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Comparison of Foot Posture Index-6 Scores between High-Risk Children and Typically Developing Children Aged between 2 to 4 Years - A Cross-Sectional Study

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Abstract: ***Background**: Foot posture undergoes rapid changes during preschool years. Developmental risk factors, including prematurity, developmental delay, and hypotonia, may influence foot alignment. This study compared Foot Posture Index-6 (FPI-6) scores between high-risk and typically developing children aged 2–4 years and assessed associations with selected birth and developmental variables. **Methods**: This cross-sectional study included 60 children (30 high-risk and 30 typically developing). Anthropometric measurements, birth history, and developmental milestones were recorded. Bilateral foot posture was assessed using the FPI-6. **Results**: High-risk children showed higher prematurity prevalence (86.7% vs 3.3%), lower birth weight (2.51 ± 0.50 vs 2.76 ± 0.33 kg), more NICU admissions, and delayed developmental milestones. Mean FPI-6 scores were significantly higher in the high-risk group for both right (5.90 ± 5.15 vs 1.03 ± 0.67) and left feet (5.77 ± 4.88 vs 1.00 ± 0.64; both $p < 0.001$). Lower birth weight and gestational age, and delayed standing and walking, were significantly associated with higher FPI-6 scores ($p < 0.001$). **Conclusion**: High-risk preschool children demonstrated significantly altered foot posture compared with typically developing peers. Early foot-posture screening may be beneficial during comprehensive pediatric assessment. However, the cross-sectional design and convenience sampling limit causal interpretation and generalizability.*

Keywords: Foot Posture Index-6; preschool children; high-risk children; prematurity; developmental delay; pronation.

1. Introduction

The foot supports body weight and contributes to balance, shock absorption and propulsion during standing and walking [1]. Its alignment develops throughout childhood as the bones, joints, ligaments and muscles mature. The medial longitudinal arch changes with age and weight-bearing experience [2].

Between 2 and 4 years, children undergo rapid musculoskeletal and motor development. A relatively pronated posture and flexible flatfoot are common at this age, and their prevalence generally decreases as children grow [3–6].

Foot posture refers to the alignment of the rearfoot, midfoot and forefoot, ranging from supinated through neutral to pronated [7]. Although some variation is part of normal development, marked or persistent changes may be relevant to gait, balance and mobility. Clinicians therefore need to distinguish age-related variation from postures that require monitoring [8,9].

Prematurity, developmental delay, hypotonia and prolonged neonatal intensive care unit (NICU) admission may be associated with delayed motor milestones and differences in muscle tone, strength and postural control [10,11]. These factors may also influence weight-bearing and lower-limb alignment. Comparing foot posture in high-risk preschool children with that of typically developing children may help clarify whether these groups differ.

The Foot Posture Index-6 (FPI-6) is an observational tool used to assess standing foot posture. It includes six features:

1) Talar head palpation
2) Supra- and infra-malleolar curvature
3) Calcaneal frontal-plane position
4) Prominence of the talonavicular joint
5) Congruence of the medial longitudinal arch
6) Forefoot abduction/adduction relative to the rearfoot

Each feature is scored from −2 to +2. The six scores are added to provide an overall indication of supination or pronation. The FPI-6 has been studied for reliability and validity, including its use in paediatric populations (3–5).

Although paediatric physiotherapy commonly assesses motor milestones, balance and mobility, foot posture may receive less attention during developmental screening. Research has described normal foot development and flexible flatfoot, but less is known about foot posture in preschool children with developmental risk factors. This study therefore compared FPI-6 scores in high-risk and typically developing children aged 2–4 years.

2. Methodology

A comparative cross-sectional study was conducted in 60 children aged 2–4 years: 30 high-risk children (Group A) and 30 typically developing children (Group B). Participants were recruited by convenience sampling from paediatric physiotherapy units, outpatient clinics, early-intervention centres, preschools and Anganwadi centres.

