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ASSOCIATION BETWEEN FOOT ARCH STRUCTURE WITH BALANCE AND POSTURAL STABILITY IN GROWING CHILDREN

[1*]Vd. Samiksha Shende, Vd. [2]Suvarna Dhawale

PG Scholar[1], Professor & HOD[2],

Rachana Sharir, BSDT's Ayurved Mahavidyalaya, Wagholi, Pune.

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***Corresponding Author**
Vd. Samiksha Shende
PG Scholar, Rachana Sharir, BSDT's Ayurved Mahavidyalaya, Wagholi, Pune.

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ABSTRACT

Postural stability is a fundamental component of motor development in growing children and is closely linked to the structural integrity of the foot arch. The medial longitudinal arch plays a vital role in shock absorption, weight distribution, and balance control. Alterations in foot arch morphology, particularly flat foot, have been associated with impaired postural stability and increased risk of musculoskeletal dysfunction. Ayurveda provides a comprehensive understanding of balance and posture through concepts of *Pada*, *Vata dosha*, *Asthi dhatu*, and *Sandhi sthiratva*. To explore the association between foot arch structure and postural stability in growing children and to interpret this relationship through Ayurvedic principles. Children with well-formed foot arches demonstrate superior static and dynamic postural stability compared to those with low or flattened arches. From an Ayurvedic viewpoint, optimal *Pada rachana* and balanced *Vata* facilitate proper *Samanvaya*, while deranged arch structure reflects *Asthi-Snayu daurbalya* and *Vata vaishamya*. Foot arch morphology has a significant association with postural stability in growing children. Ayurvedic principles strongly support the role of structural integrity and neuromuscular balance in maintaining posture. Integrative preventive strategies focusing on foot health and lifestyle modification may enhance postural control and overall musculoskeletal development.

KEYWORDS: Foot arch, Postural stability, Ayurveda, *Pada*, *Vata dosha*, *Asthi dhatu.*

INTRODUCTION

The human foot is a highly specialized anatomical structure that plays a fundamental role in posture, locomotion, and weight-bearing activities. It is uniquely adapted for bipedalism and is composed of numerous bones, joints, ligaments, and muscles that function in a coordinated manner. Structurally, the foot contains multiple small bones arranged in a complex configuration, stabilized by layered ligamentous support and reinforced by both intrinsic and extrinsic musculature. During standing, the plantar ligaments and aponeurosis provide primary structural support. During locomotion, particularly in the stance phase, muscles play a crucial role in shock absorption and transmission of body weight.[1]

The foot forms the foundation of posture, and the medial longitudinal arch is a key determinant of balance and alignment. An arched foot is a distinctive feature of humans, setting them apart from other primates. The foot arches contribute to upright posture and facilitate weight bearing. The human foot contains 2 longitudinal arches, medial and lateral, and a transverse arch with anterior and posterior components that function cohesively. These arches render the sole concave, producing an incomplete footprint. Arches are present from birth but may be obscured in children by the subcutaneous fat pad.[1]

The foot arches serve as essential structural adaptations that facilitate multiple biomechanical functions. These structures distribute body weight proportionally across weight-bearing areas and function as segmented levers to propel the body during walking, running, and jumping. Additionally, these arches absorb shock during impact, act as springboards, and enable the foot to adapt to uneven surfaces. The foot arches also protect plantar vessels and nerves.

Functionally dynamic and pliable, the arches flatten upon ground contact and restore their curvature when the foot is elevated.[1]

Developmental variations in foot arch height are common during childhood. While flexible flat foot may be physiological in early years, persistence during later childhood has been linked to altered postural sway, gait abnormalities, and fatigue. Modern lifestyle factors such as reduced physical activity and increased indoor behaviour further influence postural outcomes.

Ayurveda conceptualises posture and balance under the functional domain of *Vata dosha*, particularly *Vyana Vata*, which governs coordination and equilibrium. *Pada* is described as

an essential *Karmendriya*, and its structural soundness is emphasised for *Sthiratva* and *Gamana*.[2,3] Understanding the foot arch–postural stability relationship is important in clinical point and offers a preventive outlook.

MATERIALS AND METHODS

This article is a conceptual review integrating modern insights with Ayurvedic textual analysis. Source of data is modern anatomy text books, *Charak Samhita, Sushrut Samhita* and other *Samhita* from ayurveda, published papers and articles.

METHODOLOGY

FORMATION OR STRUCTURE OF FOOT ARCHES[4]

Foot arches facilitate quick sprinting, jumping and waking. These also support upright posture and weight bearing. One characteristic that makes man unique is an arched foot. It sets him apart from other primates. Although the excess fat in an infant's soles obscures the arches, they are there from birth.

