BJMS
www.batnajms.net

Batna Journal of Medical Sciences 2026;13(5):03
https://doi.org/10.48087/BJMS.2026.130503

REVIEW ARTICLE

Pes Cavus and the domino effect on the musculoskeletal system: Clinical implications across the kinetic chain from foot to spine

Kamel REMITA[1], Mohamed Hassan AL FAHEL[2], Wissem Soumia HADDAD[3]

ABSTRACT

In clinical practice, patients with recurrent or refractory musculoskeletal complaints that respond inadequately to standard treatments may harbor an underlying, unifying biomechanical driver. Pes cavus, characterized by a rigid elevation of the medial longitudinal arch, represents one such frequently overlooked contributor. This foot morphology alters fundamental biomechanics by reducing shock absorption and redistributing plantar loads, thereby propagating compensatory stresses proximally along the kinetic chain. Although pes cavus is commonly perceived as a marker of underlying neuromuscular disease, this assumption is frequently incorrect. Only a minority of cases, typically severe and progressive, are associated with neuromuscular disorders, while the majority represent a normal anatomical variant of foot shape. Like pes planus, pes cavus should not be considered inherently pathological and warrants intervention only when symptomatic. Clinically significant cavus alignment may generate a cascade of pathology ranging from forefoot overload, plantar fascia stress, and Achilles and peroneal tendinopathies to ankle instability, knee pain, sacroiliac joint dysfunction, and spinal loading abnormalities. Despite these wide-ranging effects, pes cavus remains under-recognised, often resulting in fragmented, symptom-oriented management. Early identification through targeted clinical assessment and appropriate orthotic intervention can mitigate this biomechanical "domino effect," addressing the symptomatic chain from the foot to the spine. Importantly, pes cavus should be regarded as a potential contributor rather than a universal explanation for musculoskeletal pain to avoid the over-medicalisation of a benign anatomical variation.

Keywords: Pes cavus, High-arched foot, Kinetic chain, Musculoskeletal pain, Foot orthoses, Gait analysis.

1- Senior consultant, Rheumatology Clinic, Al Emadi Hospital, Doha, Qatar. 2- Orthopaedic surgery, foot surgery unit, Al Emadi hospital, Doha, Qatar. 3- Physical medicine and rehabilitation clinic, Al Emadi hospital, Doha, Qatar.

Received: 12 Jan 2026
Accepted: 20 Apr 2026

Correspondance to: Kamel REMITA
E-mail: kremita2001@yahoo.fr

1. INTRODUCTION

Clinicians frequently encounter patients with recurrent or refractory musculoskeletal complaints that respond only partially or transiently to conventional treatments. Such presentations should prompt a broader biomechanical evaluation rather than repeated isolated interventions. Among the potential contributors, pes cavus remains an under-recognized but clinically significant factor capable of generating symptoms not only in the foot and ankle but also at the knee, hip, pelvis, and spine.

Pes cavus is defined by an abnormally elevated medial longitudinal arch that persists during weight-bearing, resulting in disruption of the plantar tripod and the development of a relatively rigid foot with diminished shock-absorbing capacity. Limited pronation during gait alters plantar pressure distribution and reduces biomechanical efficiency (1,2). Reported prevalence estimates for pes cavus vary widely across studies, largely reflecting differences in definitions, assessment methods, age groups, and study populations. When cavus is defined as a *clinical condition associated with symptoms or functional impairment*, prevalence estimates are generally below

10% in adult populations (2,3). In contrast, studies based on *footprint analysis, static arch indices, or radiographic morphology* suggest that up to approximately 20–25% of individuals may demonstrate a cavus-type foot shape without symptoms, functional limitation, or neurological disease (2,4,5). When presented without contextualization, these figures may appear contradictory, but instead represent distinct points along a spectrum of foot morphology rather than conflicting epidemiological data. Contrary to common belief, pes cavus is not invariably linked to neuromuscular disease. Although severe, progressive cavovarus deformities are often neurological in origin, most notably associated with Charcot–Marie–Tooth disease, the majority of cavus feet encountered in routine practice represent normal anatomical variation. This paradigm mirrors that of pes planus, which occurs with similar prevalence and is not inherently considered pathological. As with flatfoot, pes cavus should be treated only when symptomatic; asymptomatic cavus alignment should be left alone. For conceptual clarity, pes cavus may be viewed along a continuum comprising *morphological cavus* (an anatomical variant), *clinical cavus* (a symptomatic biomechanical condition), and *pathological cavovarus* (a progressive deformity frequently associated with neuromuscular disease). Failure to distinguish these entities risks both under-recognition of clinically relevant cavus and inappropriate attribution of diffuse musculoskeletal pain to a benign structural variant. Biomechanically, cavus feet, often accompanied by hind foot varus, alter load transmission along the kinetic chain, predisposing individuals to lateral foot overload, ankle instability, tendon pathology, and progressive proximal joint stress (1,6,7). Despite this, pes cavus remains under-recognized as a potential unifying contributor in chronic musculoskeletal disorders. Early identification and appropriate intervention can substantially improve outcomes when a coherent clinical–biomechanical link exists.

