# Comparison of foot structure and function between rural and urban Indian children

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## Introduction

Development of foot continues up to 12 yrs of age. It is also known that foot anthropometry varies across populations.[1] A growing structure in first decade of life which varies globally demands extensive study. In countries like India where children continue to walk bare feet predominantly in rural parts, it is particularly essential to explore foot characteristics with an intention to safeguard their foot health and consequently lower extremity function. In India, the incidence of flat feet was most common in children who wore closed-toe shoes, less common in those who wore sandals or slippers, and least in the unshod. However, a major limitation with these studies is reliability of outcome measure used. Only a few have studied plantar pressures among barefoot walkers which can provide robust information on foot geometry and loading during walking to indicate dynamic foot function.[2] Present study compared foot structure between rural and urban Indian children using robust objective outcome measures during dynamic condition i.e walking.

## Method

The study was approved by Institution Review Board of MGM Institute of Health Sciences. Informed consent was sought from all parents and school authorities. A convenience sample of 200 healthy children aged 6-15 yrs with no history of foot pain was studied. 100 rural children from Municipal Schools of Ransai and Chikale villages located in Raigad district of Maharashtra state were matched on marginal distributions for age, height and body mass with 100 urban children from MGM School, Navi Mumbai, Maharashtra state for comparison.

Foot geometry and plantar pressure measurements were collected using emed-sf system (Novel GmbH, Munich, Germany), which is a capacitance transducer based system to record foot geometry and pressures of a person walking barefoot. All children were asked to walk bare feet across the platform at self-selected speed and 5 right and 5 left steps of mid-gait were recorded for analysis (Figure 1). Average of data from 5 right and 5 left steps were used for further analysis.[3] Arch Index was recorded to study medial longitudinal arch (MLA) height .

Figure 1: Use of emed-sf system to record footpressures and foot geometry

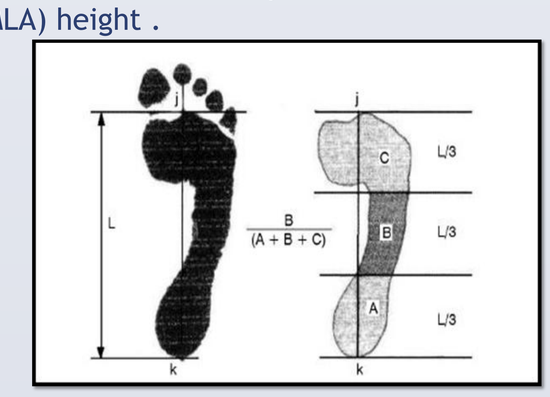


Figure 2: Calculation of Arch Index (AI)

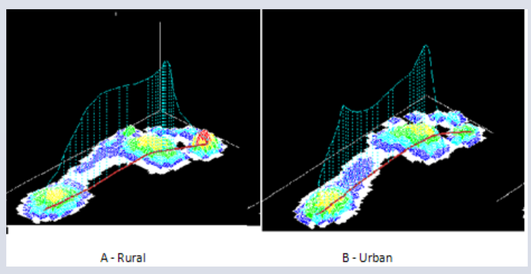


Figure 3: Typical plantar pressure distribution for: A) rural child and B) urban child

## Results

Average height, body weight and body mass index (BMI) varied significantly between two groups. (Table I) Rural children presented mean shorter foot length compared to urban children (Table I). Expressed as a percentage of total body stature, rural children had 4% significantly shorter feet. Comparison of foot width as a percentage of foot length (a measure for overall foot shape), significant differences between two groups emerged. Rural children presented with 3% wider forefoot and 28% narrower mid foot. Arch Index (AI) based on areas of forefoot, mid foot and hind foot using the emed sf system . Rural children presented with 15% higher arch compared to the urban counterparts.

Differences in pressure distribution were most prominent on heel and in metatarsal region despite similar gait line speeds. Rural children demonstrated approx. 22% lower peak pressures over entire foot with forefoot showing maximum difference. 22% lower pressures were recorded in forefoot region , approximately 5% in mid foot and 17% in hind foot; the differences in forefoot and mid foot regions being statistically significant.

## Table

| | Rural | Urban | p value |
|---|---|---|---|
| Age (years) | 9.95 (2.81) | 10.89(3.09) | 0.85 |
| Height (cm) | 128.04 (14.43) | 134.42 (18.06) | 0.01* |
| Weight (kg) | 25.54 (06.47) | 33.73 (11.71) | 0.00* |
| %Foot length/ stature (R) | 16.14 (0.81) | 16.67 (1.07) | 0.00* |
| % Forefoot width/ foot length (R) | 41.72 (3.32) | 40.49 (4.34) | 0.02* |
| % Midfoot width/ foot length (R) | 8.44 (5.44) | 11.66 (6.08) | 0.00* |
| % Hindfoot width/ foot length (R) | 26.03 (2.93) | 25.70 (3.33) | 0.44 |
| Arch Index (Rt) | 0.20 (0.06) | 0.23 (0.06) | 0.00* |
| MPP Fore foot (Rt) | 167.80 (49.10) | 204.00 (85.38) | 0.04* |
| MPP Mid foot (Rt) | 92.85 (28.61) | 96.95 (32.50) | 0.00* |
| MPP Hind foot (Rt) | 185.30 (57.82) | 217.10 (78.64) | 0.54 |
| MPP Total (Rt) | 224.45 (56.03) | 288.15 (103.53) | 0.38 |

*Results expressed as mean (SD); *p<0.05 =significant ; MPP = Maximum Peak Pressure*

## Discussion

Rural children may be shorter compared to their age-matched urban counterparts because it is likely that rural children consume less nutritious food and it is known that body nutrition is directly associated with body height. [4] It is already known that people with shorter body height tend to have shorter feet. Wider forefoot of rural children can be explained with greater prehensile activity of forefoot required to adapt to uneven terrain during push-off while walking barefoot for a large part of the day for indoor and outdoor activities which is noted even in adult rural Indian barefoot walkers. Narrow mid-foot in rural children is consistent with higher MLA compared to urban children. It is known that walking bare feet challenges use of intrinsic muscles which facilitates development of medial longitudinal arch resulting in higher prevalence of flat feet among children using footwear compared children walking bare feet. Peak plantar pressure was lower over forefoot and mid foot in habitually barefoot rural children than in urban shod peers despite adjusting for body weight and both groups walking at similar gait velocity. Lower pressure over wider forefoot of rural children may be due to redistribution of pressure over larger contact surface area of forefoot.[5] Where as lower mid-foot pressure in rural children may result from lesser contact surface area owing to narrower mid foot caused by higher medial arch.

## Conclusion

Rural Indian children presented with approximately 24 % lesser body mass and 5% lesser height; 4 % shorter feet with 3% wider forefoot and 28% narrower mid foot and higher arches compared to urban children. Rural children demonstrated approximately 22% lower pressures in forefoot and 5% in the mid foot. These changes can be considered favorable in terms of foot function and prevention of forefoot injuries.

## References

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## Acknowledgements

The authors express their gratitude to all children for their voluntary participation. Also we wish to acknowledge their parents and the school teachers for helping us in data collection.