

MORPHOLOGICAL FIT OF RUNNING SHOES: PERCEPTION AND PHYSICAL MEASUREMENTS

Makiko Kouchi^{1,2}, Masaaki Mochimaru^{1,2}, Hidetaka Nogawa³, Sadayuki Ujihashi³
¹Digital Human Research Center, AIST, ²CREST, JST, ³Tokyo Institute of Technology

INTRODUCTION

To realize a shoe recommendation system based on the measured 3D foot and shoe last data, we need to know what is the appropriate size for a specific foot. If we can provide a shoe of appropriate size, the comfort can be improved by inserts (Mundermann et al., 2001). Through interviews with 26 young adult male long distance runners, we found they preferred running shoes that held the heel and instep tightly, but there were larger inter-individual difference in the preference of tightness at the ball. Also, in-shoe pressures at the ball of the foot were significantly correlated with the shape difference between the foot and shoe (Ujihashi et al., 2002). These findings suggest the possibility to estimate the fit of running shoes from 3D shapes of the foot and last. In the present study, we investigate the conditions for the “appropriate size” for running shoes using sensory evaluation and the shapes of the foot and last.

SUBJECTS AND MATERIALS

Subjects were 31 young adult male athletes (mean age 20.2 years) without any pathological conditions of the foot. Their foot length size (FL size) and foot circumference size (FC size) judged from foot measurements were 23.5-28 [cm] and A-EEEE, respectively (Japanese Industrial Standard for shoe size). 3D foot shapes were measured using an INFOOT system (I-ware Laboratory).

16 pairs of running shoes (8 FL size x 2 FC size: normal and wide) of the same brand and the same appearance were prepared. Last shapes were also obtained for these shoes.

METHODS

Each subject selected the most preferred size by wearing and comparing the 16 pairs of shoes. The repeatability of the size selection was examined for 8 subjects by a blind test. 6 subjects selected the same size on 2 different occasions, and 2 subjects selected shoes of 1 FL size larger or smaller on the second occasion.

Shapes of the foot and the last for the most preferred shoe were superimposed considering the thickness of the insole (Fig. 1), and the following 4 fit indicators were calculated to describe the fit of the most preferred shoe: 1) foot breadth allowance (FBA): $(\text{FB of last} - \text{FB of foot}) / \text{FB of foot} [\%]$; 2) foot circumference allowance (FCA): $(\text{FC of last} - \text{FC of foot}) / \text{FC of foot} [\%]$; 3) heel breadth allowance (HBA): $(\text{HB of last} - \text{HB of foot}) / \text{HB of foot} [\%]$; 4) foot length allowance (FLA): $(\text{FL of last} - \text{FL of foot}) / \text{FL of foot} [\%]$. The larger these values are, the looser the preferred shoe, and the smaller these values are, the tighter the preferred shoe.

Each subject evaluated the tightness or looseness of 3 shoes at 5 locations of the foot (toes, ball, dorsal arch, plantar arch, lateral mid foot, and heel) using a visual analogue scale after running a 200 m distance. The 3 shoes were the most preferred size (Co), one FL size larger than Co (+1), and one FL size smaller than Co (-1). The order of evaluation was [Co], [+1], [Co], [-1], or [Co], [-1], [Co], [+1]. Two evaluations for [Co] were used to examine the repeatability.

The correlation coefficients between the foot and fit indicators were calculated. Partial correlation coefficient with FL or FC or HB held constant were also calculated. Results of sensory evaluation were analyzed using ANOVA (SPSS). A multiple comparison was performed using Tukey' method.

RESULTS

FBA and FCA were highly negatively correlated with FB and FC (Fig. 2), and HBA was highly negatively correlated with HB. When FL was partialled out, these correlations remained highly significant. FLA was significantly correlated with foot dimensions, but they disappeared when FB, FC, or HB was partialled out. Partial correlation coefficient with FL held constant between FB and FBA was -0.958, and that between HB and HBA was -0.942. Runners with wider ball and heel preferred tighter shoes, and runners with narrower ball and heel preferred looser shoes.

No significant difference in perception was found between 2 evaluations of the most preferred shoe [Co]. Significant differences between [Co] and [-1] was observed at the toe, ball, and plantar arch, while significant differences between [Co] and [+1] was observed at all parts except plantar arch. It seems that tightness is perceived at the anterior part of the foot, and looseness was perceived at both anterior and posterior parts of the foot.

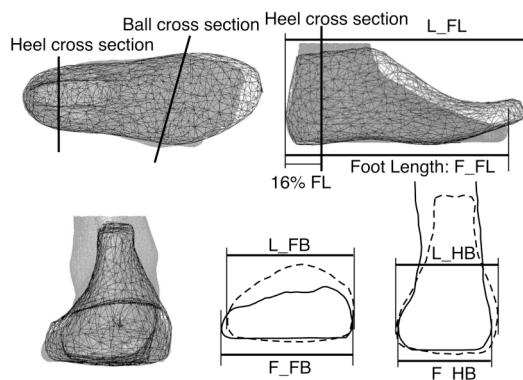


Fig. 1. Comparison of the foot and last.

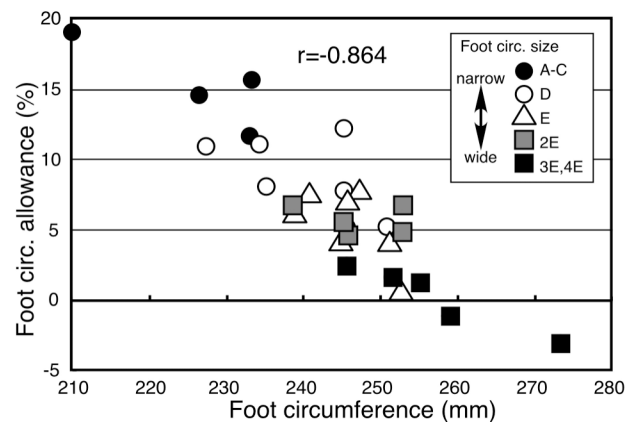


Fig. 2. Relationship between foot circumference and FCA

DISCUSSION

The present finding, runners with wider feet prefer tighter shoes, strongly suggests that the perception of fit or comfort is significantly affected by the experience. Since available FC sizes are limited, runners with wider feet always wear tighter shoes, and they are accustomed to wearing tight shoes. This means that there may be a better shoe for a runner, but he/she does not like it because it is different from his/her preference developed by experience. In order to develop an evidence based recommendation or custom shoe system that can convince runners, it is necessary to know the risk of wearing shoes too tight or too loose for the foot, as well as to know the relationship between the foot and shoe in which the adverse effects of the shoes are minimal.

REFERENCES

- Mundermann, A., D.J. Stefanyshyn and B.M. Nigg (2001) Relationship between footwear comfort of shoe inserts and anthropometric and sensory factors. *Med. Sci. Sports Exerc.* 33:1939-1945.
- Ujihashi, S., K. Tanimura, M. Mochimaru, and M. Kouchi (2002). Relationship between the fitting comfort of running shoes, in-shoe pressure and the foot and last forms, *Proceedings of Dynamics and Design Conference 2002*. In Japanese with English abstract.