

Static Foot Disorders in Young Athletes: Insights from a Podoscopic Study in Algeria

Background: Static foot disorders (SFD) are morphological and biomechanical abnormalities of the foot during weight-bearing that alter plantar arches, foot segment alignment, and plantar load distribution. They may disrupt the lower-limb biomechanical chain, affect athletic performance, and increase injury risk. Data on SFD in young North African athletes remain scarce. **Objective:** To evaluate the prevalence and podoscopic profile of SFD in a population of young Algerian athletes. **Methods:** This descriptive cross-sectional study was conducted in Tougourt, southeastern Algeria. A total of 426 young athletes aged 18–21 years (mean age 19.5 ± 0.89 years) participated. Footprints were recorded using an electronic podoscope with LED light, two webcams, and GPS 110 software. The Chippaux–Smirak Index (CSI) was used to classify foot type: $CSI \leq 24\%$ = pes cavus; $CSI 25\text{--}45\%$ = neutral foot; $CSI \geq 46\%$ = pes planus. Rearfoot alignment was also assessed. **Results:** Mean BMI was 21.06 ± 3.18 kg/m²; 69.5% had normal weight, and 90.4% practiced sport regularly. Team sports represented 70.1% of participants, endurance sports 22.6%, combat sports 4.2%, and strength sports 3.1%. The prevalence of pes cavus was 57.3%, neutral foot 27.2%, and flatfoot 15.5%. Rearfoot alignment was normo-axed in 62.9%, valgus in 26.8%, and varus in 10.3%. **Conclusion:** SFD are frequent in young Algerian athletes, with pes cavus being the predominant foot type. Podoscopic screening should be integrated into pre-participation evaluation to guide prevention, footwear prescription, and early management of athletes at risk.

Keywords: static foot disorders; pes cavus; flatfoot; podoscope; Chippaux–Smirak Index; athletes; Algeria

Introduction

The foot plays a central role in athletic performance. As Westlin (1997) stated, “More than the worker, more than the soldier, the athlete needs his feet.” In sport, the foot must simultaneously provide stability, shock absorption, propulsion, and sensory feedback. Consequently, any structural or functional abnormality may affect performance and increase the risk of injury.

Static foot disorders (SFD) are defined as morphological and biomechanical abnormalities of the foot during weight-bearing, characterized by lasting changes in the plantar arches, alignment of foot segments or toes, and distribution of plantar loads, resulting in disruption of the lower-limb biomechanical chain (Xu et al., 2026; Cano, 2025). SFD include primarily pes planus (flatfoot) and pes cavus (high-arched foot), which may be associated with altered plantar pressure, postural control, and injury risk.

Several evaluation tools are available for SFD, including clinical examination, the Foot Posture Index (FPI-6), podoscopic footprint analysis, and radiographic measurements such as the Djian–Annonier angle and Méary–

Toméno axis. Podoscopy is a simple, non-invasive, and accessible method that provides objective data on plantar support and foot morphology.

SFD have been associated with lower-limb injuries. A systematic review and meta-analysis by Tong and Kong (2013), including 29 studies, reported a significant association between SFD and lower-extremity injuries (OR = 1.23; 95% CI: 1.11–1.37; $p < 0.001$). The association appeared slightly stronger for high-arched foot (OR = 1.31) than for flatfoot (OR = 1.23). Pérez-Morcillo et al. (2019) found that both flatfoot and cavus foot were strongly associated with running-related injuries. Campbell et al. (2025) also confirmed that lower-limb stress fractures are more common in tactical athletes with biomechanical risk factors.

In young athletes, musculoskeletal pain is highly prevalent. Ellapen et al. (2014), in a study of junior male soccer players, reported that 72.2% experienced soccer-related musculoskeletal pain, with the knee (42.9%) and ankle (28.6%) being the most affected sites. These findings highlight the importance of early screening for risk factors, including podiatric ones, in young athletic populations.

