# CHARACTERISTICS OF NARROW FEET OF JAPANESE FEMALES

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## INTRODUCTION

Rapid secular change in the last century resulted in a clear generation difference in the foot morphology of Japanese females [1]. The younger generation has smaller BMI and narrower feet, so younger and older generations have different types of troubles with shoes [2]. Few narrower shoes are available in the Japanese market. Narrower shoes in the mail-order market are unsuccessful. The reason could be that customers do not know their feet, or lasts for narrow shoes do not fit. The purpose of this study is to examine the characteristics in 3D morphology of narrow feet in comparison with wider feet.

## METHODS

The subjects are 69 Japanese female volunteers aged 18-30 years with foot length of 230-240 mm. The range of foot length was restricted to minimize confounding effects of allometric shape change related to the foot length.

The right foot was measured using an *Infoot system* (I-ware Laboratory Co., Ltd.) A homologous foot shape model consisting of 295 data points was created for each foot using Di+ software (I-ware Laboratory Co., Ltd.) The morphological distance between two foot models was defined as the sum of the Euclidean distances between corresponding data points, and the distance matrix was analyzed using Multidimensional Scaling (MDS). To help to interpret MDS scales, virtual shapes with scores of ±3 standard deviation were calculated for each scale [3].

Subjects were divided into two groups based on the foot circumference size in Japanese shoe sizing system: Group N (N=23, FC size≤ C) and Groups MW (N=46, FC size≥D). The equality of means was tested using a t-test. To examine the differences between the 2 groups, the average shape was calculated for each group. The shape difference was visualized using Geomagic studio (Geomagic Inc.)

## RESULTS AND DISCUSSION

A 5-dimensional solution explained 94% of the information carried by the distance matrix. Figure 1 shows the virtual shapes at both ends of each scale. Scores for Dim-2 (r=-0.62) and Dim-4 (r=0.51) have moderate correlation with foot length, and scores for Dim-5 is moderately correlated with foot circumference (r=-0.48). Scores for Dim-1, Dim-4, and Dim-5 showed significant difference between the two groups ($p<0.05$). These observations indicate that Dim-1 and Dim-5 show variations most strongly related to the narrowness of the foot. It implies that though the narrow foot is defined by small foot circumference, small thickness (low dorsal arch) is its most conspicuous characteristic.

Figure 2 shows the comparison results between the two average shapes visualized using cross sections at 20%, 50%, 70%, and 95% of foot length from the heel. Figure 2 shows that (1) the difference in breadth is much smaller at the heel compared to the differences at the instep or at the ball; (2) the shape difference at the plantar arch is negligible, though the difference in dorsal arch height is considerable; (3) the height difference at the big toe nail is very small. These findings strongly suggest that a grading method based on adjusting the foot circumference does not conform with the allometric differences in foot morphology related to the difference in the foot circumference.

Since the number of subjects is not large, the findings in this study need further confirmation using a larger sample.

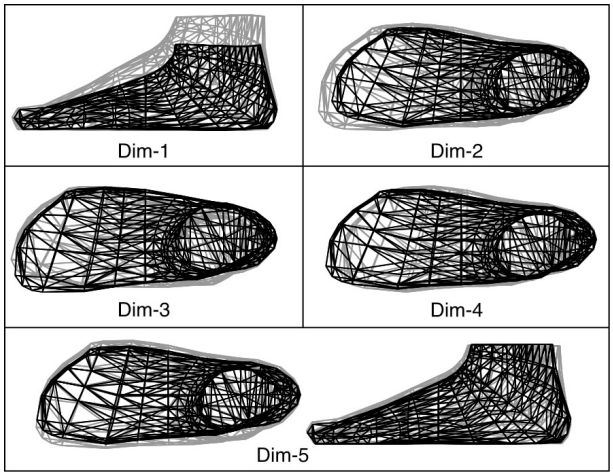


**Figure 1**: Virtual shapes at +3 standard deviations (black line) and −3 standard deviations (gray line) on dimension 1 to dimension 5.

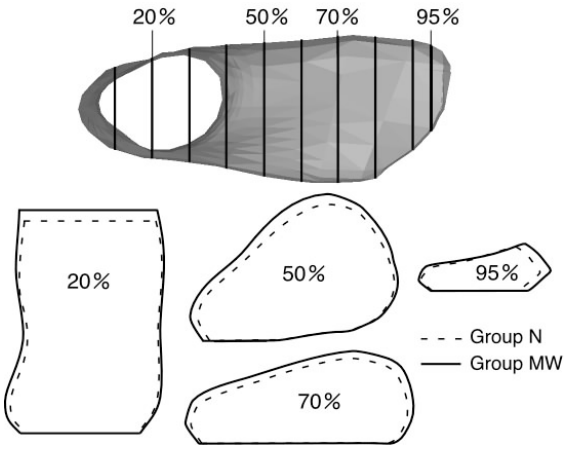


**Figure 2**: Comparison of average shapes.

## REFERENCES

1. Kouchi M, *Anthropol Sci*. **106** (Suppl.):161-188, 1998.
2. Dohi M, et al., *Jap J Ergonomics* **37**:228-237, 2001.
3. Mochimaru M, Kouchi M, *SAE Technical Paper* **2000-01-2149**, 2000.