Group A included children with a documented history of prematurity (less than 37 weeks), developmental delay, hypotonia, prolonged NICU stay or identified motor risk. Children had to be able to stand independently or with minimal support. Group B included children with age-appropriate milestones and no diagnosed neurological, developmental or orthopaedic condition. Children with congenital foot deformities, previous lower-limb surgery or fracture, severe difficulty standing, genetic syndromes, acute illness or no parental consent were excluded.

Static foot posture was assessed separately on each foot using the six FPI-6 items: talar head palpation, malleolar curvature, calcaneal position, talonavicular prominence, medial longitudinal arch congruence and forefoot abduction/ adduction. Each item was scored from −2 to +2. Demographic details, birth history, height, weight and BMI were also recorded.

Ethical approval was obtained from the Institutional Ethics Committee. Written informed consent was obtained from each participant's parent or guardian, and data were anonymised.

Data were analysed using IBM SPSS Statistics version 26.0 and Jamovi version 2.3.28. Normality was assessed using the Shapiro–Wilk test and visual inspection. Depending on distribution and variable type, between-group comparisons used independent-samples t-tests, Mann–Whitney U tests, chi-square tests or Fisher's exact tests. Spearman correlation was used to assess associations between perinatal/ developmental variables and FPI-6 scores. Statistical significance was set at $p < 0.05$.

3. Results

Sixty children were included, with 30 participants in each group. Results are presented below; continuous variables are reported as mean ± standard deviation and categorical variables as number (percentage).

Table 1: Demographic and Anthropometric Characteristics

Variable	Group A - High Risk (n=30)	Group B - Typ Dev (n=30)	Test Used	p-value
Number of participants	30 (50.0%)	30 (50.0%)	—	—
Mean age (years) ± SD	3.02 ± 0.68	3.03 ± 0.66	Mann-Whitney U	0.9398
Male, n (%)	11 (36.7%)	14 (46.7%)	Chi-square (χ^2)	0.3755
Female, n (%)	19 (63.3%)	16 (53.3%)	Chi-square (χ^2)	0.3755
Height (cm), Mean ± SD	80.53 ± 5.70	77.00 ± 7.78	Mann-Whitney U	0.0051*
Weight (kg), Mean ± SD	9.59 ± 3.30	9.48 ± 3.97	Mann-Whitney U	0.3967
BMI (kg/m²), Mean ± SD	15.07 ± 5.68	16.57 ± 7.40	Mann-Whitney U	0.0420*

The groups were similar in age, sex and weight. Height and BMI differed significantly, and these differences should be considered when interpreting the foot-posture findings.

Table 2: Birth History and Neonatal Parameters

Variable	Group A - High Risk (n=30)	Group B - Typ Dev (n=30)	Test Used	p-value
Gestational Age < 37 wks, n (%)	26 (86.7%)	1 (3.3%)	Chi-square (χ^2)	< 0.001*
Gestational Age ≥ 37 wks, n (%)	4 (13.3%)	29 (96.7%)	Chi-square (χ^2)	< 0.001*
Birth weight (kg), Mean ± SD	2.51 ± 0.50	2.76 ± 0.33	Independent t-test	0.0279*
NICU Admission, n (%)	11 (36.7%)	1 (3.3%)	Chi-square (χ^2)	0.0052*
Duration of NICU stay (days)	4.91 ± 7.64	0.00 ± 0.00	Mann-Whitney U	< 0.001*
Normal Vaginal Delivery, n (%)	9 (30.0%)	17 (56.7%)	Chi-square (χ^2)	0.0187*
Cesarean Section, n (%)	21 (70.0%)	11 (36.7%)	Chi-square (χ^2)	0.0187*
Assisted Delivery, n (%)	0 (0.0%)	2 (6.7%)	Fisher's Exact	0.0187*

Preterm birth, lower birth weight and NICU admission were more common in Group A. NICU stay was also longer in this group. Mode of delivery differed between groups.