SFD may also be associated with chronic venous disease. Uhl et al. (2012) reported that static foot disorders were present in 31% of limbs affected by chronic venous disease, with higher adjusted odds for pes cavus (AOR = 4.19) and pes planus (AOR = 3.14). Soti et al. (2024) similarly identified SFD as a risk factor for chronic venous disease, particularly in individuals under 30 years of age.

In addition, flatfoot has been linked to postural chain alterations. Kowalski (2004) described the “foot–knee–spine triad,” and Puzovic et al. (2015) found a significant association between flat feet and thoracic kyphosis in young basketball players. These findings highlight the importance of early detection of SFD in young athletes.

Despite this evidence, few studies have focused on SFD in Algerian athletes. The aim of this study was therefore to evaluate the prevalence of static foot disorders in a population of young Algerian athletes using an electronic podoscope and the Chippaux–Smirak Index.

Materials and Methods

Study design and setting

This was a descriptive cross-sectional study conducted among young athletes in Touggourt, southeastern Algeria. The study was designed to establish a podoscopic profile of young Algerian athletes.

Participants

A total of 426 young athletes participated in the study. Inclusion criteria were: age between 18 and 21 years, regular or occasional sports practice, and no acute foot injury at the time of assessment. The mean age was 19.5 ± 0.89 years.

Age distribution was: 18 years, 12.2%; 19 years, 39.0%; 20 years, 34.7%; and 21 years, 14.1%.

Mean BMI was 21.06 ± 3.18 kg/m². BMI categories were: underweight 20.0%, normal weight 69.5%, overweight 8.0%, and obese 2.6%. Regarding sports practice, 90.4% practiced regularly and 9.6% occasionally. The main sport categories were team sports (70.1%), endurance sports (22.6%), combat sports (4.2%), and strength sports (3.1%).

Podoscopic assessment

Footprints were recorded using an electronic podoscope equipped with LED light, two webcams, and a computer running GPS 110 software. The Global Postural System (GPS 110) software enabled podometric analysis using linear and angular measurements on recorded images. Participants stood barefoot in a standardized bipedal position on the podoscope. Footprint images were recorded, printed, compared, and analyzed.

Figure 1. Electronic Podoscope



Chippaux–Smirak Index

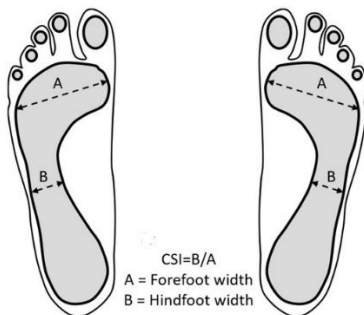
The Chippaux–Smirak Index (CSI) was calculated as the ratio between the minimum width of the foot at the level of the isthmus and the maximum width of the forefoot:

$$\text{CSI} = \frac{\text{Minimum width at the isthmus}}{\text{Maximum width of the forefoot}} \times 100$$

Foot type was classified as follows:

- $\text{CSI} \leq 24\%$: pes cavus
- $\text{CSI} 25\text{--}45\%$: neutral foot
- $\text{CSI} \geq 46\%$: pes planus

Figure 2. Chippaux–Smirak Index



Rearfoot Alignment

Rearfoot alignment was assessed from posterior podoscopic views. Participants were classified as normo-axed, valgus, or varus.

Statistical Analysis

Descriptive statistics were used. Quantitative variables are presented as mean $\pm$ standard deviation. Qualitative variables are presented as frequencies

and percentages. Data were processed using GPS 110 software and standard spreadsheet analysis.

Ethical Considerations

The study was conducted in accordance with institutional ethical guidelines. All participants provided informed consent before inclusion.