CLASSIFICATION OF ARCHES

1) **LONGITUDINAL**

- MEDIAL
- LATERAL

2) **TRANSVERSE**

- ANTERIOR
- POSTERRIOR

Medial Longitudinal Arch

Compared to the lateral, this arch is significantly taller, more flexible, and more durable. The following is its constitution.

Ends: The heads of the first, second, and third metatarsals make up the anterior end. The arches are not formed by the phalanges. The calcaneum's medial tubercle forms the posterior end of this arch.

Summit: The superior articular surface of the talus body forms the summit of the arch.

Pillars: The anterior pillar is weak and lengthy. The talus, navicular, three cuneiform bones, and the first three metatarsal bones combine to form it. The posterior pillar is robust and

short. The medial portion of the calcaneum forms it.

Lateral Longitudinal Arch

Designed to transfer weight and thrust to the ground, this arch is characterized by its low height and restricted motion. The medial longitudinal arch, on the other hand, serves as a shock absorber.

The lateral longitudinal arch has the following structure.

Ends: The heads of the fourth and fifth metatarsal bones form the anterior end of the arch. The calcaneum's lateral tubercle forms the posterior end.

Summit: The summit is located at the level of the subtalar joint's articular facets on the calcaneum's superior surface.

Pillars: The anterior pillar is weak and lengthy. The cuboid bone is metatarsal, and by the fourth and fifth. The posterior pillar is robust and short. The lateral portion of the calcaneum forms it.

Main Joint: The main joint of the arch is the calcaneocuboid joint.

Anterior Transverse Arch: The heads of the five metatarsals form the anterior transverse arch. Because the heads of the first and fifth metatarsals make touch with the ground and form the two ends of the arch, it is complete.

Posterior Transverse Arch

The larger portions of the tarsus and metatarsus create the posterior transverse arch. Only the lateral end of the arch touches the ground, creating a "half dome" that is completed by the opposing foot's corresponding half dome.

FOOT ARCH AND POSTURAL STABILITY

There are three type of foot arch[5]

1) High Arch also known as pes cavus, cavus feet, varus foot, supinated, underpronating, non-pronating.
2) Neutral Foot also known as normal, middle, average arch, rectus foot.
3) Low Arch also known as flat foot, pes planus, flat arch, planus feet, valgus foot, pronated.

- Balance can be defined as the ability to maintain the body’s center of mass within its base

of support with minimal movement.[5]

- Postural stability refers to the ability to maintain the body's center of gravity within the base of support during static and dynamic activities. In growing children, postural control undergoes continuous refinement as the musculoskeletal and nervous systems mature.

The children with normal or high medial longitudinal arches exhibit

- Reduced postural sway
- Better static balance on force platform analysis
- Improved dynamic balance during gait and play activities Conversely, children with low arches or flat feet demonstrate:
- Increased mediolateral sway
- Delayed balance reactions
- Compensatory proximal muscle activation

AYURVEDIC REVIEW ON PRAMANA SHARIR[6]

There are very few references to Paada Sharir in Ayurvedic literature. Sushruta explained the Anga-Pratyanga Pramana, he clarified the anguli Pramana of Paada in Aaturopkramaniya Adhyaya. Sushruta claims that the leg's great toe and index finger are two Angula. The ring finger is one-fifth less than the middle finger, the little finger is one-fifth less than the ring finger, and the middle finger is one-fifth more than the index finger. The length and width of the Prapaada and Paadatal (foot sole) are 4 and 5 Angula, respectively. Leg is 14 Angula long, while Parshni is 5 Angula long and 4 Angula wide. Paada, Gulfa, Jangha, and Janu have a Parinaha (circumference) of 14 Angula. Charaka states that Paada's dimensions are 4x6x14 Angula. Sushruta explained Pramana Sharir of the Paada region more precisely and thus considered for the study. He considered measurement of individual plantar region i.e. Paada agra, Paadamadhya and Parshni. Thus while considering health of foot area, the collective consideration of these measurements in terms of ratio becomes more significant.

Assessment of Foot Arch

1. **Navicular Drop Test[7]**

- Measures the difference in navicular height between sitting and standing positions. Increased navicular drop indicates reduced medial longitudinal arch height and correlates with ligamentous laxity. In Ayurveda, this reflects *Asthi–Snayu daurbalya*.

2. Foot Print Analysis (Staheli Arch Index / Chippaux–Smirak Index)[8]

- Footprints obtained using ink or podoscope help quantify arch type (normal, low, or high).
- These parameters are usually used to categorize the footprint as pes cavus, pes planus or normal foot.
- Flattened footprints indicate compromised *Pada rachana*.