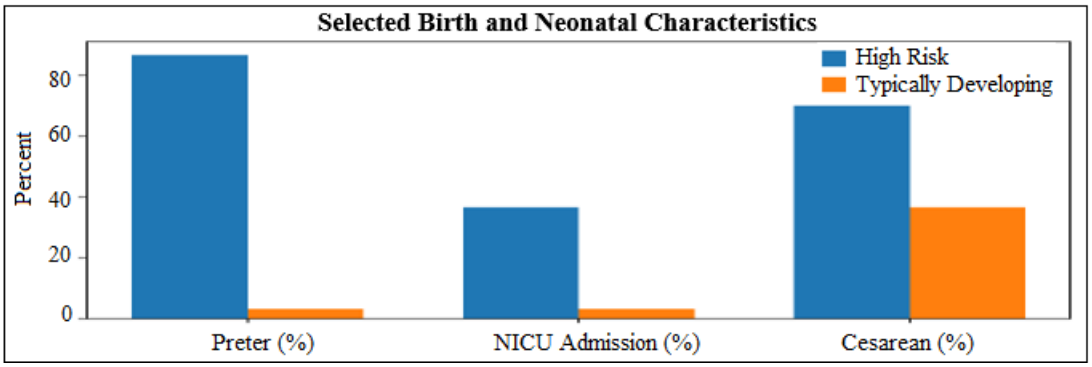


Figure 1: Selected Birth and Neonatal Characteristics

Table 3: Developmental Milestones

Milestone Variable	Group A - High Risk (n=30)	Group B - Typ Dev (n=30)	Test Used	p-value
Sitting age (months)	8.31 ± 2.74	7.61 ± 0.83	Mann-Whitney U	0.4090
Crawling age (months)	11.73 ± 4.01	9.54 ± 0.92	Mann-Whitney U	0.0217*
Standing age (months)	17.30 ± 5.30	11.05 ± 1.04	Mann-Whitney U	< 0.001*
Walking age (months)	23.03 ± 6.41	12.89 ± 1.45	Mann-Whitney U	< 0.001*

Sitting age did not differ significantly. Group A achieved crawling, standing and independent walking later than Group B.

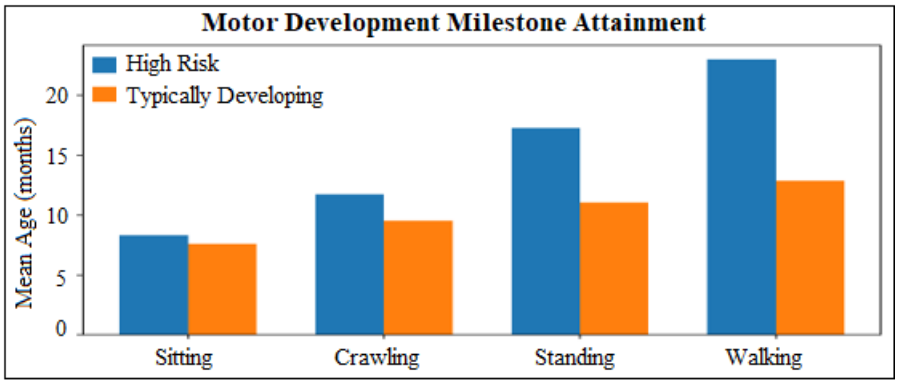


Figure 2: Motor Developmental Milestone Attainment

Table 4: Right Foot FPI-6 Scores

FPI-6 Component	Group A Mean ± SD	Group B Mean ± SD	Test Used	p-value
Talar head palpation	0.93 ± 1.11	0.17 ± 0.38	Mann-Whitney U	< 0.001*
Malleolar curvature	0.90 ± 1.18	0.13 ± 0.35	Mann-Whitney U	< 0.001*
Calcaneal position	1.07 ± 1.05	0.20 ± 0.41	Mann-Whitney U	< 0.001*
Talonavicular prominence	1.13 ± 0.73	0.17 ± 0.38	Mann-Whitney U	< 0.001*
Medial longitudinal arch	0.97 ± 1.00	0.20 ± 0.41	Mann-Whitney U	< 0.001*
Forefoot abduction/adduction	1.00 ± 1.02	0.17 ± 0.38	Mann-Whitney U	< 0.001*
Total Right FPI-6 Score	5.90 ± 5.15	1.03 ± 0.67	Mann-Whitney U	< 0.001*

All six right-foot FPI-6 component scores and the total score were higher in Group A (5.90 ± 5.15) than Group B (1.03 ± 0.67); all comparisons were statistically significant ($p < 0.001$).