Results

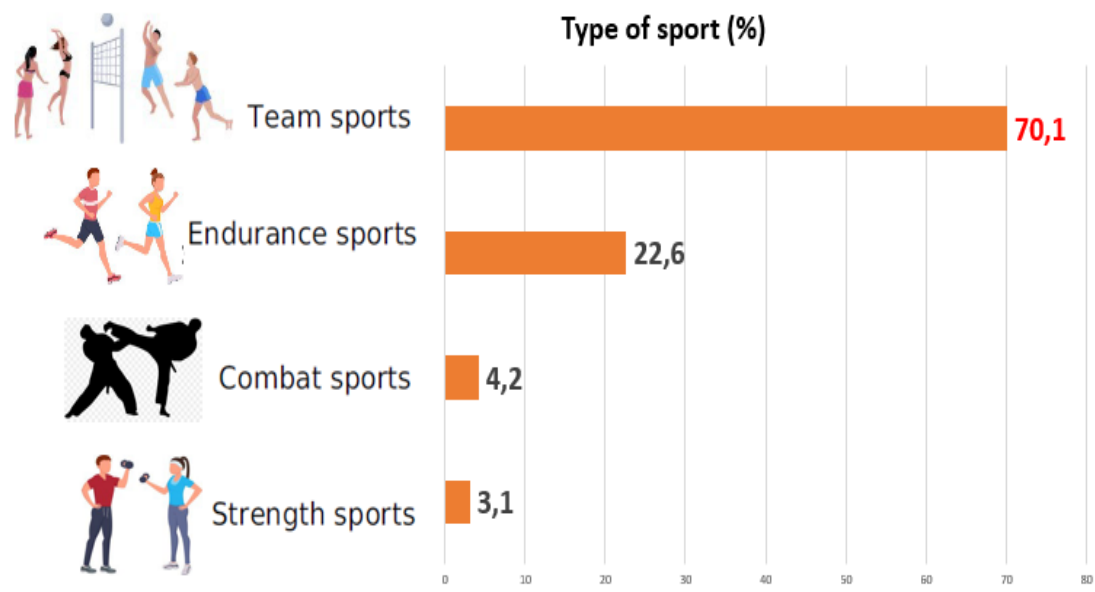
Sample Characteristics

A total of 426 young athletes participated. Table 1 summarizes the main characteristics.

Table 1. *Sample characteristics (N = 426)*

Variable	Value
Age, years (mean $\pm$ SD)	19.5 $\pm$ 0.89
Age range, years	18–21
BMI, kg/m ² (mean $\pm$ SD)	21.06 $\pm$ 3.18
Underweight, %	20.0
Normal weight, %	69.5
Overweight, %	8.0
Obese, %	2.6
Regular sport practice, %	90.4
Occasional sport practice, %	9.6

