

FOOT SHAPE DIMENSIONS FOR DESIGN CRITERIA OF CHILDREN LASTS

Paulien Kok, M.Sc¹, Patricia Bax, M.Sc¹, Cathy Smits, M.Sc¹
¹TNO Science and Industry, the Netherlands

INTRODUCTION

Accurate fitting of a shoe is very important for comfort and functionality. Because the foot skeleton of young children is not consolidated and the influence of for example compression can be harmful, accurate fitting is essential and should be considered for last design. The morphology of the children foot differs from the adult foot so a children last should be designed considering the children anthropometric foot shape.

There is a lack on recent, 3-dimensional data about children foot measures that can be used for last criteria. The data that exist, are results based on hand measurements (Forriol 1990, Gould 1990, Wenger 1983). In literature and shoe business, it is often assumed that the ball girth is 2.5 times the ball width. This assumption is based on 2-Dimensional foot data and on empirical research. In the study of Bax and Smits (Bax 2004) a correlation was found between the ball girth and the ball width for an adult male (with specific age) population using 3-Dimensional foot data.

In the European ARCHIBALD project, Spanish, Dutch and Czech companies work together with RTD Institutes to improve children shoes. Goal of the project is to develop new guidelines for children footwear for children from 0 to 4 years. This study was designed to investigate the foot shape dimensions for design criteria for lasts. The aspects that were included in this study are:

1. Foot dimensions in growth of children (0-4 years);
2. Differences in foot shape dimension between Dutch boys and Dutch girls;
3. Differences in foot shape dimension between children from South Europe (Spain) and children from North Europe (The Netherlands and Belgium);
4. The possibility of determination of the ball girth from the ball width for children of 0-4 years.

PROCEDURES

In Spain as well as in the Netherlands children from 1-4 years old (sizes 19-30) have been included in an anthropometrical study. In Spain, the measurements were done on 605 children at infant schools in 15 peninsular regions. In the Netherlands and Belgium feet of 614 children (334 boys and 280 girls) were scanned. These measurements were carried out in shoe shops, day-care centers and consultation centers divided over seven regions at 21 different locations. 3-dimensional foot dimensions were measured with use of the Shoemaster FotoFit scanner[®]. The raw data scans were analyzed with TNO software for automatic determination of (anatomical) foot measures.

RESULTS

From the anthropometrical data of this study, looking at the growing rate of the foot in the length (defining 5 mm difference in foot length is one size) it appears that:

- Dutch boys and girls between 1-2 years old need 3-4 times a year a different shoe size;
- Dutch boys and girls between 2-3 years old need 2-3 times a year a different shoe size;
- Dutch boys between 3-4 years old need 1-2 times a year a different size;
- Dutch girls between 3-4 years old need 2-3 times a year a different size.

Differences have been found between Dutch boys and girls taking age and foot length as a fixed factor or as covariant. It appears that Dutch boys are significantly heavier and have a significantly higher BMI than Dutch girls. Dutch boys have a significantly longer foot length than girls. Dutch boys

also have a significantly larger ball girth, instep girth, instep height and a larger heel width than Dutch girls.

There appears to be differences in foot measures and general gait aspects between the children of the countries. Again, age, foot length, and gender were taken as a fixed factor or covariant. In this study, children from North Europe are significantly taller than children from South Europe. Children from Spain start to walk earlier. Spanish children have a significantly higher BMI than children from North Europe. When looking at differences of foot measures, Spanish children have a significantly larger ball girth, ball width, ball height, toe height, instep girth, instep height and heel width, than children from North Europe. Spanish children have a significantly larger heel width / ball width than children from North Europe.

When looking at the possibility of determination of the ball girth from the ball width for children of 0-4 years we calculated the correlation coefficient between these two foot parameters. We found a strong correlation between ball girth and ball width (0.942) (see figure 1). With the model $y = 1.964 * x + 26.859$ the ball girth (y) can be predicted from the ball width (x), with a 2.7 mm mean error with a standard deviation of 2.1 mm. Age, gender and foot length do not influence the correlation between ball girth and ball width (Anova test).

REFERENCES

- Bax, P and C. Smits, (2004). Determination of ball girth from ball width and ball height. (article in preparation)
- Forriol F. and J. Pascual, (1990). Footprint analysis between three and seventeen years of age, *Foot & Ankle*, **11**(2): 101-4.
- Gould, N et al., (1990). Foot growth in children age one to five years, *Foot & Ankle*, **10**(4):211-3.
- Wenger D.R., et al., (1983). Foot growth rate in children age one to six years, *Foot Ankle*, **3**(4): 207-10

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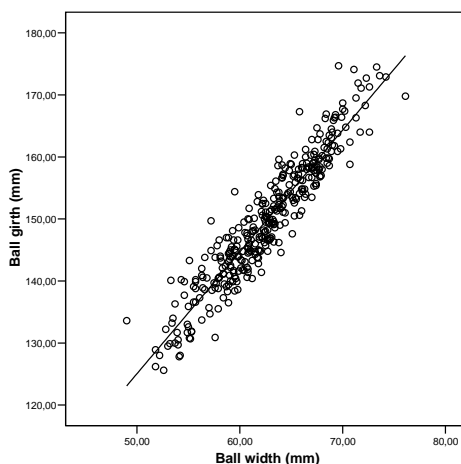


Figure 1: Relation between ball width and ball girth