot posture index. *Clin. Biomech.* **2006**, *21*, 89–98. https://doi.org/10.1016/j.clinbiomech.2005.08.002
21. Staheli, L.T.; Chew, D.E.; Corbett, M. The longitudinal arch. *J. Bone Joint Surg. Am.* **1987**, *69*, 426–428. https://doi.org/10.2106/00004623-198769030-00014
22. Yucekul, A.; Ozpinar, A.; Kilickan, F.D.B.; et al. Relationship between pelvic incidence-adjusted spinopelvic parameters and lower extremity compensations. *Eur. Spine J.* **2023**, *32*, 3599–3607. https://doi.org/10.1007/s00586-023-07677-6
23. Vialle, R.; Levassor, N.; Rillardon, L.; Templier, A.; Skalli, W.; Guigui, P. Radiographic analysis of sagittal spinal alignment in asymptomatic subjects. *J. Bone Joint Surg. Am.* **2005**, *87*, 260–267. https://doi.org/10.2106/JBJS.D.02043
24. Okamura, K.; Nagamune, N.; Fukuda, K.; Kanai, S. Classification of foot kinematics during gait in individuals with pronated foot. *J. Biomech.* **2024**, *173*, 112258. https://doi.org/10.1016/j.jbiomech.2024.112258
25. Cömert, G.M.; Gruber, M. Exercise modalities for improving frontal plane knee and foot posture. *Sports* **2025**, *13*, 52. https://doi.org/10.3390/sports13020052
26. Chinpeerasathian, C.; Sin Oo, P.; Siriphorn, A.; Pensri, P. Effect of foot orthoses on balance among individuals with flatfoot: A systematic review. *PLoS ONE* **2024**, *19*, e0299446. https://doi.org/10.1371/journal.pone.0299446
27. Khorramroo, F.; Hijmans, J.M.; Mousavi, S.H. The impact of wide step width on lower limb coordination. *PLoS ONE* **2025**, *20*, e0321901. https://doi.org/10.1371/journal.pone.0321901
28. Mousavi, S.H.; Khorramroo, F.; Jafarnezhadgero, A. Gait retraining targeting foot pronation: A systematic review. *PLoS ONE* **2024**, *19*, e0298646. https://doi.org/10.1371/journal.pone.0298646
29. Yalfani, A.; Ahmadi, M.; Asgarpoor, A. The effect of kinetic factors of dynamic knee valgus on patellofemoral pain. *J. Bodyw. Mov. Ther.* **2024**, *37*, 246–253. https://doi.org/10.1016/j.jbmt.2023.11.001
30. Lafage, R.; Duvvuri, P.; Elysee, J.; et al. Quantifying lower limb compensation in posture. *Spine* **2023**, *48*, 1082–1088. https://doi.org/10.1097/BRS.0000000000004646
31. Böhm, H.; Dussa, C.U. Impact of mild leg length discrepancy on pelvic alignment in children. *Gait Posture* **2025**, *118*, 122–129. https://doi.org/10.1016/j.gaitpost.2025.02.003
32. Farivar, M.; Harris, S.; Agana, A.; King, A.C. Lower limb cross-over effects on postural control. *Biomechanics* **2024**, *4*, 50–62. https://doi.org/10.3390/biomechanics4010004
33. Gonzalez-Medina, G.; Perez-Cabezas, V.; Ruiz-Molinero, C.; et al. Effectiveness of global postural re-education. *J. Clin. Med.* **2021**, *10*, 5327. https://doi.org/10.3390/jcm10225327
34. Sacco, I.C.; Trombini-Souza, F.; Suda, E.Y. Impact of biomechanics on rehabilitation. *J. Biomech.* **2023**, *154*, 111604. https://doi.org/10.1016/j.jbiomech.2023.111604