

FOOTWEAR'S INFLUENCE ON YOUNG CHILDREN'S GAIT PATTERN

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INTRODUCTION

Footwear is one of the most important external factors influencing young children's gait pattern. The main goals of this study were to analyze both the **differences between shod and unshod conditions** and the **influence of footwear properties** on toddler's gait pattern. In order to achieve these objectives, a methodology combining design of experiments, skill circuit's measurements and biomechanical tests to gather both kinetic and kinematic gait data was developed.

This study gives a new insight on the influence of footwear in gait acquisition of young children and provides valuable design criteria for children footwear.

REVIEW AND THEORY

During human childhood, gait acquisition is achieved under the influence of both intrinsic and extrinsic factors. Intrinsic factors include, **musculoskeletal system strengthening, body size and weight increase, neural maturation** and **walking experience acquisition** among others, all of them influencing children's gait (Adolph, K. et al., 2003). One of the most important extrinsic factors, is **footwear**, which acts as an interface between children's feet and ground, playing two different roles: by one side, footwear interacts between foot and ground modifying the natural foot movement and the forces acting between them and, by the other one, it provides stimulus to the feet being one of the main information sources children have to improve their gait ability. Attending to these arguments, it is reasonable to suppose that shoes will affect greatly children's gait pattern and gait maturation.

Few studies exist centred on shoe's influence on healthy young children's gait pattern. Gould (1985) compared gait skills features (stability, cadence and number of falls among others) through visual expert analysis in toddlers aged between 11 to 36 months wearing shoes and sneakers, using a skill circuit. In a more completed analysis, Kristen et al (1998) compared kinetic data (ground reaction forces) of young children aged from 1 to 4 years while being shod and barefoot. Finally, Oeffinger et al. (1999) analyzed the differences on both kinematic and kinetic gait variables between shod and barefoot conditions on children ranging from 7 to 10 years.

There are not many studies exploring the differences on gait patterns between shod and barefoot conditions on young children in the process of gait acquisition and maturation. Moreover, there is a lack of studies about how different footwear properties affect toddler's gait pattern.

PROCEDURES

Children's gait pattern was assessed under **six different wearing conditions**: being barefoot, wearing a reference shoe and wearing four different prototypes developed by varying the properties of the reference shoe (counter stiffness, mounting insole stiffness, forefoot fitting and rearfoot fitting).

A total of 102 children from 1 to 4 years old from two infant schools in Spain participated on the study after their parents knew the experimental procedures and gave their written consent. Each child performed three valid trials under three different wearing conditions: barefoot, reference shoe and one of the prototypes. Children were grouped into 6 walking age ranges of ½ year for the tests. The following measurements were carried out:

- **Skill circuit measurements:** After a pilot study, two different skill circuits adapted to gait development (Alcantara et al. 1998) were used to measure gait skill: one circuit from 1 to 3 years, and another one from 3 to 4 years. These circuits included fixed goal tasks compromising either single or complex movements that children perform which could be influenced by footwear. Each child performed three valid trials for each wearing condition in random order to eliminate training effects. The number and location of errors were registered and graded according to their seriousness.
- **Time/distance parameters:** Two photocells were used to measure gait velocity of children. Furthermore, step length and width were measured by means of talcum powder. Cadence and step duration were calculated afterwards.
- **Force plate parameters:** Dynamic measurements of ground reaction forces were carried out. A Dinascan/IBV force plate was placed in the middle point of a 4 m length even path where children walked performing three valid trials. Ground reaction forces and the path of the centre of pressures were recorded.

In order to find and eliminate anomalous cases, data was inspected by means of **descriptive analysis**. In the skill circuits, the frequency of errors was examined considering for the posterior analysis obstacles with a total frequency of errors higher than 5% and smaller than 90%. Kruskal-Wallis nonparametric statistical analysis was applied to data from the skill circuits.

Time/distance and force parameters were normalized to body height or weight in order to compare measurements between subjects of different ages and complexion. Analysis of Variance (ANOVA) was performed with this data, using as factors the walking age and the differences between footwear prototypes. Statistical and mathematical applications SPSS 11, Matlab 6 and Excel XP were used in the data analysis.

RESULTS AND DISCUSSION

In this study, two main aspects of footwear's influence on children's gait pattern were evaluated. Firstly, footwear's global influence was assessed by comparing tests results between shod and unshod conditions. Secondly, the influence of footwear properties on gait pattern was analyzed. In both cases statistical differences ($p < 0.05$) were found.

In general, children wearing shoes showed a greater number of stabilization centres (Baratto et al. 2002), greater relative step length and gait velocity, and smaller relative step width and duration, which are some of the changes that characterize the gait pattern maturation process. Moreover, some of the footwear modifications showed the same influence.

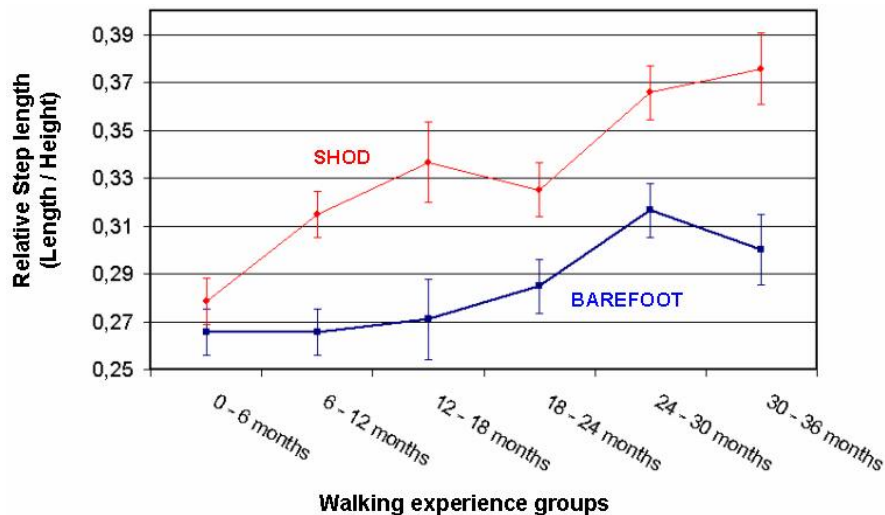


Figure 1. Relative step length measures on shod and unshod conditions.

Results of this study support the initial hypothesis about the footwear's influence on toddler's gait pattern and how a more mature (adult-like) gait pattern is observed when choosing the appropriated footwear characteristics. However, influencing in this way children's gait pattern during gait acquisition could restrain children's natural development affecting musculoskeletal structures strengthening or even sensorimotor maturation. Future research in this field is needed in order to clarify the implications of influencing children's gait pattern through footwear.

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