# FOOT STRIKE CONTACT LOCATION AND FOOT LOADING DURING THE DEVELOPMENT OF RUNNING IN CHILDREN AGE 3 TO 11 YEARS

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## INTRODUCTION

Foot plantar loading contributes key knowledge toward the understanding of the development of running in children. Foot loading during walking has been studied extensively [1,7,4,6]. Only one study was found that examined foot loading in children during running [5]. The purpose of the current study, the Kids Global Research Project, was to examine the development of running in children from 4 different countries: Germany, Japan, USA and Brazil. This abstract presents the USA foot pressure data. The purpose of the research was to determine foot strike contact location and to quantify foot loading during running in children age 3 to 11 years. It was hypothesized that during the development of running, younger children would land flatfooted or on their forefoot and older children would land on their heel. It was also hypothesized that forefoot loading, after taking body weight into account, would increase over age due to an increase in muscle strength and an improvement in coordination.

## METHODS

Healthy active boys and girls were recruited at the age of 3, 5, 7 and 9 years (resulting in 4 groups). After obtaining the informed parental consent they visited the lab once a year for 3 consecutive years. Data of sixty-one children were included resulting in 183 data sets over the 3 years (Table 1). Children ran barefoot on a foam runway at a self-selected speed. The foam runway (Peak G 15.9) surrounded, but did not cover, an EMED pressure sensing plate (Novel GmbH, Germany; 4 sensors/cm$^2$, 50Hz). Timing gates were used to record running speed. A minimum of 5 trials per child were collected. Of these 5 trials, 3 consistent trials were selected for further analysis. Foot strike location was determined for each trial using the initial coordinates of the center of pressure (COP). A foot strike was classified as “heel strike” when the COP started in the rear 1/3 of foot length [2].

The foot was divided into 4 anatomical areas to quantify loading: hindfoot, midfoot, forefoot, and toes. Foot loading was computed by integrating pressure over area. Absolute peak force (N) and peak force normalized to body weight (% BW) were extracted from the data. A repeated measures ANOVA was used to compare absolute foot loading, normalized foot loading and self-selected running speed within and between groups ($p<0.05$).

## RESULTS and DISCUSSION

At the younger ages, 80% or more of the children landed on their heel (Table 1). By the age of 6 most children were heel strikers (> 93.3%). In a large sample of elite adult distance runners, 74.9% were heel strikers [3]. Either, the percentage of heel strikers in our sample of children is greater than that of elite adult runners, or the elite adult runners ran at a relatively faster speed. It is also possible that elite runners have modified their foot strike location due to training.

**Table 1.** The age, number of children, mean body mass and the percentage of heel strikers is shown.

| Age (yrs) | Number of children | Mean body mass (kg) | Heel strike (%) |
|---|---|---|---|
| 3 | 15 | 14.5 | 86.7 |
| 4 | 15 | 16.7 | 80.0 |
| 5 | 34 | 19.5 | 82.4 |
| 6 | 19 | 22.8 | 100.0 |
| 7 | 31 | 25.6 | 93.5 |
| 8 | 12 | 29.2 | 100.0 |
| 9 | 27 | 31.2 | 96.3 |
| 10 | 15 | 33.2 | 93.3 |
| 11 | 15 | 37.4 | 100.0 |

Absolute peak force increased over age in all 4 anatomical foot areas ($p<0.001$; Figure 1). The largest increase was seen under the forefoot followed by the hindfoot. Once normalized to body

weight, the peak force under the forefoot increased with age ($p<0.026$) whereas the peak force under the hindfoot and toes did not change over age (Figure 2). Some changes in normalized peak force under the midfoot were found over age which may be attributed to arch development. These findings indicate that body weight is a leading contributor to the magnitude of foot loading during running in children age 3 to 11.

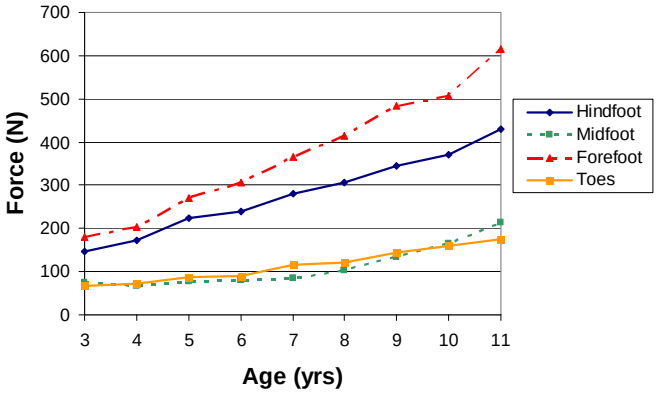


**Figure 1.** Absolute peak force under each anatomical area is shown over age.

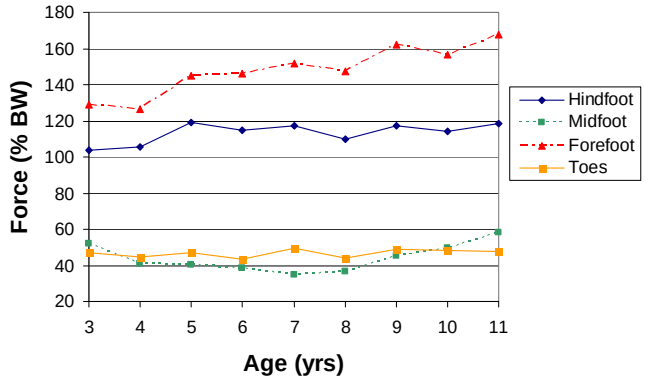


**Figure 2.** Normalized peak force under each anatomical area is shown over age.

The increase in normalized peak force under the forefoot can be explained by an increase ($p<0.001$) in self-selected running speed with age (Figure 3). Normalized peak force under the forefoot and running speed are highly correlated ($R^2=0.86$). Other potential factors increasing normalized forefoot loading over age are an increase in muscle strength and an improvement in coordination.

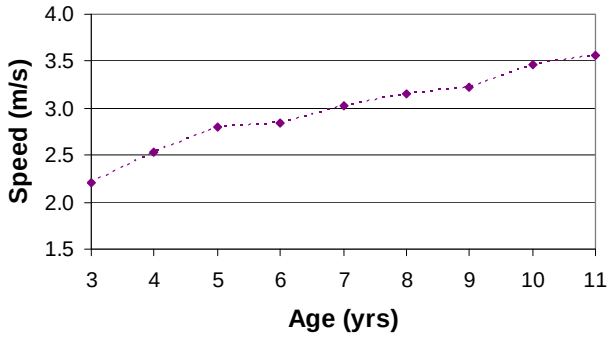


**Figure 3.** Self-selected running speed is shown over age.

## CONCLUSIONS

Our hypothesis that during running the younger children in our study would land flatfooted or on their forefoot did not hold. The majority of children over the entire age range examined, ages 3 to 11, were heel strikers.

Foot loading was largely influenced by body weight. As hypothesized, normalized forefoot foot loading did increase over age and can be explained by an increase in running speed. An increase in muscle strength and an improvement in coordination with age may also play a role in the increase in foot loading over age. These findings have implications for footwear design.

## REFERENCES


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