

# Studies on Clothing Comfort Evaluation of Footwear by Measuring Psychophysiological Response

Satoshi HOSOYA, Masayoshi KAMIJO, Masayuki TAKATERA, Tsugutake SADOYAMA  
and Yoshio SHIMIZU

Shinshu University, Japan

The footwear such as socks and shoes is the clothing which are necessary to our life. In this study, clothing comfort of the footwear was carried out by physiological responses and subjective evaluation. As a result, the effect to walking comfort by the height of a heel in female shoes became clear. Then suitability evaluation system of shoes was proposed from the measuring results. On the other hands, the clothing comfort of the hosiery was evaluated from ECG analysis. By this analysis, it became clear that the factor which influences the clothing comfort of the hosiery was the clothes pressure in the hosiery. In the future, plane shape of the foot and solid shape must be considered in order to design the hosiery.

*Keyword:* Footwear, Psychophysiological Response, *Kansei* products

## 1. Introduction

The footwear such as shoes and socks is the clothing which is indispensable for the modern. In these footwear, the following are required : Clothing physiology and sanitary functionality and action following characteristic, fashionability, wearing comfort besides.

By the present, there are comparatively many results of noticing the relationship between sanitation functionality of products such as heat retaining property and permeability and feeling in clothes on the research on the wearing comfort of the footwear. And, the subjective evaluation of the wearing comfort depends on the questionnaire.

By combining the physiological response with the subjective evaluation from the viewpoint of the wearing comfort as in this study, comfort evaluation only in the wear for the footwear did be not carried

out, and as it was acquired and was active actually, the evaluation of the footwear on the wearing comfort was tried.

To begin with, in the research on the shoes, the walking comfort was evaluated on heel high of lady shoes from the biomechanical/psychophysiological measurement, and the construction of measurement and evaluation and design support system in response to the necessity of the shoes selection which emphasized human and suitability with foot disease was tried. And, in the research on the hosiery, the objective evaluation from psychophysiological measurement and analysis of the suitability was carried out, and the necessity for hosiery design which suited the footprint of Japanese was examined.

## 2. Walking comfort evaluation of lady shoes with the heel

## 2.1 Purpose

At present, it is possible that the consumer chooses the shoes from the rich type. In the other, diseases such as hallux valgus increase by the unnatural walking using the shoes which is not suitable for the foot. Therefore, the importance of the shoes selection in which the comfortable walking is possible recently is noticed. In this chapter, what kind of effect is caused landing condition and foot pressure center transfer, fatigue of the leg muscles of which the heel high is a factor of the walking comfort, is clarified, and walking comfort evaluation of the lady shoes with the heel and the systematization are tried.

## 2.2 Method

The subjects are the university students of 10 persons of the healthy girl. The sole pressure under walking was the pressure sensor sheet, and the muscular activities of lower leg were measured by the surface electromyogram method. The experiment carried out each 10 time doings and measurement of totals 30 times in low heel (1.5cm), middle heel (4.5cm), high heel (7.0cm).

## 2.3 Results and Discussion

### (1) Sole pressure distribution and foot pressure center transfer locus

Figure 1 showed the size of sole pressure per unit area in the forefoot. The pressure which depended on the forefoot with the rise of the heel significantly increased. The possibility of being one of the reasons why that it is walked by wearing the shoes with the high heel, has produced diseases such as the pain of the tiptoe was also indicated, because very large pressure had been applied on the thumb.

It became the rectilinear transfer from the heel to the tiptoe with there is normal blast walking moved to the thumb in the low heel, it is grounded from the heel, and in passing through the outside of the foot, and hoop and heel rising, and the blast disappeared. There was normal blast walking moved to the thumb in the low heel, it is grounded from the heel, and in passing through the outside of the foot. However, it became the rectilinear transfer from the heel to the tiptoe with the rise of the heel, and the blast disappeared. And, there was some a locus of the load

point on the tendency which shook in four quarters in high-heeled shoes.

From the above fact, it was indicated that to notice size and contact area of the pressure which depends on the forefoot especially, foot pressure center locus and in the evaluation system was effective for the comfort evaluation of the walking.