2. METHODOLOGY

This narrative review aimed to integrate current evidence on pes cavus as a biomechanical driver of musculoskeletal pain along the kinetic chain. A focused literature search was conducted in PubMed, Embase, and the Cochrane Library for publications from January 1990 to March 2025 using key terms including pes cavus, high-arched foot, cavovarus, foot biomechanics, kinetic chain, gait analysis, and orthoses. Eligible sources included peer-reviewed original studies, narrative and systematic reviews, biomechanical and gait-analysis research, clinical guidelines, and clinically informative case series. Non-English articles without accessible abstracts, duplicate publications, and studies lacking direct relevance to cavus foot biomechanics or musculoskeletal manifestations were excluded. Reference lists of key articles were manually reviewed to identify additional relevant literature.

Given the heterogeneity of study designs and outcomes, no formal quality scoring or hierarchy of evidence was applied. Studies were selected and interpreted based on methodological soundness, clinical relevance, and consistency of biomechanical findings. Extracted data were synthesized thematically into domains addressing classification, biomechanical mechanisms, kinetic-chain effects, clinical assessment, and management strategies, with the goal of providing a practical, clinically oriented framework.

3. CLASSIFICATION AND TYPES OF PES CAVUS

Pes cavus is a three-dimensional deformity involving abnormal sagittal and coronal plane alignment, with variable forefoot and hind foot contributions and differing degrees of flexibility. Accurate classification integrates clinical examination, including neurological assessment and the Coleman block test, with targeted weight-bearing radiography (1,8,9).

Morphological (Anatomical–Biomechanical) Classification

Morphological classification focuses on segmental alignment, dominant deforming forces, and the relationship between forefoot position and hind foot orientation. Although neuromuscular disorders frequently underlie these patterns, classification is based primarily on biomechanical presentation rather than aetiology (1,8).

Pes Cavovarus

Pes cavovarus is the most frequently encountered cavus subtype, characterized by plantarflexion of the first ray, hindfoot varus, and digital clawing due to imbalance between intrinsic and extrinsic foot musculature (1,8). While strongly associated with hereditary neuropathies such as Charcot–Marie–Tooth disease, neurologically driven cases represent a minority and are typically more severe and progressive. The majority of cavovarus feet reflect idiopathic or constitutional variants within the normal spectrum of foot morphology (3,5,10).

From a biomechanical standpoint, plantarflexion of the medial forefoot drives compensatory calcaneal varus, resulting in lateral column overload, altered ankle mechanics, and instability during stance and gait (8). Weight-bearing radiographs typically demonstrate an increased calcaneal pitch and an abnormal talo–first metatarsal (Meary's) angle (8,11).

Pes Calcaneocavus

Pes calcaneocavus is defined by a cavus arch configuration accompanied by relative calcaneal dorsiflexion, most often secondary to weakness or paralysis of the triceps surae. Historically associated with poliomyelitis, this pattern is also observed in other neuromuscular conditions affecting plantarflexion strength (8). Loss of plantarflexion power allows unopposed dorsiflexion at the ankle, while persistent forefoot plantarflexion maintains a rigid high-arch morphology. Radiographic assessment reveals altered talocalcaneal relationships and abnormal sagittal plane alignment (8,11).

Neutral-Heel (“Pure”) Pes Cavus

Neutral-heel pes cavus is characterized by elevation of the medial longitudinal arch without significant hindfoot varus or calcaneal dorsiflexion (1,8). The deformity is predominantly forefoot-driven, with the calcaneus remaining close to neutral alignment (8). This presentation shows less consistent association with overt neuromuscular disease and is more frequently described in congenital or idiopathic contexts (1,10). Imaging typically confirms preserved hindfoot alignment with increased arch height and midfoot rigidity (8).

Flexibility and Combined Patterns

Across all morphological subtypes, pes cavus deformities are further stratified by flexibility. Flexible deformities demonstrate partial or complete correction during unloading or the Coleman block test, indicating a forefoot-driven mechanism. Rigid deformities persist regardless of positioning, reflecting fixed osseous and ligamentous adaptation (9,11). In clinical practice, mixed patterns are common, underscoring the need for comprehensive biomechanical and radiographic assessment (1,8).

Podoscopic (Footprint-Based) Classification

Podoscopic evaluation offers a functional adjunct by assessing plantar contact distribution during static weight-bearing (12,13). In pes cavus, footprint analysis typically reveals reduced or absent midfoot contact, with disproportionate loading beneath the heel and metatarsal heads (12). Based on midfoot contact reduction, pes cavus is commonly categorized as mild, moderate, or severe.

- **Mild cavus:** Partial narrowing of midfoot contact, with continuity between forefoot and heel impressions.
- **Moderate cavus:** Marked reduction of midfoot contact, with near separation of forefoot and heel.
- **Severe cavus:** Near-complete or complete absence of midfoot contact, resulting in isolated forefoot and heel impressions (12–14).

Although podoscopy does not define hindfoot alignment, it provides valuable insight into functional loading patterns and complements clinical and radiographic findings (12,13).

4. BIOMECHANICS OF THE HIGH-ARCH FOOT

Pes cavus represents a distinct biomechanical phenotype defined by limited adaptability during weight-bearing and gait. Under physiological conditions, the foot dissipates impact forces through controlled pronation and deformation of the midfoot. In contrast, the cavus foot, characterized by excessive medial longitudinal arch height, reduced midfoot contact, and increased structural stiffness—behaves more as a rigid lever. This shifts its primary role from shock absorption toward load transmission (15–17). Consequently, ground reaction forces are inadequately attenuated and are propagated proximally along the kinetic chain (18,19).

