

COMPARISON OF FOOT MORPHOLOGY AND PREFERRED SHOE FOR IMPROVING RUNNING SHOE FITTING

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The purpose of this study was to compare the shoe internal space and foot shapes of different type for increasing sense of shoe fitting. 347 healthy subjects (male=160; female=187) without any pathological conditions of the foot participated in this study. 11 pairs of running shoes have different size (230-280mm) with same material and appearances were prepared and the shapes of shoe last were also measured for these shoes. In order evaluating the sense of shoe fitting, 6 fit indicators were analysed by comparing the shape of shoe last with foot morphology. We could find that people with wider feet tend to wear tighter shoes and narrower feet preferred to wear looser shoes that seems to significantly affect by the experience. And the sense of shoe fitting was significant different from gender and foot type which can be used as important data for recommending shoe size and to make customized shoe.

KEYWORDS: Running shoe; Shoe fitting; Comfort; Customized shoe; Footwear;

INTRODUCTION: Sports shoe fitting is an important factor in athletic performance and foot health. Shoe fitting is connected for the changes in the coordination of the athlete's biomechanical parameters(Krauss, Valiant, Horstmann, & Grau, 2010). Shoe fitting is determined by the material of shoe, the shape of shoe last and the upper design of shoe(Hawes et al., 1994). Among them, the shape of the shoe last is very important in the sense of fitting because it represents the internal shoe space(Baek & Lee, 2016; Krauss et al., 2010). The shape of the shoe last was made from foot morphology. If the shape of the shoe last properly matches the foot morphology, shoe fitting would be increased.

However, the foot morphology is different from person to person, many studies on foot morphology have been conducted continuously(Jurca, Žabkar, & Džeroski, 2019; Tomassoni, Traini, & Amenta, 2014; Wunderlich & Cavanagh, 2001). Basically, the foot morphology shows significant difference by region, gender and age and the foot morphology also slightly different from personal background. Therefore, to improve the fitting of the shoe, it is necessary to compare the foot morphology with the internal space of the shoe. In addition, since the fit of shoes is related to a change in athletic ability i.e., energy efficiency and increase in agility, the issue of personalized products has recently been highlighted for sports athletes(Baek & Lee, 2016; Wunderlich & Cavanagh, 2001).

So, this study aims to directly compare the shape of and individual's foot with the size of preferred shoe, to find out how different types of shoes are preferred among groups, and to use them as data for making customized shoes.

METHODS: 347 healthy subjects (male=160; female=187) without any pathological conditions of the foot participated in this study. 11 pairs of running shoes have different size (230-280mm) with same material and appearances were prepared and the shape of shoe lasts were also measured for these shoes. All subjects selected the most preferred shoe size by wearing and comparing the 11 pairs of shoes. They were conducted 3D foot scanning for measuring their foot morphology using an INFOOT system (I-ware Laboratory). In order to find result of the shoe fitting directly, they filled out the questionnaire after worn their preferred shoe and walked 20m pathway with their preferred speed. Finally, the shapes of shoe last were measured using 3D scanner the same as foot data. First of all, the ratio of each parameter (ball circumference, ball width, instep circumference, heel width, instep height) to foot length was analysed to normalize individual foot characteristics. The shapes of the foot and the shoe last for the most preferred were superimposed for comparing foot morphology and internal space of shoe. And the following 6 fit indicators were calculated to

describe the fit of the most preferred shoe: 1)Foot length allowance(FLA): (FL of last – FL of foot) / FL of foot [%] 2)Foot circumference allowance (FCA) : (FC of last – FC of foot) / FC of foot [%] 3)Foot breadth allowance(FBA) : (FB of last – FB of foot) / FB of foot [%] 3)Foot instep circumference allowance(FICA) : (FIC of last – FIC of foot) / FIC of foot [%] 5) Heel breadth allowance(HBA) : (HB of last – HB of foot) / HB of foot [%] 6) Foot height allowance (FHA) : (FH of last – FH of foot) / FH of foot [%] (Kouchi, Mochimaru, Nogawa, & Ujishashi, 2005). The larger these values are, the looser the preferred shoe, and the smaller these values are, the tighter the preferred shoe. The correlation coefficients between the foot and fit indicators were calculated. And MANOVA were also calculated for finding group and gender difference in shoe fit indicators. A multiple comparison was performed using Bonferroni method. The alpha value was set at 0.05.

RESULTS:

5 fit indicators were highly negatively correlated with foot morphology data except on foot length. Correlation coefficient between FC and FCA was -0.857, FB-FBA was -0.835, FIC-FICA was -0.896, HB-HBA was -0.829 and FH-FHA was high value at -0.905 while FLA-FL was lower correlation at -0.291. These results mean participant with higher foot size preferred tighter shoes, and with lower size preferred looser shoes.

