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COMPARISONS OF FOOT ANTHROPOMETRY AND PLANTAR ARCH INDEXES BETWEEN GERMAN AND BRAZILIAN CHILDREN

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SUMMARY

The aim of this study was to compare the anthropometric characteristics of children's feet from 3 to 10 years of age from German and Brazilian populations. We compared 5 indirect measures of two databases from German and Brazilian children's feet. Static footprints were taken in both countries. Forefoot, midfoot and rearfoot widths were measured and Chippaux-Smirak and Staheli indices were calculated for longitudinal plantar arch evaluation. Brazilian children showed a significantly narrower forefoot for all ages, larger rearfoot for 4 year-old children and narrower rearfoot for 5 to 8 year-old children. Despite that, the Chippaux-Smirak and Staheli indices showed no differences of the plantar arch constitution among them for almost all ages. The exception was the 4 year-old Brazilian children that showed a higher Chippaux-Smirak index compared to German children (3.53 ± 0.36 ; 3.35 ± 0.28). Our study shows anthropometric differences in absolute forefoot and rearfoot widths of German and Brazilian children. We also noticed a very similar behavior of longitudinal plantar arch development between them. The exception seems to happen at 4 years of age, where Brazilian children seem to have their foot anthropometry very similar to the 3 year-old and seem to have a rapid development of the plantar arch from 4 to 5 years when compared to German children.

INTRODUCTION

Due to the world globalization, all communication, trades and research become closely related between different countries. It is clear that anthropometric data are very important for product design and development in global markets. Appropriate use of anthropometry may improve wellbeing, health, comfort and safety also/especially for footwear design.

Not only genetic inheritance, but also differences in social and economic development have an important influence on the demographic and anthropometric characteristics, so that they might lead to varied body dimensions and proportions. In order to strengthen ties of research and trades, it is important to identify these differences between nations.

To analyze the feasibility of multicentric research, it is necessary to compare the population of different centers and check if they share the same anthropometric characteristics, since potential differences could bias the results of a specific study.

The aim of this study was to compare anthropometric characteristics of children's feet from 3 to 10 years of age from German and Brazilian populations. We also analyzed the differences between them with two indirect measures of the medial longitudinal arch of the foot.

METHODS

Two anthropometric databases were used in this survey. The German database partially published as Bosch et al. [1] consisted of 107 healthy German children of both sexes followed over 9 years in a longitudinal approach (table 1). Exclusion criteria were orthopaedic, neurologic, systemic diseases or pre-term births. Height and body mass were recorded at every appointment. Furthermore, static foot shape parameters were recorded from a Harris mat footprint in bilateral stance. The database involved anthropometric and biomechanical measurements.

The Brazilian database has been published as Onodera et al. [2] and consisted of 391 kids of both sexes from 3 to 10 years that were recruited from Children's Centers at the University of São Paulo (table 1). Footprints were acquired with a Harris mat in bipedal stance with bilateral weight bearing. Six length and width parameters were measured with rulers over the footprints.

Local Ethics Committee approved each investigation and the parents signed an informed consent form. For the present study, the German database was divided into age groups of 3 to 10 years in order to be comparable to the Brazilian database which was already divided into age subgroups. Due to the small number of individuals of ages 7 and 8 years in the Brazilian database, they were grouped to form an age subset from 7 to 8 years old.

For the purpose of comparison, three commonly used anthropometric foot dimensions were analyzed: forefoot,

midfoot and rearfoot widths, along with the longitudinal plantar arch classification by the calculation of the Chippaux-Smirak (CSI) [3] and Staheli Indexes (SI) [4].

The normal distribution (Kolmogorov-Smirnov test) and homogeneity of variances (Levene test) were tested for all of the data in each group. For parametric variables, the independent T-test was used, and for non-parametric variables, the Mann-Whitney U-test was used. The alpha level was set to 5%.

RESULTS AND DISCUSSION

The German children showed a significantly wider forefoot than Brazilians for all age groups (table 2). On the other hand, the midfoot width appeared to be similar between the two databases for all ages (table 2). The rearfoot width was similar between both databases for the 3, 9 and 10 year-old groups (table 2). Brazilian children had larger rearfoot in the age of 4 and German children had larger rearfoot for 5, 6, 7 and 8 years (table 2).

German children were heavier than Brazilians in all age groups and taller from 6 to 9 years (table 1). Therefore, we suggest that these greater body proportions may have contributed to the German kids' larger forefeet and rearfeet. Bosch et al. [1] have found that a 1 kg difference in body weight was related to a wider foot. The German kids were approximately 1.5 kg heavier and this could justify their wider forefoot in all ages and wider rearfoot in older ages.