Anatomical Determinants of Cavus Biomechanics

Pes cavus results from the interaction of skeletal alignment, ligamentous restraint, and neuromuscular control. Radiographic and cadaveric studies consistently identify increased calcaneal pitch, plantar flexion of the first ray, and altered talonavicular relationships as key osseous contributors to arch elevation (8,20). Ligamentous structures further reinforce this rigidity. The plantar fascia and the spring ligament play a central role, and in cavus feet these tissues often exhibit increased stiffness or functional shortening (21). Neuromuscular imbalance further amplifies cavus biomechanics. Weakness of the intrinsic foot muscles, combined with relative dominance of extrinsic muscles, may accentuate forefoot-driven cavus alignment (22).

Functional Consequences: Shock Absorption and Gait Adaptation

Impaired shock absorption is among the most clinically relevant functional consequences of pes cavus. Gait analysis studies demonstrate consistently reduced pronation range and diminished midfoot motion during early stance, limiting force dissipation (16,23). As a result, higher peak ground reaction forces are transmitted proximally. Plantar pressure studies confirm these alterations, showing a reduced plantar contact area and disproportionately elevated pressures beneath the heel and lateral forefoot in cavus feet (6,12). Characteristic gait adaptations include earlier heel rise, a shortened stance phase, and increased reliance on the lateral column during propulsion (23,24).

Stability and Load Distribution Along the Kinetic Chain

Despite its rigid structure, the cavus foot is frequently functionally unstable. Increased inversion moments at the subtalar and ankle joints, together with lateralized plantar loading, predispose patients to recurrent lateral ankle sprains and chronic ankle instability (25). Altered load transmission is not confined to the ankle. Increased distal stiffness influences tibial rotation and frontal-plane knee mechanics, with studies suggesting an association between rigid foot morphology and increased lateral compartment or patellofemoral joint stress (18,26). Proximally, compensatory strategies at the hip and pelvis, such as increased external rotation, may emerge (27). At the axial level, diminished foot compliance may contribute to increased lumbar spine loading, particularly in individuals exposed to repetitive impact (19,28).

5. CLINICAL IMPLICATIONS: A KINETIC CHAIN PERSPECTIVE

Pes cavus should be approached as a global biomechanical disorder rather than an isolated foot deformity. Patients often present with diverse and seemingly unrelated symptoms, leading to fragmented management. At the level of the foot, the most common symptomatic manifestations include metatarsalgia, plantar fascial overload, Achilles tendinitis, and peroneal tendinitis. These reflect rigid lever mechanics, lateral column dominance, and impaired shock absorption (6,12,29) Importantly, the presence of a cavus foot alone does not imply causality. Clinical relevance should be inferred only when foot morphology plausibly explains the symptom pattern, alternative diagnoses have been reasonably excluded, and symptoms demonstrate concordance with known cavus-related loading characteristics. (Table 1).

Table 1. Clinical clues prompting foot examination for suspected Pes Cavus.

Presenting Region	Clinical Clue	Foot-Origin Features
Plantar / Lateral Foot	Diffuse or lateral foot pain	Non-focal plantar pain; cuboid, fifth metatarsal, or lateral heel tenderness
Forefoot	Metatarsalgia	Pressure-related pain under first and fifth metatarsal heads
Toes	Claw or hammer toe deformities	MTP hyperextension with IP flexion
Skin	Focal callus formation	Hyperkeratosis at metatarsal heads, lateral heel, or toe tips
Achilles Tendon	Posterior heel pain or stiffness	Limited dorsiflexion; mid-portion or insertional symptoms
Ankle	Recurrent sprains or instability	Repeated inversion injuries; proprioceptive symptoms
Forefoot / Rearfoot	Stress fractures	Recurrent or low-energy metatarsal or calcaneal fractures
Knee	Anterior or lateral knee pain	Patellofemoral or lateral compartment symptoms without primary knee disease
Hip	Lateral hip or gluteal pain	Overuse or fatigue-related pain without intrinsic hip pathology
Pelvis / Spine	Sacroiliac or low back pain	Asymmetric load-related pelvic pain or mechanical low back pain

Foot-Level Sequelae

The rigidity and altered load distribution inherent to pes cavus predispose the foot to a characteristic pattern of musculoskeletal pathology (Figure 1):

- **Plantar fascia overload and lateral column stress:** Increased arch height elevates baseline tension within the plantar aponeurosis, predisposing it to repetitive microtrauma (21). Reduced medial midfoot contact shifts load laterally, increasing pressure beneath the cuboid and fifth metatarsal (29).
- **Digital deformities and callus formation:** Imbalance between intrinsic and extrinsic toe musculature leads to claw toe or hammer toe deformities, concentrating plantar pressures at the metatarsal heads and toe tips (30). Calluses typically develop beneath the first and fifth metatarsal heads, along the lateral heel, and at the tips of clawed toes (31).
- **Achilles tendon involvement:** Rigid, supinated feet concentrate loading through a relatively shortened posterior muscle–tendon unit, increasing tensile stress within the triceps surae–Achilles complex and predisposing to tendinopathy (6,32).