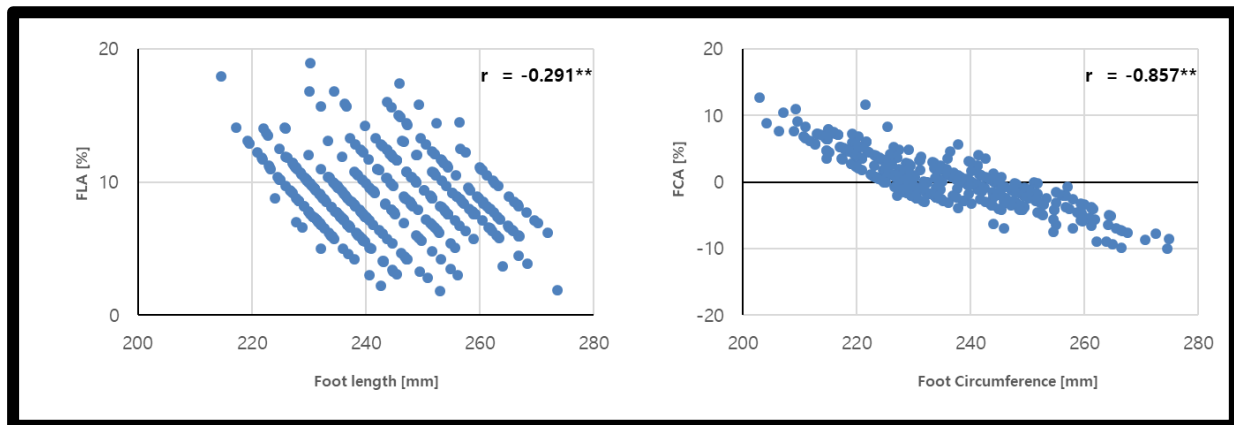


Figure 1: Relationship between foot length-FLA and foot circumference and FCA

There were statistically significant differences among the gender and group in 5 fit indicators except on HBA. For gender comparison, females preferred tighter FLA than male while other fit indicators (FCA, FBA, FICA, HBA, FHA) showed that females preferred looser than males. The standardized and independent factors, ratio of foot width, ball circumference, instep circumference, heel width, instep height and foot length were used for cluster analysis. 3 groups different foot types were identified from these 5 parameters.

We found that 5 indicators significantly different among foot types except on heel breadth allowance. Interestingly, FLA showed that wider group preferred looser shoe fitting about length while other 5 fit indicators showed that tighter shoe fitting in the wider group preferred.

DISCUSSION: The purpose of this study was to compare the shoe internal space and foot shapes of different type for increasing sense of shoe fitting. As same as the findings of this, previous study showed that runners with wider feet preferred tighter shoes. These results suggest that shoe fitting and comfort of shoes is strongly connected by personal experience(Kouchi et al., 2005). However, it might be simply a difference by experience because the shoe last is made for each shoe size in a proportion from the reference size of shoe last (this case was 260mm). It could be thought that these proportions are used to the form of disparity and narrowing compared to the ratio of the foot shape. From a young age, a group with wider foot shape may inevitably wear relatively tight shoes and felt that it was appropriate for them. Therefore, we would find from further research, if the appropriate fit indicators could change physical ability for different foot type group.

Table 1. the results of 6 fit indicators between gender and group

	Male (n=160)			Female (n=187)			F-value* (gender)	F-value* (group)
	Group1 (n=52)	Group2 (n=89)	Group3 (n=19)	Group1 (n=55)	Group2 (n=110)	Group3 (n=22)		
FLA	7.7019 (2.36)	10.01 (2.60)	12.66 (3.10)	6.87 (2.34)	8.43 (2.24)	11.92 (3.22)	10.31	61.80
FCA	1.45 (3.25)	-2.47 (2.80)	-4.54 (3.60)	4.96 (3.17)	0.61 (2.67)	-2.27 (3.07)	57.79	99.36
FBA	-3.68 (3.38)	-7.69 (3.27)	-9.16 (3.64)	-0.50 (3.85)	-5.02 (3.14)	-7.07 (3.29)	35.08	71.80
FICA	3.36 (2.95)	-1.00 (2.66)	-7.45 (4.89)	8.59 (3.20)	4.16 (3.16)	-0.31 (3.26)	200.05	157.53
HBA	1.45 (4.09)	-0.51 (5.09)	-2.50 (3.47)	3.75 (4.83)	2.35 (4.63)	1.37 (5.48)	23.49	7.91
FHA	18.18 (6.27)	14.95 (6.01)	8.97 (4.16)	26.94 (8.02)	20.26 (6.42)	12.96 (4.90)	51.08	51.62

* indicates significance at the alpha >.05 level.

CONCLUSION: This study identified the relationship between foot morphology and shoe fitting about internal space of shoe. Contrary to our hypothesis, we could find that people with wider feet tend to wear tighter shoes and narrower feet preferred to wear looser shoes that seems to significantly affect by the experience. And the sense of shoe fitting was significant different from gender and foot type which can be used as important data for recommending shoe size and to make customized shoe.

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