

Quantification of Static Seating Comfort of Motorcycle Seats

Mitsue KOYANO*

Takeshi KIMISHIMA*

Kengo NAKAYAMA*

ABSTRACT

We established a posterior characteristics index (PCI) to quantitatively evaluate static seating comfort of motorcycle seats. This index expresses such characteristics as the shape and size of the posterior as well as the weight of a person. The static seating comfort of motorcycle seats was analyzed using the PCI and seated body pressure distribution data.

As a result, it was found that the contact surface area and level of surface area change in the body pressure distribution data obtained while the test subject was seated are effective indices for static seating comfort common to all test subjects.

1. Introduction

Static seating comfort, dynamic riding comfort, and fatigue caused by riding for long periods of time are important properties for motorcycle seats. Of these, static seating comfort is a particularly important factor when consumers select a motorcycle.

Motorcycle seats must be able to conform to the rider's movement (various riding positions) so that the driver can control the motorcycle. This type of seat performance is generally in conflict with static seating comfort performance. Therefore, motorcycle seats are characterized by having multiple shapes that provide a balance between the static seating comfort and the various riding positions required by the motorcycle model concept.

In conventional seat development, design parameters (e.g., hardness, shape, and materials) have been directly manipulated based on subjective feeling evaluations. However, this made it difficult to predict the effect of changes when multiple design parameters were changed simultaneously. On the other hand, body pressure distribution is influenced by personal differences of the test subject and seating area caused by, for example, differences in posterior size and bone structure. Therefore, conventional evaluations were performed with specified subjects. However, actual development requires a predictive equation which enables evaluation without specified subjects.

Therefore, the authors focused on body pressure distribution as a quantitative property intermediate between design parameters and the senses and developed the Posterior Characteristics Index (PCI). The PCI was then used for quantitative performance prediction of static seating comfort. The prediction flow is shown in Fig.1.

This paper describes an overview of the PCI and the results of quantitative prediction of static seating comfort.

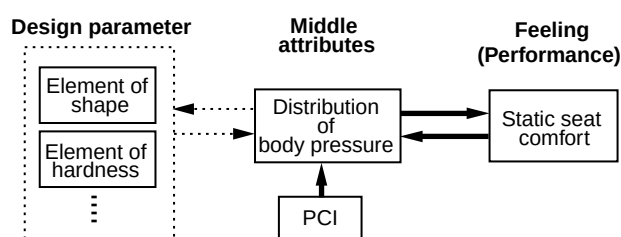


Fig.1 Prediction flow of static seat comfort

2. Static Seating Comfort Factor Analysis

2.1. Body Pressure Distribution of Motorcycle Seats

The shape of a motorcycle seat is designed taking into account not just sitting but also various riding positions, holding properties, and ease of foot-to-ground contact while stopping. The body pressure distributions of specified test subjects on scooters and on-road type and off-road type motorcycles are shown in Fig.2. These examples demonstrate the diversity of distributions obtained due to differences in seat shape.

2.2. Body Pressure Distribution of the Human Posterior

To learn the characteristics of the human posterior, body pressure distribution was measured with test subjects seated on a standard experimental seat (500 × 500 mm, 30 mm thick polyurethane foam) designed to contact the entire posterior area. The body pressure distributions of males and females by weight are shown in Fig.3. We can see from these results that there are differences in the characteristics of human posteriors, especially in terms of load, contact surface area, and level of contact surface pressure changes.

* Asaka R&D Center

The body pressure distributions of test subjects of different weights seated on the same motorcycle seat are shown in Fig.4. They indicate the same tendency as those of the subjects seated on the standard experimental seat though the absolute values are different.

Thus, when static seating comfort is evaluated using body pressure distribution data, it is necessary to minimize the effects of test subject posterior characteristics on evaluation results.