- **Ankle instability and recurrent sprains:** Hindfoot varus alignment and lateralized plantar loading increase inversion moments at the ankle, predisposing patients to recurrent lateral ankle sprains (9,25).
- **Stress fractures:** Stress fractures of the metatarsals (particularly the second and fifth) and calcaneus reflect the cumulative effects of focal load concentration and reduced shock absorption (26,33).

Proximal Kinetic Chain Effects

Altered distal mechanics propagate proximally, influencing knee loading, hip rotation, pelvic stability, and spinal biomechanics (Figure 2):

- **Knee:** Hindfoot varus and forefoot rigidity increase lateral knee loading and abnormal tibiofemoral stress and may disrupt patellofemoral tracking (18,34).
- **Hip:** Rigid cavus alignment promotes an external rotation bias at the hip during stance as a functional adaptation, which may increase gluteal muscle demand and contribute to overuse (35,36).
- **Pelvis and Sacroiliac Joints:** Altered lower-limb mechanics affect pelvic load transfer. Chronic lateral column overloading may contribute to asymmetric pelvic tilt and increased sacroiliac joint stress (37).
- **Spine:** Reduced shock absorption may contribute to compensatory lumbar hyper-lordosis as the spine attempts to dampen excessive impact forces (19,28).

Figure 1. Foot-Level musculoskeletal sequelae in Pes cavus.

Clinically, disorders most frequently associated with symptomatic cavovarus alignment include sacroiliac joint pain, medial tibial stress syndrome (shin splints), Achilles and peroneal tendinopathies, and activity-related leg muscle pain (6,18,26,33). Improvement of proximal symptoms,including sacroiliac joint–related low back pain has been observed following correction of cavus-related foot mechanics using custom-made orthoses, supporting, but not proving a contributory biomechanical role.

Neurological Correlations

While in practice most cases are not neurological, pes cavus has a well-established association with specific disorders:

- **Charcot–Marie–Tooth disease (CMT)** and related neuropathies are a key cause of progressive cavus deformity; bilateral involvement, family history, and distal weakness should prompt neurological evaluation (10,38,39).
- **Subtle neuromuscular deficits:** Many cases labelled idiopathic may demonstrate subclinical weakness or proprioceptive impairment on detailed examination (5).
- **Red flags:** Rapid unilateral onset, upper motor neuron signs, or systemic features warrant urgent imaging and neurological referral (39,40).