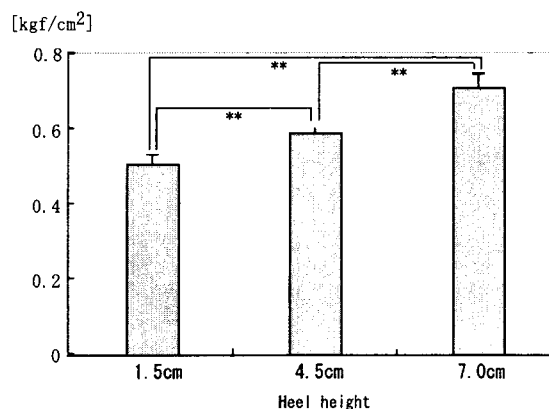


Figure 1 The measuring result of sole pressure in the forefoot

### (2) The burden to cruris from the viewpoint of the muscular activities

It was guessed that the fatigue increased, as a result of fatigue decision by frequency analysis the electromyogram signal of lower leg in the walking, the height of the heel influences in the muscle fatigue of anterior tibial muscle and gastrocnemius muscle, and as the heel rises. The evaluation by the muscle fatigue of the leg muscles seems to be important as an index to the walking comfort evaluation of the shoes.

## 2.4 The suitability evaluation system of the shoes

The above study result was made index, and the construction of the walking comfort evaluation system was tried. Example of the evaluation system screen is shown in figure 2. The system measures sole pressure and electromyogram as the user walked on the treadmill over 20 minutes, and it carries out suitability evaluation considering walking comfort.

For the human who the comfortable shoes selection for the walking that the disease is held in the foot, if such system is used, is the off fruit problem, it seems to be possible to carry out the support which chooses the pair of shoes which suits the characteristic.

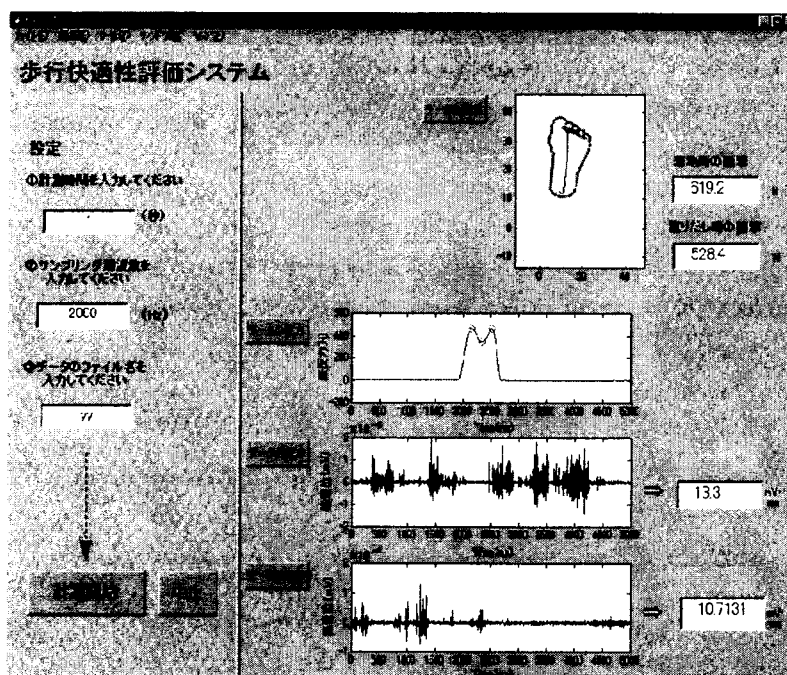


Figure 2 The screen of the suitability evaluation system of the shoes

### 3. Study on the suitability of the hosiery

#### 3.1 Purpose

Though in present state, the research on the hosiery is carried out in great numbers, the research which noticed the suitability of the hosiery is not carried out. The human footprint the shape is different in right and left, and there is a distinction of right and left on the shoes. However, the hosiery than the shoes for hours does not have the distinction of right and left, and it is an equal shape. Therefore, it must be improved to the psychophysiological effective hosiery concerning support and improvement, wear sensation of the motor function, because present hosiery can not be called not always suiting the foot. Therefore, present hosiery not always suits our foot. So, it must be improved to the psychophysiological effective hosiery from the plane of support of the motor function and plane of the improvement and clothing comfort. In this chapter, footprint and shape of the hosiery are noticed, and the suitability is psychologically evaluated. Then, hosiery design which suits the footprint of Japanese is proposed.