1 **Figure 3.** *Sport type distribution*

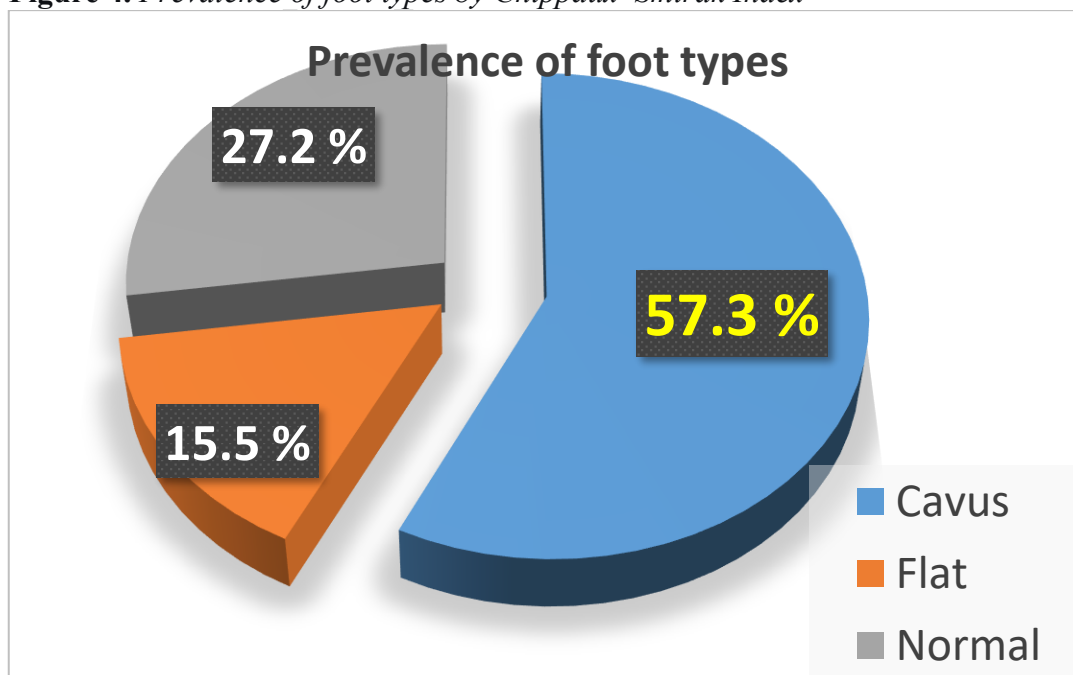


2
3
4 *Prevalence of static foot disorders*

5
6 Using the CSI, the distribution of foot types was as follows (Figure 3):

- 7
8 • Pes cavus: 57.3%
9 • Neutral foot: 27.2%
10 • Pes planus: 15.5%
11 •

12 **Figure 4.** *Prevalence of foot types by Chippaux–Smirak Index*

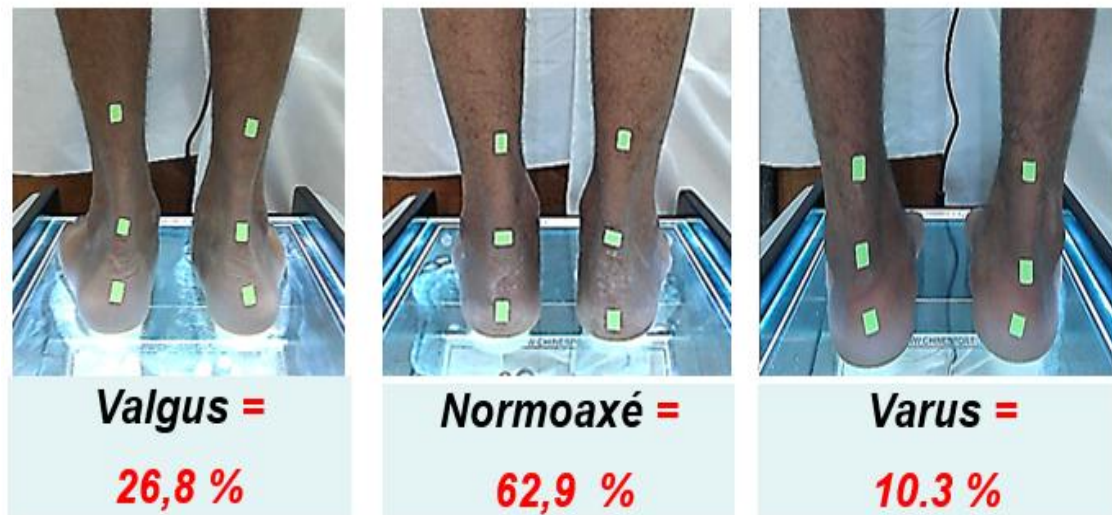


Rearfoot alignment

Rearfoot alignment results were:

- Normo-axed: 62.9%
- Valgus: 26.8%
- Varus: 10.3%

Figure 5. *Rearfoot alignment*



Discussion

Prevalence of SFD in young Algerian athletes

This study provides one of the first podoscopic profiles of young Algerian athletes. SFD were highly prevalent: only 27.2% had a neutral foot, while 57.3% had pes cavus and 15.5% had pes planus. These results indicate that foot morphology abnormalities are common in this population.

The prevalence of flatfoot in our study (15.5%) is within the lower-middle range compared with other athletic populations. A comparative analysis across sports reported flatfoot prevalence ranging from 0% to 94.1% depending on sport, country, and measurement method (Miliani, 2024). For example, flatfoot prevalence was 6% in amateur soccer players, 7% in volleyball players, 9% in basketball players, and 13% in handball and taekwondo athletes in Turkey. Higher values have been reported in some Indonesian athlete groups.