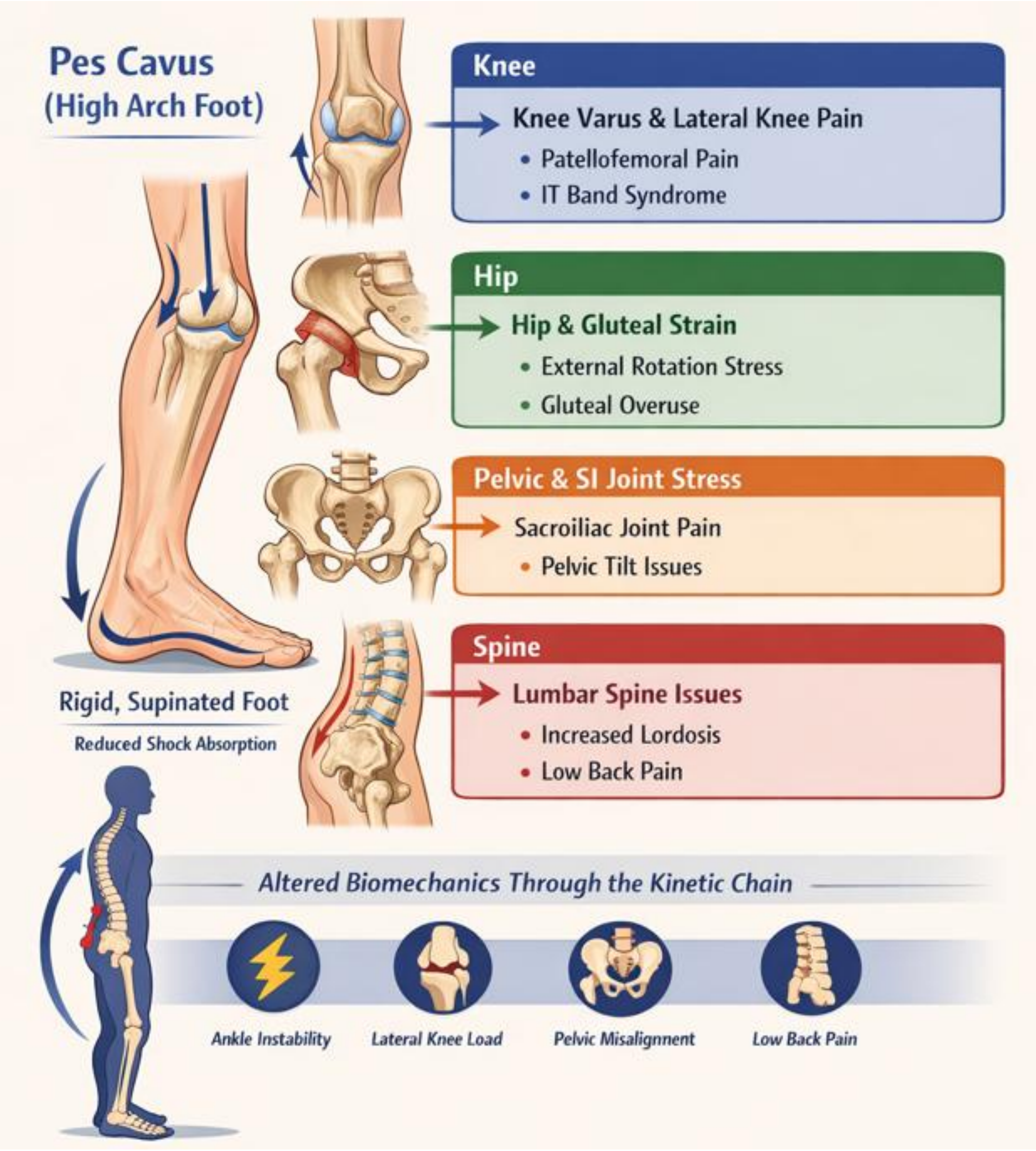

Figure 2. Pes cavus Proximal kinetic chain effects.

6. CLINICAL ASSESSMENT AND DIAGNOSTIC APPROACH

Clinical evaluation of pes cavus should follow a structured approach, beginning at the foot and progressing proximally to identify secondary adaptations (41,42). Weight-bearing imaging is central for objective characterization. Standard foot radiographs permit assessment of arch parameters, while MRI is reserved for soft-tissue pathology. EMG/NCS are indicated when clinical features raise concern for neuropathy (40,43).

Functional testing refines diagnosis. The **Coleman block test** is essential for differentiating forefoot-driven cavus from fixed hindfoot varus (20,41). Single-leg squat testing provides insight into proximal control (42). Measures such as **plantar pressure mapping** can assist in quantifying deformity severity and guiding orthotic prescription (12,44). Integration of history, examination, and targeted imaging is critical for selecting appropriate management strategies (41–44) (Table 2).

Table 2. Structured diagnostic assessment for suspected Pes cavus. This table provides a systematic, step-by-step guide for the clinical evaluation of a patient.

Assessment domain	**Key components**	**Purpose & clinical pearls**
History & inspection	History of recurrent sprains, lateral foot/knee/back pain. Weight-bearing inspection ("peek-a-boo" heel sign), callus mapping.	Identify symptom patterns; visual confirmation of hindfoot varus and abnormal loading.
Physical examination	Coleman block test; ankle stability tests (anterior drawer, talar tilt); muscle strength (intrinsics, peroneals); neurological screen.	Differentiate forefoot-driven (flexible) versus rigid hindfoot varus; assess dynamic stability and neurological contribution.
Imaging	Weight-bearing radiographs (AP/lateral foot: Meary's angle, calcaneal pitch); long-leg alignment films; MRI for soft tissue or stress injury.	Quantify bony deformity; assess limb alignment and proximal joints; evaluate tendons, ligaments, and bone marrow edema.
Functional testing	Single-leg squat or step-down tests; plantar pressure analysis; gait analysis.	Assess dynamic proximal control and kinetic-chain compensation; objectify plantar pressure distribution.

7. MANAGEMENT CONSIDERATIONS

Management of pes cavus must be individualized, considering symptom burden, deformity rigidity, functional demands, and neurological status (45). A stepwise approach is generally preferred (Table 3).

Table 3. Overview of management strategies for Pes cavus. *Treatment pyramid from conservative to surgical management.*

Management Tier	**Specific Interventions**	**Primary Goals & Rationale**
First-Line (Conservative)	**Custom foot orthoses:** lateral/forefoot wedging, deep heel cups, total-contact arch	Redistribute plantar pressure, increase contact area, reduce peak loads
	Appropriate footwear: cushioned midsoles, rocker-bottom soles, wide toe box	Enhance shock absorption, facilitate roll-over, accommodate digital deformities
	Targeted physiotherapy: peroneal and intrinsic strengthening, gastrocnemius–soleus stretching, gait retraining	Improve dynamic stability, address muscle imbalance, optimize loading patterns
Second-Line (Surgical)	**Soft-tissue procedures:** peroneus longus-to-brevis transfer, Achilles tendon lengthening	Correct dynamic muscle imbalance
	Osteotomies: lateralizing calcaneal osteotomy, dorsiflexion first-metatarsal osteotomy, midfoot osteotomies (Cole, Japas)	Realign bony architecture; procedure selected according to apex of deformity
	Arthrodesis (severe, rigid deformity): triple arthrodesis	Provide definitive correction and stability at the expense of hindfoot motion
Adjunctive Care	**Multidisciplinary coordination:** podiatry/orthopedics, physiotherapy, neurology, orthotist	Ensure holistic management, particularly in neurologically mediated cavus
	Patient education and activity modification	Set realistic expectations, promote self-management, reduce high-impact loading

Foot Orthoses and Shoe Modifications

Orthoses are the cornerstone of conservative management for symptomatic pes cavus (46). By redistributing plantar load, they reduce painful peak pressures and repetitive tissue overload (6). For cavovarus feet, optimal custom-made insole design typically includes a lateral heel wedge, metatarsal support, arch support, and toe or digital support when clawing is present. This geometry-specific approach redistributes plantar load, improves stability, and reduces both distal and proximal symptoms (46,47). Rocker-sole designs and cushioned midsoles may enhance shock attenuation (48).