2.3. Hypothetical Equation for the Evaluation of Static Seating Comfort

First, we hypothesized that a seat with a large contact surface area and low levels of contact surface pressure changes throughout the body pressure distribution range has better static seating comfort. Next, we examined factors influencing static seating comfort, such as contact surface area, variations in contact surface pressure and the PCI of test riders, on different seats. Multiple regression analysis

was then performed ⁽¹⁾.

$$\text{Static seating comfort} = a_0 + a_1 \times (\text{contact surface area}) + a_2 \times (\text{contact surface pressure variations}) + a_3 \times (\text{PCI})$$

where,

Contact surface area is the total surface area of the portion of the subject's posterior in contact with the seat

Contact surface pressure variations are the variations in contact surface pressure of the contacting portion

PCI: Characteristics of the test subject's posterior

a_0 : Constant term

$a_1 \sim a_3$: Partial regression coefficients

3. Determining PCI

Prior to experimentation, the PCI for each test subject is established. Fifteen males and fifteen females were selected as test subjects based on the typical body weight distribution for Japanese. Fig.5 shows the body pressure weight

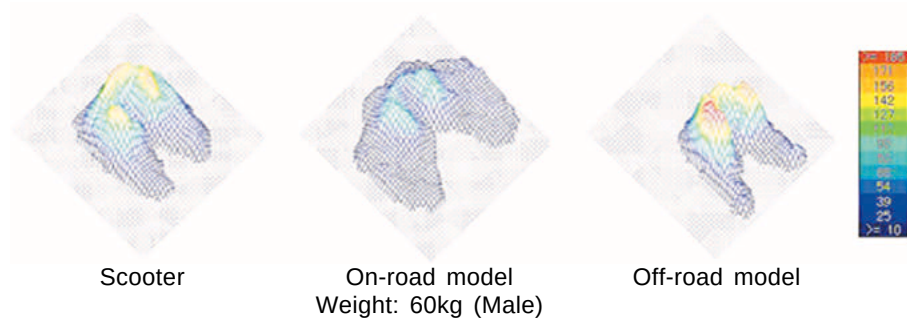


Fig.2 Body pressure distribution according to seat difference

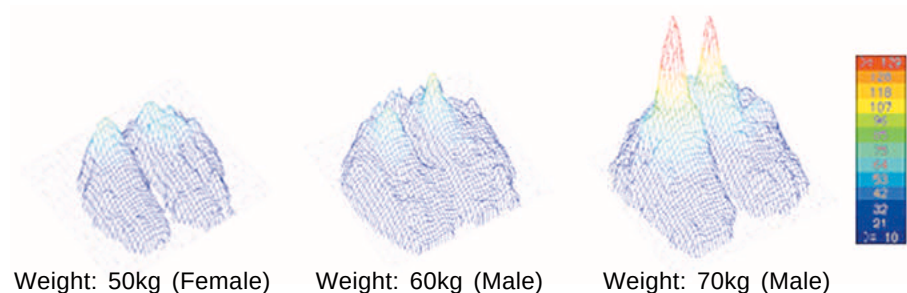


Fig.3 Body pressure distribution according to weight difference for test subjects seated on the standard experimental seat

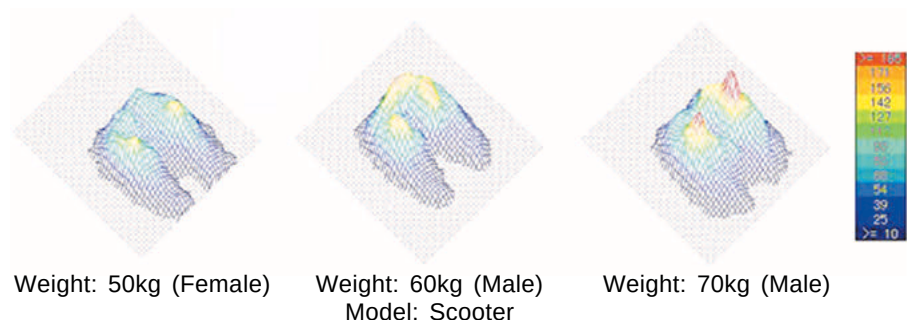


Fig.4 Body pressure distribution according to rider weight difference

distribution of each subject when seated on the standard experimental seat. We can see that there are considerable differences in contact surface area and contact surface pressure variations in these body pressure distributions. Based on this result, we judged that the overall characteristics of the posterior could be represented by the contact surface

area, the contact surface pressure variations and the test subject's weight, and principal component analysis was conducted. The results are shown in Table 1.