Table 5: Left Foot FPI-6 Scores

FPI-6 Component	Group A Mean ± SD	Group B Mean ± SD	Test Used	p-value
Talar head palpation	1.07 ± 0.83	0.17 ± 0.38	Mann-Whitney U	< 0.001*
Malleolar curvature	1.13 ± 0.82	0.13 ± 0.35	Mann-Whitney U	< 0.001*
Calcaneal position	0.87 ± 1.14	0.17 ± 0.38	Mann-Whitney U	< 0.001*
Talonavicular prominence	1.13 ± 0.73	0.20 ± 0.41	Mann-Whitney U	< 0.001*
Medial longitudinal arch	1.07 ± 0.78	0.17 ± 0.38	Mann-Whitney U	< 0.001*
Forefoot abduction/adduction	1.00 ± 1.02	0.17 ± 0.38	Mann-Whitney U	< 0.001*
Total Left FPI-6 Score	5.77 ± 4.88	1.00 ± 0.64	Mann-Whitney U	< 0.001*

The left-foot findings followed the same pattern. The total score was 5.77 ± 4.88 in Group A and 1.00 ± 0.64 in Group B ($p < 0.001$).

Table 6: Foot Posture Classification

Foot Posture Category	Group A - High Risk n (%)	Group B - Typ Dev n (%)	Total Cohort n (%)
Highly Supinated (-12 to -5)	1 (3.3%)	0 (0.0%)	1 (1.7%)
Supinated (-4 to -1)	2 (6.7%)	0 (0.0%)	2 (3.3%)
Neutral (0 to +5)	11 (36.7%)	28 (93.3%)	39 (65.0%)
Pronated (+6 to +9)	5 (16.7%)	2 (6.7%)	7 (11.7%)
Highly Pronated (+10 to +12)	11 (36.7%)	0 (0.0%)	11 (18.3%)

Neutral posture was recorded in 93.3% of Group B and 36.7% of Group A. In Group A, 53.4% had a pronated or highly pronated classification. The distribution differed significantly between groups ($\chi^2 = 23.85$, $p < 0.001$). Total FPI-6 scores were significantly higher in Group A for both the right and left feet ($p < 0.001$ for each comparison).