Physiotherapy: Stretching, Strengthening, and Gait Retraining

Physiotherapy should address both distal and proximal contributors. Stretching of the gastrocnemius–soleus complex is frequently indicated (49). Progressive strengthening of intrinsic foot muscles and ankle evertors (peroneals) may improve dynamic foot control (50). Gait-retraining strategies targeting step pattern, cadence, and loading symmetry can complement orthotic management, particularly in physically active individuals (51).

Surgical Options (Overview)

Surgical intervention is reserved for patients with progressive deformity, recurrent instability, ulceration, or failure of conservative care (52). Procedures range from tendon transfers to osteotomies of the first ray, midfoot, or calcaneus. Selection depends on whether the deformity is forefoot- or hindfoot-driven and on the degree of rigidity (9,53).

Multidisciplinary Care

Optimal management frequently requires a multidisciplinary approach involving orthopaedics/podiatry, physiotherapy, neurology, and orthotics services (45). Coordinated care improves diagnostic accuracy and aligns strategies with patient-specific functional goals (54).

8. KNOWLEDGE GAPS AND FUTURE DIRECTIONS

High-quality longitudinal data on the natural history of pes cavus and its kinetic chain effects remain limited (5). There is no universally accepted, standardized assessment battery for evaluating kinetic-chain involvement, and heterogeneity across studies limits guideline development (55). In particular, the threshold at which morphological cavus becomes clinically relevant remains poorly defined and represents a key area for future investigation. Future research should focus on whether early, targeted interventions can prevent or mitigate downstream symptoms. Advances in personalized insole design (e.g., 3D-printed orthoses) and standardized rehabilitation protocols may help shift management toward prevention and functional preservation (47,55).

CONCLUSION

Pes cavus represents a frequently overlooked *potential* biomechanical contributor to musculoskeletal pain across the kinetic chain. While commonly misattributed to neuromuscular disease, most cavus feet reflect normal anatomical variation and remain asymptomatic throughout life. Clinical relevance arises not from arch height alone, but from the interaction between foot rigidity, load distribution, activity demands, and individual adaptive capacity. Over-medicalization of morphological cavus should be avoided; intervention is warranted only when a coherent clinical–biomechanical link exists between foot structure and symptoms. When appropriately identified, however, symptomatic cavus alignment may act as a modifiable driver of distal and proximal overload. Accurate diagnosis grounded in comprehensive biomechanical assessment, combined with early use of customized orthoses and targeted rehabilitation, can help break this domino effect. Recognizing pes cavus neither as a universal explanation for musculoskeletal pain nor as an incidental finding, but rather as a context-dependent factor within the kinetic chain, allows clinicians to balance vigilance with restraint and improve long-term functional outcomes.

Competing interests: The authors declare that they have no competing interest.

Funding: This research received no external funding.