From the results of principal component analysis, we judged that the primary principal component expresses the total value for body weight, contact surface area, and contact

(F): Female (M): Male

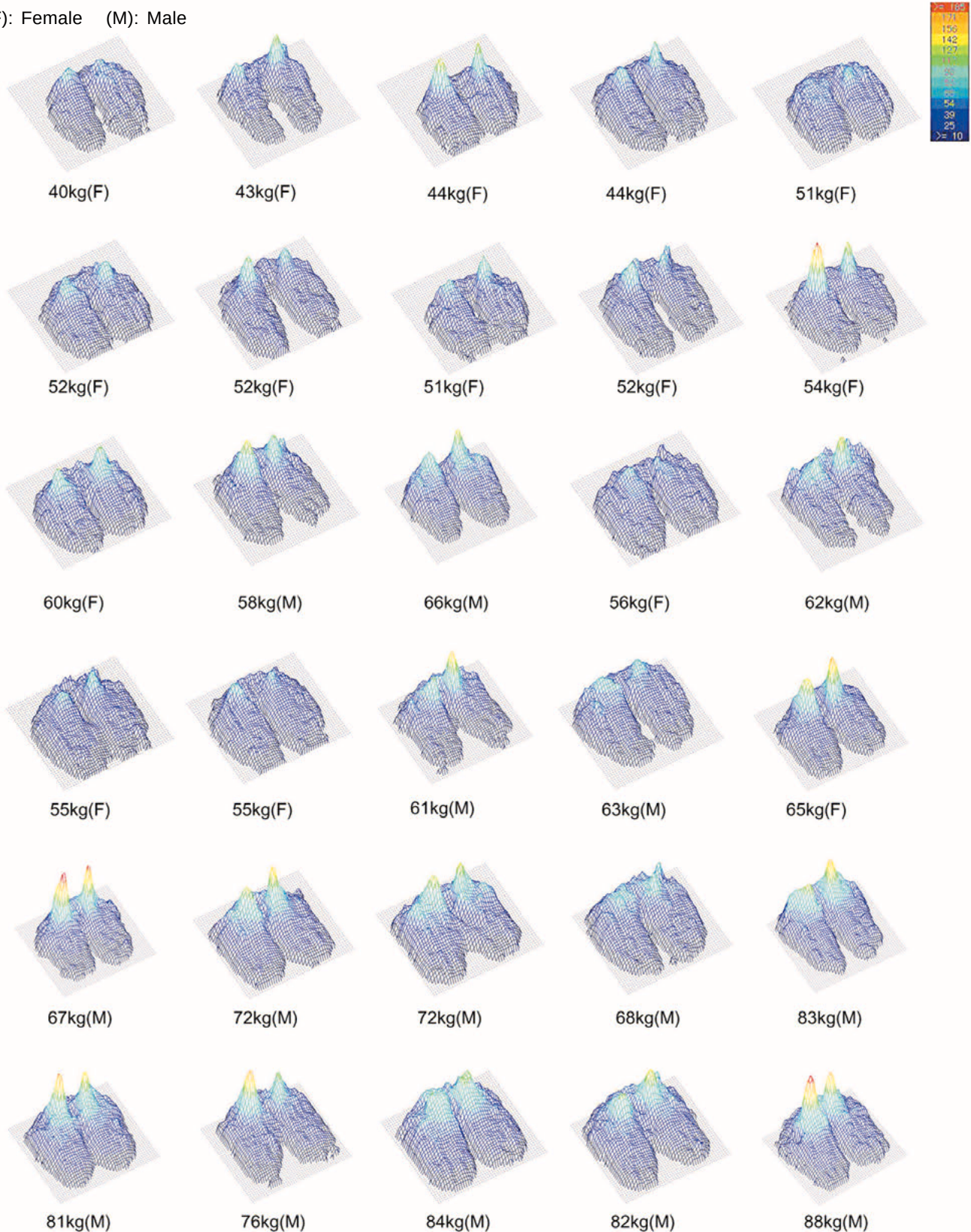


Fig.5 Body pressure distribution for various test subjects seated on the experimental standard seat

Table 1 Eigen value and eigen vector

Eigen value

No.	Eigen value	Contribution rate
Principal component 1	1.154	0.505
Principal component 2	1.129	0.376

Eigen vector

Items	Principal component 1	Principal component 2
Contact area	0.742	-0.005
Pressure changes	-0.123	0.917
Rider weight	0.686	-0.473

surface pressure variations and this component made the PCI. This PCI was then applied in a hypothetical equation. The principal component scores are shown in Fig.6.