Conversely, the prevalence of pes cavus in our study (57.3%) appears particularly high. In the literature, pes cavus prevalence has been reported as 42.1–52.6% in swimmers, 37.5% in Nigerian football players, 34.0% in German football players, 30.0% in Canadian football players, 20.0–25.0% in weightlifters, 21.9% in female volleyball players, 12.5–16.7% in rowers, and

5.56% in elite basketball players. Thus, young Algerian athletes in this sample present a markedly high proportion of pes cavus.

Flatfoot and injury risk

Flatfoot has been associated with increased injury risk in some studies. Setiawan et al. (2023) reported that athletes with flat feet sustained knee injuries in 69% of cases and ankle injuries in 31% of cases. Mei-Dan et al. (2005) found that a low medial longitudinal arch was associated with a 2.9 times higher risk of ankle sprains. Williams et al. (2001) reported that flatfoot may increase soft-tissue strain, leading to tendinopathy and plantar fasciitis.

However, the relationship is not uniform. Michelson et al. (2002) found that asymptomatic flatfoot was not a significant risk factor for lower-extremity injury in athletes. This supports a symptom-based approach to orthotic prescription rather than systematic orthotic use in asymptomatic athletes. Takabayashi et al. (2021, 2022) also showed that flatfoot runners exhibit greater coordination variability between the shank and rearfoot, which may lead to increased joint loading and overuse injuries such as patellofemoral pain syndrome.

In young athletes, Ellapen et al. (2014) reported a high prevalence of musculoskeletal pain, particularly in the knee and ankle, among junior soccer players. They emphasized the need for regular strength training as a protective mechanism. Our findings extend this perspective by suggesting that podoscopic screening could help identify athletes with SFD who may benefit from targeted preventive strategies.

Pes cavus and injury risk

Pes cavus is characterized by a high medial longitudinal arch, increased supination, and reduced shock absorption. It reduces the plantar support surface, and since $\text{pressure} = \text{force} / \text{surface area}$, this can lead to increased plantar pressure. Burns et al. (2005) and Desai et al. (2010) reported that the majority of athletes with high arches present with increased plantar pressure, often leading to metatarsalgia and painful pressure areas.

Pes cavus is also frequently associated with calcaneal varus, lateral ankle overload, increased stress on lateral ligaments, and reduced dynamic stability. This predisposes athletes to repeated ankle sprains, chronic lateral ankle instability, altered joint mechanics, and talocrural osteoarthritis (Lin et al., 2022). In our study, rearfoot valgus was more common than varus, but the high prevalence of pes cavus remains a concern for lateral ankle and lateral foot overload.

Postural and systemic implications

SFD may affect the entire postural chain. Kowalski (2004) described the foot–knee–spine triad, and Puzovic et al. (2015) found that children with flat feet had a significantly higher prevalence of thoracic kyphosis. Uhl et al. (2012) and

Soti et al. (2024) also linked SFD to chronic venous disease, possibly through altered function of the Lejars plantar venous plexus, which acts as a peripheral venous pump.

These findings suggest that SFD should not be considered isolated foot problems but rather part of a broader biomechanical and vascular picture. In patients with peripheral arterial disease, structured walking interventions have been shown to improve walking performance and self-perceived walking ability (Brenner et al., 2022). Although our population was composed of young, healthy athletes rather than patients with vascular disease, this observation reinforces the importance of preserving foot function and mobility across the lifespan. It also suggests that exercise-based interventions targeting the foot and lower limb may have broader systemic benefits.

Prevention and clinical implications

Prevention is possible. Sedaghati et al. (2023), in a systematic review and meta-analysis, showed that exercise training programs significantly improved postural control and dynamic balance in individuals with flat feet and cavus feet. Corrective exercises included lower-limb strengthening, intrinsic foot muscle training, functional training, and neuromuscular/agility exercises.