REFERENCES

1. Burns J, Ouvrier R. The cavus foot. J Am Acad Orthop Surg. 2006;14(5):302–9.
2. Mosca VS. Cavus foot deformity in children and adolescents. J Pediatr Orthop. 2010;30(2 Suppl):S1–9.
3. Nagai MK, Chan G, Guille JT, Kumar SJ, Scavina M, Mackenzie WG. Prevalence of Charcot-Marie-Tooth disease in patients who have bilateral cavovarus feet. J Pediatr Orthop. 2006;26(4):438–43. doi: 10.1097/01.bpo.0000226278.16449.c4
4. Riskowski JL, Dufour AB, Hagedorn TJ, Hillstrom HJ, Casey VA, Hannan MT. Associations of foot posture and function to lower extremity pain: results from a population-based foot study. Arthritis Care Res (Hoboken). 2013;65(11):1804–12. doi: 10.1002/acr.22049
5. Burns J, Crosbie J, Hunt A, Ouvrier R. The effect of pes cavus on foot pain and plantar pressure. Clin Biomech (Bristol, Avon). 2005;20(9):877–82. doi: 10.1016/j.clinbiomech.2005.03.006
6. Green B, Ménard AL, Leduc S, Nault ML. Subtle cavovarus foot: a missed risk factor for chronic foot and ankle pathologies. Int J Foot Ankle. 2020;4:048.
7. Mann RA, Hsu JD. Cavus foot deformity. Instr Course Lect. 1992;41:229–40.
8. Coleman SS, Chesnut WJ. A simple test for hindfoot flexibility in the cavovarus foot. Clin Orthop Relat Res. 1977;(123):60–2.
9. Burns J, Ouvrier R. Pes cavus: classification and management. Curr Opin Pediatr. 2006;18(1):40–7.
10. Saltzman CL, El-Khoury GY. The hindfoot alignment view. Foot Ankle Int. 1995;16(9):572–6. doi: 10.1177/107110079501600911
11. Cavanagh PR, Rodgers MM. The arch index: a useful measure from footprints. J Biomech. 1987;20(5):547–51. doi: 10.1016/0021-9290(87)90255-7
12. Vijayakumar K, Senthilkumar S, Chandratre SG, Bharambe V. Grading the severity of pes planus and pes cavus using podoscopic plantar surface area analysis. J Anat Soc India. 2021;70:85–92.
13. Staheli LT, Chew DE, Corbett M. The longitudinal arch: a survey of eight hundred and eighty-two feet in normal children and adults. J Bone Joint Surg Am. 1987;69(3):426–8.
14. Saltzman CL, Nawoczenski DA. Complexities of foot architecture as a base of support. J Orthop Sports Phys Ther. 1995;21(6):354–60. doi: 10.2519/jospt.1995.21.6.354
15. Williams DS, McClay IS. Measurements used to characterize the foot and the medial longitudinal arch. Phys Ther. 2000;80(9):864–71. doi: 10.1093/ptj/80.9.864
16. Donatelli R. The Biomechanics of the Foot and Ankle. 2nd ed. Philadelphia: F.A. Davis; 1996.
17. Powers CM. The influence of abnormal lower-extremity mechanics on knee injury. J Orthop Sports Phys Ther. 2010;40(2):42–51. doi: 10.2519/jospt.2010.3252
18. Nigg BM, Wakeling JM. Impact forces and muscle tuning: a new paradigm. Exerc Sport Sci Rev. 2001;29(1):37–41. doi: 10.1097/00003677-200101000-00008
19. Coleman SS. Complex foot deformities. Clin Orthop Relat Res. 1983;(181):76–86.
20. Kitaoka HB, Luo ZP, An KN. Effect of plantar fascia release on the mechanical properties of the foot. Foot Ankle Int. 1997;18(1):8–13. doi: 10.1177/107110079701800103
21. Kura H, Luo ZP, Kitaoka HB, An KN. Quantitative analysis of the intrinsic muscles of the foot. Anat Rec. 1997;249(1):143–51. doi: 10.1002/(SICI)1097-0185(199709)249:1<143::AID-AR17>3.0.CO;2-P
22. Hunt AE, Smith RM. Mechanics and control of the flat versus normal foot during gait. Clin Biomech (Bristol, Avon). 2004;19(4):391–7. doi: 10.1016/j.clinbiomech.2004.01.001
23. Hertel J. Functional instability following lateral ankle sprain. Sports Med. 2000;29(5):361–71. doi: 10.2165/00007256-200029050-00005
24. Milner CE, Ferber R, Pollard CD, Hamill J, Davis IS. Biomechanical factors associated with tibial stress fracture in female runners. Med Sci Sports Exerc. 2006;38(2):323–8. doi: 10.1249/01.mss.0000183477.75808.92
25. Levinger P, Gilleard W. The effect of foot posture on rearfoot motion during walking. Gait Posture. 2007;25(4):544–51. doi: 10.1016/j.gaitpost.2006.06.009
26. Kosashvili Y, Fridman T, Backstein D, Safir O, Bar-Ziv Y. The correlation between pes planus and anterior knee or intermittent low back pain. Foot Ankle Int. 2008;29(9):910–3. doi: 10.3113/FAI.2008.0910
27. D'Ambrogi E, Giurato L, D'Agostino MA, Giacomozzi C, Macellari V, Caselli A, et al. Contribution of plantar fascia to the increased forefoot pressures in diabetic patients. J Am Podiatr Med Assoc. 2003;93(5):365–9.
28. Myerson MS. The diagnosis and treatment of forefoot disorders. Instr Course Lect. 1997;46:393–401.
29. Ledoux WR, Shofer JB, Smith DG, Sullivan K, Hayes SG, Assal M. Relationship between foot type, deformity, and ulcer occurrence in the diabetic foot. J Rehabil Res Dev. 2005;42(5):665–72. doi: 10.1682/JRRD.2004.07.0079
30. Oliveira-Junior ASO, de Souza ALG, Naves CAS, Diniz VHA, Pires TBO, Amaral JSS, et al. Subtle cavus foot: prevalence of associated injuries. Sci J Foot Ankle. 2018;12(2):112–6.
31. Williams DS, McClay IS, Hamill J. Arch structure and injury patterns in runners. Clin Biomech (Bristol, Avon). 2001;16(4):341–7. doi: 10.1016/S0268-0033(01)00005-5
32. Willy RW, Hoglund LT, Barton CJ, Bolgia LA, Scalzitti DA, Logerstedt DS, et al. Patellofemoral pain: clinical practice guidelines linked to the international classification of functioning, disability and health from the Academy of Orthopaedic Physical Therapy of the American Physical Therapy Association. J Orthop Sports Phys Ther. 2019;49(9):CPG1–CPG95. doi: 10.2519/jospt.2019.0302
33. Souza TR, Mancini MC, Araújo VL, Carvalhais VO, Ocarino JM, Silva PL, et al. Clinical measures of hip and foot-ankle mechanics as predictors of rearfoot motion and posture. Man Ther. 2014;19(5):379–85. doi: 10.1016/j.math.2014.03.009
34. Nadler SF, Malanga GA, Feinberg JH, Prybicien M, DePrince M, Stitik TP. Relationship between hip muscle imbalance and occurrence of low back pain in collegiate athletes: a prospective study. J Am Osteopath Assoc. 2001;101(1):16–22.
35. Pel JJM, Spoor CW, Pool-Goudzwaard AL, Hoek van Dijke GA, Snijders CJ. Biomechanical analysis of reducing sacroiliac joint shear load by optimization of pelvic muscle and ligament forces. Ann Biomed Eng. 2008;36(3):415–24. doi: 10.1007/s10439-007-9385-8