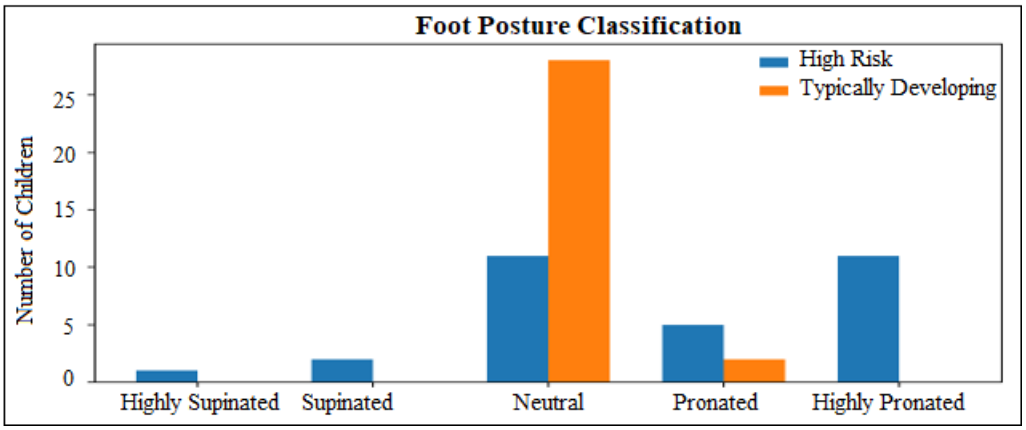


Figure 3: Foot Posture Classification

Table 7: Correlation Analysis

Clinical Predictor	FPI-6 Outcome	Correlation Coeff (r)	p-value	Inference
Gestational age (weeks)	Right Foot Total FPI-6	r = -0.568	< 0.001*	Strong Negative Correlation
Gestational age (weeks)	Left Foot Total FPI-6	r = -0.574	< 0.001*	Strong Negative Correlation
Birth weight (kg)	Right Foot Total FPI-6	r = -0.421	< 0.001*	Moderate Negative Correlation
Birth weight (kg)	Left Foot Total FPI-6	r = -0.508	< 0.001*	Moderate Negative Correlation
Standing age (months)	Right Foot Total FPI-6	r = 0.581	< 0.001*	Strong Positive Correlation
Standing age (months)	Left Foot Total FPI-6	r = 0.551	< 0.001*	Strong Positive Correlation
Walking age (months)	Right Foot Total FPI-6	r = 0.648	< 0.001*	Strong Positive Correlation
Walking age (months)	Left Foot Total FPI-6	r = 0.655	< 0.001*	Strong Positive Correlation

Correlation analysis demonstrated significant associations between birth and developmental variables and bilateral FPI-6 scores (all $p < 0.001$). Gestational age showed a strong negative correlation with right ($r = -0.568$) and left ($r = -0.574$) foot FPI-6 scores. Birth weight was moderately negatively correlated with right ($r = -0.421$) and left ($r = -0.508$) foot scores. Conversely, the age at achieving standing and walking milestones showed strong positive correlations with FPI-6 scores bilaterally. Walking age demonstrated the strongest association (right: $r = 0.648$; left: $r = 0.655$). These findings indicate that lower gestational age and birth weight, along with delayed achievement of standing and walking milestones, were associated with higher FPI-6 scores.

4. Discussion

This cross-sectional study was performed to make a comparison of foot posture in high-risk versus typically developing children between 2 to 4 years old using the Foot Posture Index-6 (FPI-6), and to evaluate the relationship between foot posture and specific demographic, anthropometric, perinatal, and developmental traits. The results clearly indicate a notable difference in foot posture between the two groups. The high-risk children scored significantly higher on the FPI-6 for both their right and left feet, which pointed to a more pronated foot posture. Moreover, the high-risk group also had a much higher percentage of pronated and highly pronated feet as compared to the typically developing group. FPI-6 is a reliable clinical test used for the assessment of foot posture in standing position. [1,2]

The study included 60 children, equally divided into high-risk and typically developing groups. Mean age was comparable between the groups (3.02 ± 0.68 vs 3.03 ± 0.66 years; $p = 0.9398$), with no significant difference in sex distribution ($p = 0.3755$). Age comparability is important because foot posture undergoes developmental changes during early childhood [2].

Height differed significantly between the groups (80.53 ± 5.70 vs 77.00 ± 7.78 cm; $p = 0.0051$). Similarly, BMI showed a significant difference (15.07 ± 5.68 vs 16.57 ± 7.40 kg/m²; $p = 0.0420$), whereas body weight was comparable (9.59 ± 3.30 vs 9.48 ± 3.97 kg; $p = 0.3967$). These differences should be considered while interpreting the foot posture findings [10,11].

Prematurity was significantly more prevalent in the high-risk group than in the typically developing group (86.7% vs 3.3%;

$p < 0.001$). Mean birth weight was also significantly lower in high-risk children (2.51 ± 0.50 vs 2.76 ± 0.33 kg; $p = 0.0279$). NICU admission (36.7% vs 3.3%; $p = 0.0052$) and duration of NICU stay ($p < 0.001$) were significantly higher in the high-risk group. Caesarean delivery was also more frequent (70.0% vs 36.7%; $p = 0.0187$).