Besides the differences in forefoot and rearfoot width, there were no differences in the longitudinal plantar arch indices (CSI and Staheli's) for all ages, except for the 4 year-olds, where Brazilian children showed higher CSI which means lower plantar arches, compared to German kids (figure 1).

CONCLUSIONS

German children tend to have a wider forefoot than Brazilian children and wider rearfoot in half of the age

groups. The midfoot does not follow the same pattern as the other parts of the foot.

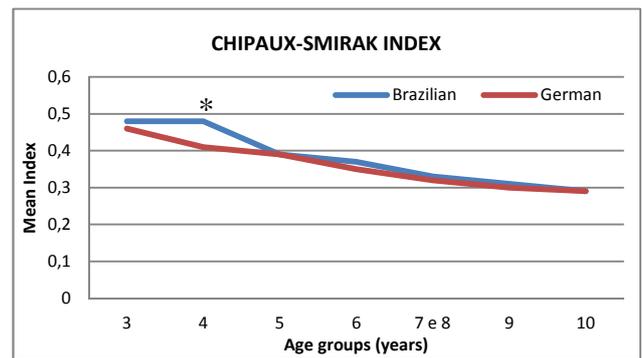


Figure 1 - Chippaux-Smirak index of German (red line) and Brazilian kids (blue line). * represents statistical difference.

The differences in absolute widths did not affect the development of longitudinal plantar arch, which develops comparably in both populations in most of the ages. The only exception is for the 4 year-old children, where German kids develop the plantar arch gradually from 3 to 10 and Brazilian children of 4 years have their foot anthropometry very similar to the 3 year-old children and after that they develop their plantar arch rapidly from 4 to 5 years.

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Table 1 - Height, body mass and percentage of males by age for German and Brazilian databases.

Age groups	n		Height (cm)		Weight (kg)		% of Boys	
	Brazil	Germany	Brazil	Germany	Brazil	Germany	Brazil	Germany
3	32	94	96.1 (3.6)	99.4 (4.5)*	15.1 (1.8)	15.6 (1.6)	37.5	46.8
4	73	94	105.0 (4.5)	106.9 (4.3)*	17.8 (2.7)	18.0 (1.9)	45.2	46.8
5	62	88	111.1 (5.5)	114.2 (4.9)*	19.8 (3.1)	20.5 (1.7)	33.9	47.7
6	74	82	115.6 (5.4)	121.0 (5.2)*	21.6 (3.2)	23.3 (1.4)*	48.6	50.0
7 and 8	32	84	125.5 (6.3)	129.6 (6.6)*	25.3 (3.8)	26.9 (3.7)*	43.7	46.7
9	83	55	136.0 (6.7)	139.1 (6.1)*	31.6 (5.2)	32.2 (4.4)*	54.2	47.3
10	35	48	140.5 (6.8)	145.5 (6.8)*	36.8 (9.4)	36.6 (5.2)	62.9	45.8

* statistically higher values between German and Brazilian databases (t-test for independent samples, $p < 0.05$).

Table 2 - Means and (standard deviations) of forefoot, midfoot and rearfoot widths of Brazilian and German children.

Age groups	Forefoot Width (cm)		Midfoot Width (cm)		Rearfoot Width (cm)	
	Brazil	Germany	Brazil	Germany	Brazil	Germany
3	5.61 (0.55)	5.82* (0.39)	2.68 (0.86)	2.71 (0.96)	3.25 (0.36)	3.23 (0.29)
4	6.06 (0.62)	6.26* (0.40)	2.95 (1.13)	2.60 (0.98)	3.53* (0.36)	3.35 (0.28)
5	6.18 (0.61)	6.70* (0.41)	2.41 (1.22)	2.60 (0.92)	3.49 (0.39)	3.59* (0.31)
6	6.48 (0.52)	6.98* (0.44)	2.42 (1.18)	2.47 (1.04)	3.64 (0.35)	3.76* (0.32)
7 and 8	6.78 (0.51)	7.40* (0.48)	2.29 (0.88)	2.38 (1.11)	3.79 (0.35)	3.90* (0.34)
9	7.47 (0.59)	7.84* (0.51)	2.28 (1.30)	2.35 (1.17)	4.11 (0.44)	4.14 (0.35)
10	7.71 (0.61)	8.15* (0.51)	2.27 (1.39)	2.43 (1.30)	4.19 (0.59)	4.30 (0.41)

* statistically higher values between German and Brazilian databases [t-test (parametric data) or Mann-Whitney test (non-parametric data), $p < 0.05$].