36. Borges CS, Fernandes LFR, Bertoncello D. Relationship between lumbar changes and plantar arch modifications in women with low back pain. Acta Ortop Bras. 2013;21(3):135–8. doi: 10.1590/S1413-78522013000300002
37. Maranho DA, Volpon JB. Acquired pes cavus in Charcot-Marie-Tooth disease. Rev Bras Ortop. 2015;44(6):479–86. doi: 10.1016/S2255-4971(15)30144-0
38. Pareyson D, Saveri P, Pisciotta C. New developments in Charcot-Marie-Tooth neuropathy and related diseases. Curr Opin Neurol. 2017;30(5):471–80. doi: 10.1097/WCO.0000000000000474
39. Reilly MM, Shy ME. Diagnosis and new treatments in genetic neuropathies. J Neurol Neurosurg Psychiatry. 2009;80(12):1304–14. doi: 10.1136/jnnp.2008.158295
40. Coleman SS, Block J. Surgical treatment of flexible deformities of the forefoot. Clin Orthop Relat Res. 1977;(123):105–13.
41. Nawoczenski DA, Ludewig PM. Quantitative assessment of foot posture and function during gait. J Orthop Sports Phys Ther. 1998;27(2):103–11. doi: 10.2519/jospt.1998.27.2.103
42. Armstrong DG, Lavery LA, Nixon BP, Boulton AJ. It's not what you put on, but what you take off: techniques for debriding and off-loading the diabetic foot wound. Clin Infect Dis. 2004;39(Suppl 2):S92–9. doi: 10.1086/383269
43. Fernández-Seguín LM, Díaz-Mancha JA, Sánchez-Rodríguez R, Escamilla-Martínez E, Gómez Martín B, Ramos Ortega J. Comparison of plantar pressures and contact area between normal and cavus foot. Gait Posture. 2014;39(2):789–92. doi: 10.1016/j.gaitpost.2013.10.018
44. Seaman TJ, Ball TA. Pes cavus. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2023 [updated 2023 Aug 8]. Available from: https://www.ncbi.nlm.nih.gov/books/NBK556016/
45. Najafi B, Wrobel JS, Burns J. Mechanism of orthotic therapy for the painful cavus foot deformity. J Foot Ankle Res. 2014;7(1):2. doi: 10.1186/1757-1146-7-2
46. Ma M, Song Q, Liu H. Effect of personalized orthopedic insoles on plantar pressure during running in subtle cavus foot. Front Bioeng Biotechnol. 2024;12:1343001. doi: 10.3389/fbioe.2024.1343001
47. Yang Z, Jiang W, Fu W, Wang H, Zhou H, Gu Y. Effects of running shoe design features on plantar pressure in recreational runners. Front Bioeng Biotechnol. 2022;10:959842. doi: 10.3389/fbioe.2022.959842
48. Downey MS, Banks AS. Gastrocnemius recession in the treatment of nonspastic ankle equinus. J Am Podiatr Med Assoc. 2002;92(2):109–13. doi: 10.7547/87507315-92-2-109
49. Jung DY, Kim MH, Koh EK, Kwon OY, Cynn HS, Lee WH. A comparison in the muscle activity of the abductor hallucis and the medial longitudinal arch angle during toe curl and short foot exercises. Phys Ther Sport. 2011;12(1):30–5. doi: 10.1016/j.ptsp.2010.08.001
50. Cheung RTH, An WW, Au IPH, Zhang JH, Chan ZYS, MacPhail SL. Measurement agreement of sensing insoles for foot strike detection during running. PLoS One. 2018;13(8):e0201963. doi: 10.1371/journal.pone.0201963
51. Manoli A 2nd, Smith DG, Hansen ST Jr. Scarred muscle excision in lower-extremity ischemic contractures. Orthopedics. 1993;16(11):1189–91.
52. Queen RM, Mall NA, Nunley JA, Simonds JL. Differences in plantar loading between flat and normal feet during different athletic tasks. Gait Posture. 2009;29(4):582–6. doi: 10.1016/j.gaitpost.2008.12.014
53. Barton CJ, Lack S, Hemmings S, Tufail S, Morrissey D. The "Best Practice Guide to Conservative Management of Patellofemoral Pain": incorporating level 1 evidence with expert clinical reasoning. Br J Sports Med. 2015;49(14):923–34. doi: 10.1136/bjsports-2014-093637
54. Kastner-Klein M, Klein C, Goudriaan M, Deschamps K, Vanwanseele B. Agreement between clinical measures of foot posture in people with flatfoot. J Foot Ankle Res. 2022;15(1):33. doi: 10.1186/s13047-022-00537-2
55. Qin B, Wu S, Zhang H. Evaluation and management of cavus foot in adults: a narrative review. J Clin Med. 2022;11(13):3679. doi: 10.3390/jcm11133679