Previous studies have reported increased neuromotor developmental vulnerability among preterm and low-birth-weight children, highlighting the importance of early developmental monitoring [5–7,12.] These neonatal differences provide relevant context for the altered foot posture observed in the present study.

No significant difference was observed in the age of achieving independent sitting (8.31 ± 2.74 vs 7.61 ± 0.83 months; $p = 0.4090$). However, high-risk children achieved crawling (11.73 ± 4.01 vs 9.54 ± 0.92 months; $p = 0.0217$), standing (17.30 ± 5.30 vs 11.05 ± 1.04 months; $p < 0.001$) and walking (23.03 ± 6.41 vs 12.89 ± 1.45 months; $p < 0.001$) significantly later than typically developing children.

These findings indicate delayed gross motor development, particularly in milestones involving balance, postural control and lower-limb weight-bearing. Similar developmental vulnerabilities have been described in children with a history of prematurity [6,7,12].

The principal finding was significantly higher bilateral FPI-6 scores among high-risk children. The mean right-foot score was 5.90 ± 5.15 compared with 1.03 ± 0.67 in typically developing children. Similarly, left-foot scores were 5.77 ± 4.88 and 1.00 ± 0.64, respectively (both $p < 0.001$).

All six FPI-6 components, including talar head palpation, malleolar curvature, calcaneal position, talonavicular prominence, medial longitudinal arch and forefoot alignment, showed significantly higher scores in the high-risk group bilaterally (all $p < 0.001$).

These findings suggest bilateral alterations in static foot posture, predominantly towards pronation. The FPI-6 provides a comprehensive clinical assessment of foot alignment through evaluation of multiple anatomical components [1,8]. Age-related variations in pediatric foot posture should nevertheless be considered during interpretation [2,3].

Neutral foot posture was observed in 93.3% of typically developing children compared with 36.7% of high-risk children. Pronated or highly pronated posture was present in 53.4% of high-risk children compared with 6.7% of typically developing children. Additionally, 10% of high-risk children demonstrated supinated or highly supinated posture.

These findings indicate greater variability and a higher prevalence of pronated foot posture among high-risk children. However, physiological variations in foot posture are common during preschool years, and pronation should not automatically be considered pathological [3,5]. Individual assessment remains essential [4,15].

Gestational age demonstrated a strong negative correlation with right ($r = -0.568$) and left ($r = -0.574$) foot FPI-6 scores (both $p < 0.001$). Birth weight showed moderate negative correlations with right ($r = -0.421$) and left ($r = -0.508$) foot scores (both $p < 0.001$). These findings indicate that lower gestational age and birth weight were associated with higher FPI-6 scores.

Conversely, standing age demonstrated positive correlations with right ($r = 0.581$) and left ($r = 0.551$) foot scores, while walking age showed stronger correlations ($r = 0.648$ and $r = 0.655$, respectively; all $p < 0.001$). Walking age demonstrated the strongest association with bilateral FPI-6 scores.

These associations suggest that prematurity, lower birth weight and delayed gross motor milestone attainment are related to altered foot posture. Differences in neuromotor maturation, postural control and weight-bearing patterns may contribute to these observations [6,7,12–14]. However, the interrelationship between these variables and the cross-sectional design prevent establishing independent or causal effects.

5. Conclusion

In this sample of 60 children aged 2–4 years, high-risk children had significantly higher right- and left-foot FPI-6 scores than typically developing children. Pronated or highly pronated posture was more common in the high-risk group, while neutral posture was common in the typically developing group.

The high-risk group also had more preterm births and NICU admissions, lower birth weight and later attainment of several gross-motor milestones. Gestational age, birth weight and the timing of standing and walking were associated with FPI-6 scores. These findings indicate associations and do not establish causality.

A brief foot-posture assessment may be useful as part of a comprehensive paediatric physiotherapy evaluation. FPI-6 findings should be considered together with gait, symptoms, muscle tone, strength, joint range, balance and function. Longitudinal studies with larger samples are needed to confirm these findings and examine developmental changes over time.

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