- **Arch Height Index (AHI)[9]**
- Ratio of dorsum height to truncated foot length, used for objective classification of arch structure in growing children.

Assessment of Postural Stability

1. Single-Leg Stance Test[9]

Evaluates static balance by measuring the duration a child can stand on one foot. It is useful assessment for determining balance impairment. Poor performance suggests impaired neuromuscular coordination, indicative of Vata Vaishamya.

2. Paediatric Balance Scale (PBS)[10]

A modified version of the Berg Balance Scale, assessing functional balance during everyday tasks.

3. Star Excursion Balance Test (SEBT)[11,13]

Assesses dynamic postural control by measuring reach distance in multiple directions. Reduced reach is associated with low arch support and altered proprioception.

4. Force Platform / Stabilometry[12]

Quantifies postural sway in anteroposterior and mediolateral directions. Increased sway reflects compromised sensory integration from the plantar surface.

Table 1: Foot Arch Assessment Tests and Ayurvedic Correlation.

Clinical Test	It Assesses	Interpretation	Ayurvedic Correlation
Navicular Drop Test	Change in navicular height on weight bearing	Ligamentous laxity, low medial longitudinal arch	*Asthi–Snayu daurbalya*, improper *Dhatu poshana*
Foot Print Analysis (Staheli / Chippaux–Smirak Index)	Contact area of midfoot	Classification of flat, normal, or high arch	Altered *Pada rachana*, *Kapha vriddhi* with laxity

Arch Height Index (AHI)	Structural height of medial arch	Objective arch morphology	Quality of *Asthi dhatu* and *Sandhi sthiratva*

Table 2: Postural Stability Tests and Ayurvedic Correlation.

Clinical Test	Type of Balance	Clinical Significance	Ayurvedic Interpretation
Single-Leg Stance Test	Static balance	Neuromuscular coordination	*Vyana Vata* balance, *Sthiratva*
Paediatric Balance Scale	Functional balance	Balance during daily activities	Integrated *Vata* function and *Bala*
Star Excursion Balance Test (SEBT)	Dynamic balance	Proprioception and limb control	Sensory integration of *Pada talam*, *Vata anulomana*
Force Platform / Stabilometry	Static postural sway	Sensory-motor control	*Vata vaishamya* due to impaired plantar feedback

DISCUSSION

The association between foot arch morphology and postural stability is well supported by modern paediatric biomechanics. The foot arch acts as a dynamic stabilizer, modulating ground reaction forces and sensory input essential for balance.

Ayurvedic concepts parallel these observations by highlighting *Pada* as a functional and structural foundation. Childhood is dominated by *Kapha dosha*, providing softness and stability, but excess *Kapha* combined with reduced activity may predispose to laxity and poor arch formation. This results in compromised *Vata* regulation and postural instability.

Ayurveda advocates preventive measures such as *Vyayama*, *Padabhyanga*, barefoot walking on natural surfaces, and balanced nutrition to enhance foot strength and postural control. These interventions may improve sensory integration and musculoskeletal alignment in growing children.

Several biomechanical studies have demonstrated a significant association between altered foot arches and impaired balance. Children with flat feet have been reported to exhibit greater mediolateral and anteroposterior postural sway, decreased single-leg stance performance, and reduced reach distances during dynamic balance assessments such as the Star Excursion Balance Test. Likewise, abnormalities in plantar pressure distribution and reduced proprioceptive feedback have been associated with diminished postural control. These findings support the concept that structural integrity of the foot arch contributes directly to efficient balance regulation and coordinated movement.

The Navicular Drop Test evaluates functional collapse of the medial longitudinal arch during weight bearing, while footprint indices such as the Staheli and Chippaux–Smirak Index objectively classify arch type. The Arch Height Index further quantifies structural arch morphology. Similarly, the Single-Leg Stance Test, Paediatric Balance Scale, Star Excursion Balance Test, and stabilometric analysis assess different dimensions of static and dynamic balance. Collectively, these assessment tools facilitate early detection of children who may be at risk for balance impairment secondary to altered foot arch structure.

CONCLUSION

There is a significant association between foot arch structure and postural stability in growing children. Proper development of the medial longitudinal arch supports balance, coordination, and efficient posture maintenance. Ayurvedic principles provide a coherent explanatory framework linking foot structure, *Vata dosha*, and neuromuscular stability.

Early screening of foot arch abnormalities and implementation of integrative preventive strategies can play a crucial role in promoting optimal postural development and long-term musculoskeletal health in children.

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