4. Evaluation Test and Analysis

4.1. Selection of Subjects

A panel of five test subjects that reasonably represent the variations in the primary principle components, as shown in Fig.6, was selected from among the subjects used to establish the PCI.

4.2. Samples and Evaluation Test Method

Seven motorcycles and five subjects were used in the test. The subjects sat upright on each test motorcycle in a normal operating position. They took a normal riding posture as shown in Fig.7, and immediately thereafter evaluated

static seating comfort of the seat using the nine-point scale shown in Fig.8. In addition, body pressure distribution was measured under the same conditions as the static seating comfort evaluation. Fig.9 shows the system used to measure body pressure distribution.

4.3. Evaluation Test Results

Table 2 shows the results of the subjective feeling evaluation of static seating comfort. The range of standard deviation for the evaluation scores was 0.27 ~ 0.65.



Fig.7 Example of riding posture

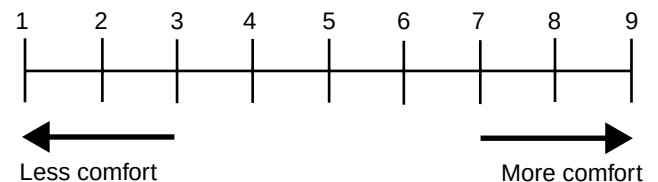


Fig.8 Evaluation scale for nine-point score

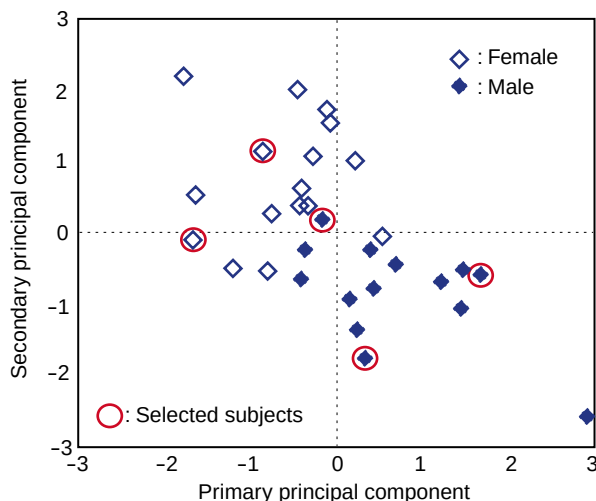


Fig.6 Graph of principal component scores and relation to each parameter

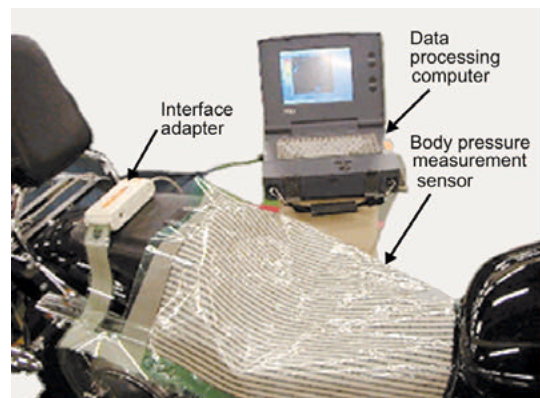


Fig.9 Body pressure measurement system

Table 2 Evaluation results

Sample motorcycles	Average of evaluation score	Standard deviation
Touring model A	8.2	0.55
Touring model B	7.5	0.27
American model A	7.9	0.41
American model B	6.3	0.54
European model	5.4	0.65
Scooter	3.4	0.54
Off road model	1.5	0.41

4.4. Results of Analysis

Multiple regression analysis was conducted for static seating comfort using the body pressure distribution data obtained during testing and the PCI for each subject. As a result, it was found that the contact surface area, contact surface pressure variations, and the PCI of each subject indicated by the hypothetical equation affected static seating comfort with a significance of 1%.