For athletes, management should include:

- Pre-participation podoscopic screening
- Education on foot care and footwear
- Appropriate shoe selection
- Orthotic prescription when symptomatic
- Progressive corrective exercise programs
- Monitoring of training load and injury history

Sports physicians, physiotherapists, and coaches should familiarize themselves with SFD because they can affect performance and functional prognosis.

Limitations and Perspectives

This study has several limitations. It was a descriptive cross-sectional study conducted in a single region of Algeria, so the results may not be generalizable to all Algerian athletes. Foot type was assessed using the CSI only, without radiographic confirmation or FPI-6. Injury outcomes were not prospectively collected, so associations with injury cannot be established. Sport type and training load were based on self-report.

Our study was limited to a static podoscopic analysis. Further work integrating dynamic functional assessments and exercise-based interventions, such as those described by Brenner et al. (2022), could help to better understand the functional consequences of static foot disorders in athletes and the potential benefits of targeted exercise programs. Future studies should include multicenter

designs, longitudinal follow-up, and combined clinical, podoscopic, and radiographic assessments.

Conclusion

Static foot disorders are frequent in young Algerian athletes. In this podoscopic study, pes cavus was the predominant foot type (57.3%), followed by neutral foot (27.2%) and flatfoot (15.5%). Rearfoot alignment was mostly normo-axed (62.9%), with valgus in 26.8% and varus in 10.3%.

These findings support the need to create a podoscopic profile of young Algerian athletes and to integrate foot screening into pre-participation evaluation. Early identification of SFD may help prevent lower-limb injuries, improve performance, and guide individualized prevention strategies. Sports physicians should be aware of these disorders and their potential functional consequences.

References

- Brenner, I. K. M., Brown, C. A., Hains, S. M. J., Tranmer, J., Zelt, D., & Brown, P. (2022). Effects of a low-intensity walking intervention on walking performance measures in patients with peripheral artery disease. *Athens Journal of Health and Medical Sciences*, 9(2), 95–112. <https://doi.org/10.30958/ajhms.9-2-3>
- Burns, J., Crosbie, J., Hunt, A., & Ouvrier, R. (2005). The effect of pes cavus on foot pain and plantar pressure. *Clinical Biomechanics*, 20(9), 877–882.
- Campbell, P. G., Pope, R., Simas, V., Canetti, E. F. D., Schram, B., & Orr, R. M. (2025). Incidence and risk factors for the development of stress fractures in military recruits and qualified personnel: A systematic review. *International Journal of Environmental Research and Public Health*.
- Cano, A. M. C. (2025). Structural and functional disorders in pediatric patients' foot. *Podiatry (Buenos Aires)*, 4, 261. <https://doi.org/10.56294/pod2025261>
- Curvale, G., & Rochwerger, A. (2002). Pieds creux. *Encyclopédie Médico-Chirurgicale*, 27-060-A-20.
- Desai, S., et al. (2010). The cavus foot in athletes: Fundamentals of examination and treatment. *Operative Techniques in Sports Medicine*.
- Ellapen, T. J., Narsigan, S., Abrahams, S., & Van Heerden, H. J. (2014). Sport profile of the junior male Kwa-Zulu Natal provincial soccer team, South Africa. *Athens Journal of Sports*, 1(1), 45–56.
- Kowalski, C. (2004). La triade pied-genou-colonne. *Médecine et Chirurgie du Pied*, 20, 42–44.
- Lin, C.-I., Mayer, F., & Wippert, P.-M. (2022). The prevalence of chronic ankle instability in basketball athletes: A cross-sectional study. *BMC Sports Science, Medicine and Rehabilitation*, 14, 27. <https://doi.org/10.1186/s13102-022-00418-0>
- Mei-Dan, O., Kahn, G., Zeev, A., Rubin, A., Constantin, N., Even, A., Nyska, M., & Mann, G. (2005). The medial longitudinal arch as a possible risk factor for ankle sprains: A prospective study in 83 female infantry recruits. *Foot & Ankle International*, 26(2), 180–183.