#### 3.2 Method

Subjects are the healthy boys university student 17 persons. Samples are the 4 types. The hosiery is a

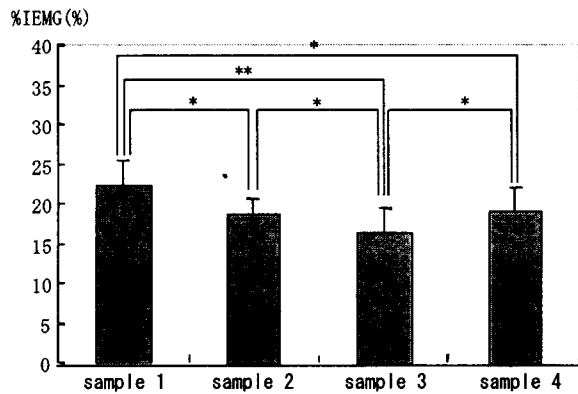
condition of transient bare feet by sample No.1. Sample No.2 is the usual hosiery. Sample No.3 is the hosiery of which the shape differs in right and left made by putting together in the footprint. Sample No.4 is the hosiery which reverses sample No.3. The following were used : Gait analysis and heart rate variability analysis, questionnaire survey in wearing the hosiery using these samples. And, clothing pressure which greatly influenced the clothing comfort in the hosiery was measured in each hosiery, and evaluation and matching, suitability were psychophysiological evaluated.

#### 3.3 Results and Discussion

Figure 3 showed muscular activities in the one step line period of anterior tibial muscle and gastrocnemius muscle in the walking. It became small sample 3 < sample 2 < sample 4 < sample 1 in order, when the muscular activity quantity was compared in each sample. It became clear that the identical walking motion could be done by clothing the hosiery with the right and left distinction, at the little muscular activities.

In this other, the difference of the shape of the hosiery reached it from the result of gait analysis and heart rate variability analysis, questionnaire, and the

fact clarified in respect of the psychophysiological effect. In short, the shape of the hosiery influences the suitability. Using the hosiery of which the foot tip division shape differed like this, the suitability was good in the condition that it is shown in figure 4, when the suitability was evaluated.



**Figure 3 The activity which added anterior tibial muscle and gastrocnemius muscle**

In the sample for present experiment, the suitability was good, when sample 3 made by putting together in the footprint, was worn. However, when the subject who width and circumference in the foot tip were big wore sample 3, it was not possible that clothing pressure to which depend on each part satisfies this condition, and the evaluation of the suitability lowered. The human foot has done solid and various shapes. Therefore, though samples of 3 that suited and made the footprint of the general human suits many subjects, all subjects are not always covered. Though the size of pair of shoes and

hosiery has mainly been expressed until now at the length of the length, it is necessary that it will notice the width ( circumference ) in future and develops the size of the hosiery as a *KANSEI* product.

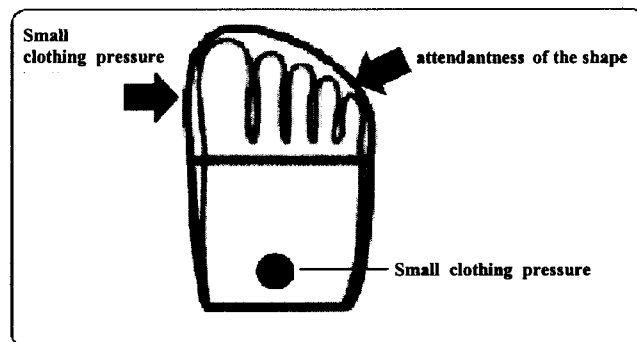
#### 4. Conclusion

It was shown that the suitability evaluation for the shoes of other various types became possible without limiting to heel high of the lady shoes from present study results. And, the importance of carrying out the product development using the index which reflects the solid shape, was able to be proposed on the hosiery. It was possible to establish clothing comfort and evaluation index of the walking comfort and new evaluation method in this study.

In the future, it will contribute in design and production field, if to simply evaluate moreover, clothing comfort and suitability in the real time is possible. In addition, it will be able to offer the useful system, when the consumer chooses the footwear of the self in stores.

#### Reference

- [1] S. Watanuki and K. Mihira(1987), About the influence that local pressure gives to skin temperature and muscle electrical current potential of lower limbs part, *Annals Physiol.Anthrop.*, 6, 2, 69-74.
- [2] S. Watanuki and K. Mihira(1987), About skin temperature in front legs part pressure and a change of muscle electrical current potential, *Physiol.Anthrop.*, 6, 2, 75-82.



**Figure 4 The condition of the hosiery with the good suitability**