Thus, substituting body pressure distribution data into the hypothetical equation enabled the evaluation of static seating comfort. Fig.10 shows the relationship between prediction scores and evaluation scores.

Static seating comfort score = $1.733 + 0.008 \times (\text{contact surface area}) - 4.882 \times (\text{contact surface pressure variations}) - 0.594 \times \text{PCI}$

($R^2 = 0.91$, residual standard deviation = 0.74)

In the above equation, we can say that the contact surface area and contact surface pressure variations are valid indices for all subjects, and that PCI absorbs the individual posterior differences.

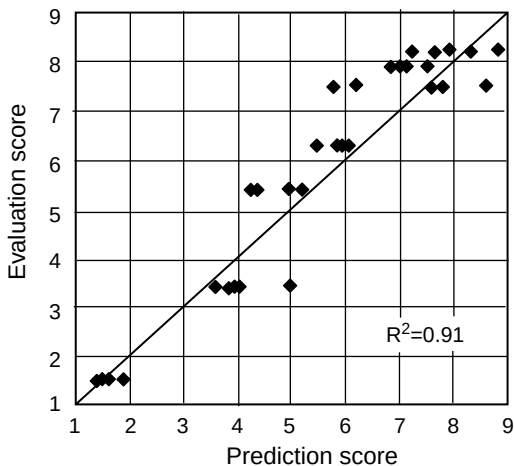


Fig.10 Correlation between prediction scores and evaluation scores

5. Validation with Other Types of Motorcycles

In order to validate the predictive equation, two on-road-touring motorcycles not used in the previous tests were evaluated in the same manner as those in the tests and body pressure distribution data were obtained. The body pressure distributions obtained through measurements on these two motorcycles are shown in Fig.11. Results of a comparison between the predicted score and the score obtained through evaluation show in Table 3 that the difference between the predicted score and subjective feeling evaluation scores are 0.2 and 0.1 in comparison to the 0.74 residual standard deviation derived from the predictive formula. This, thus, verifies the reasonableness of the predictive formula in motorcycle seat static seating comfort evaluations.

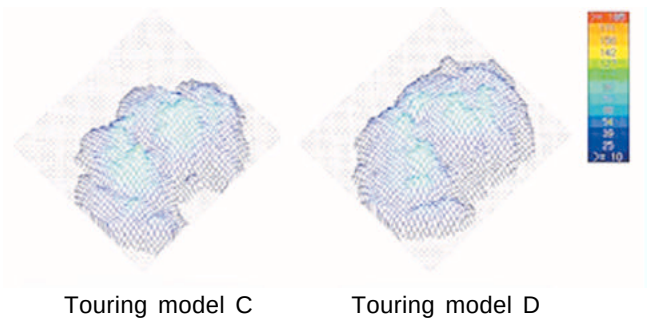


Fig.11 Results of body pressure distribution for different seats

Table 3 Comparison of evaluation scores and prediction scores

Sample motorcycles	Evaluation score	Prediction score	Residual error
Touring model C	6.0	6.2	0.2
Touring model D	7.0	7.1	0.1

6. Conclusion

1. An index of the characteristics of the human posterior was established by performing principal component analysis of body pressure distribution and body weight occurring when subjects are seated on a standard experimental seat.
2. It was found that the contact surface area and contact surface pressure variations of the body pressure distribution data obtained while the test subject was seated are effective indices for representing the static seating comfort of seats common to all subjects.

In the future, the authors will examine methods for predicting body pressure distribution from drawings.

References

- (1) T. Yoshizawa, T. Haga: Multivariate Analysis Case Methods, Book 1 JUSE Press Limited, p. 63-75 (1992)
(Written in Japanese).

■ authors ■



Mitsue KOYANO



Takeshi KIMISHIMA



Kengo NAKAYAMA