- 1 Michelson, J. D., Durant, D. M., & McFarland, E. (2002). The injury risk associated with
2 pes planus in athletes. *Foot & Ankle International*, 23(7), 629–633.
- 3
- 4 Miliani, A., Amamri, A., Medaouar, M., Cherid, H., & Rachedi, M. (2025). Effets
5 biomécaniques de la botte de combat. *Médecine et chirurgie du pied*, 40(2), 25-30.
- 6 Bahloul, A., Miliani, A., Amamri, A., Dib, M., Cherid, H., & Rachedi, M. (2024). Le pied
7 humain: des fonctions décryptées. *Médecine et chirurgie du pied*, 39(1), 14-20.
- 8 Pérez-Morcillo, A., Gómez-Bernal, A., Gil-Guillen, V. F., Alfaro-Santafe, J., Alfaro-
9 Santafe, J. V., Quesada, J. A., Lopez-Pineda, A., Orozco-Beltran, D., & Carratalá-
10 Munuera, C. (2019). Association between the Foot Posture Index and running related
11 injuries: A case-control study. *Clinical Biomechanics*, 61, 217–221.
- 12 Puzovic, V., Rotim, K., Jurisic, V., Samardzic, M., Zivkovic, B., Savic, A., & Rasulic, L.
13 (2015). The prevalence of spine deformities and flat feet among 10–12 year old
14 children who train basketball – Cross-sectional study. *Collegium Antropologicum*,
15 39(3), 625–629.
- 16 Rauf, U., et al. (2022). Comparison of dynamic balance and injury risk in flat-footed and
17 normal-arched athletes. *International Journal of Natural Medicine and Health
18 Sciences*, 2(1).
- 19 Sedaghati, P., Chamachaei, M. A., & Zarei, H. (2023). Effects of exercise training programs
20 on postural control and dynamic balance in individuals with flat feet and cavus feet: A
21 systematic review and meta-analysis. *Journal of Rehabilitation Sciences and Research*,
22 10, 1–8.
- 23 Setiawan, A., Priyanto, & Yudhistira, D. (2023). Prevalence and characteristics of sports
24 injuries in athletes with flat feet: A quantitative descriptive study. *Journal Sport Fira*,
25 8(2), 207–216.
- 26 Soti, N., Luitel, P., Paudel, S., Thapaliya, I., Gors, U., & Savania, A. (2024). Static foot
27 disorders as a risk factor for the development of chronic venous disease: A cross-
28 sectional, single-center study. *Original Article*.
- 29 Takabayashi, T., Edama, M., Inai, T., & Kubo, M. (2021). Shank and rearfoot coordination
30 and its variability during running in flatfoot. *Journal of Biomechanics*, 115, 110119.
- 31 Takabayashi, T., Edama, M., Inai, T., & Kubo, M. (2022). Differences in the coordination
32 and its variability among foot joints during running in neutral foot and flatfoot.
33 *Scandinavian Journal of Medicine & Science in Sports*. [https://doi.org/10.1111/sms.
34 14267](https://doi.org/10.1111/sms.14267)
- 35 Tong, J. W. K., & Kong, P. W. (2013). Association between foot type and lower extremity
36 injuries: Systematic literature review with meta-analysis. *Journal of Orthopaedic &
37 Sports Physical Therapy*, 43(10), 700–714.
- 38 Uhl, J.-F., Chahim, M., & Allaert, F.-A. (2012). Static foot disorders: A major risk factor
39 for chronic venous disease? *Phlebology*, 27(Suppl. 1), 42–47.
- 40 Westlin, N. (1997). *Stora fotboken*. Liber.
- 41 Williams, D. S., III, McClay, I. S., & Hamill, J. (2001). Arch structure and injury patterns
42 in runners. *Clinical Biomechanics*, 16(4), 341–347.
- 43 Xu, Z., Lin, Y., Chen, Y., Lu, J., Jiang, Y., He, J., Yu, L., Miao, W., Yan, J., & Wang,
44 X. (2026). Foot arch morphology and lower-limb biomechanical characteristics in
45 university students: A cross-sectional multifactorial analysis of 1,078 participants.
46 *Scientific Reports*.
- 47
- 48