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Original Article

A preliminary study of the measurement of external ischial tuberosity width and its gender differences

Yi-Lang Chen[1)*], Ping-Jui Yang[1)]

[1)] *Department of Industrial Engineering and Management, Ming Chi University of Technology: 84 Gung-Juan Road, Taishan 24301, New Taipei, Taiwan*

Abstract. [Purpose] Using two measurement methods, this study measured the external ischial tuberosity widths (EITW) of both males and females and investigated gender differences in these EITW values. [Subjects and Methods] Fifteen male and 15 female Taiwanese were recruited for this study. Their EITWs were measured using the impress and the seated pressure methods, and compared. [Results] The results show that the EITW values obtained using the impress method were similar to those reported by previous studies, but gender differences were observed in the measurements when that method was used (male: 11.96 cm; female: 13.53 cm). However, the males had non-significantly greater EITW values than the females when the seated pressure method was used (male: 13.42 cm; female: 13.30 cm), and this was probably due to the distinct characteristics of the buttocks of the two sexes and the seated pressure method. [Conclusion] The authors of this study propose that 12.0 and 13.5 cm are respectively the ideal design parameters for male and female EITWs in Taiwan, although13.5 cm might be more appropriate for male EITWs in the design of relatively hard seat or saddle surfaces.

Key words: External ischial tuberosity width (EITW), Seated pressure method, Impress method

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INTRODUCTION

People who lead a sedentary lifestyle throughout most of the day do so because of work, non-active recreational activities, or convenient transportation. A crucial factor for designing seats (cushions) is buttock-seat (cushion) contact, and seated pressure is one of the most frequently studied aspects of seat (cushion) design[1, 2)]. Seats with different functions may produce distinct seated pressure distributions, which are mainly influenced by the degree of seated pressure between the ischial tuberosities (ITs) of the human pelvis and the seat surface. According to the anatomical characteristics of the pelvis, general sitting postures produce two peak values of seated pressure on seat surfaces, and the distance between the points where peak values appear is a valuable reference for the practical design of seats or cushions. In other words, knowing the geometric distance between the spots of peak seated pressure, providing suitable support, and reinforcing seats by using different materials and structures are instrumental in reducing buttock load[3)].

Generally, during sitting, the ITs do not have direct contact with the seat surface because they are separated by the muscle and adipose tissues covering the pelvis. Compared with other body parts, the buttocks have thicker skin, denser sebaceous and sweat glands, and contain adequately developed superficial fascia and thick adipose tissues. The posterior and lower parts of the buttocks are thick and dense, forming fat pads that can bear the pressure generated during sitting. Consequently, understanding external ischial tuberosity width (EITW), which represents the width of the ITs covered in fat pads, is practical for designing seats and cushions. Furthermore, differences between male and female pelvic structures[4)], which lead to possible variations in EITW measurements, need to be investigated. According to a literature review, no previous study has

*Corresponding author. Yi-Lang Chen (E-mail: ylchen@mail.mcut.edu.tw)

(a) (b)

Fig. 1. Measuring the EITW values using the impress method (a) and the mFLEX pressure mapping system (b)

systematically researched the measurement of EITW, despite it being a valuable reference for designing seat surfaces (e.g., office chairs and bicycle saddles). This study therefore primarily investigated the values of EITW measurements made using the impress and the seated pressure methods as well as the gender differences in these EITW measurements.

SUBJECTS AND METHODS

This study recruited 30 healthy participants (15 males and 15 females) who were paid hourly. None of the participants had musculoskeletal disorders in their medical histories, and each was thoroughly informed of the experimental procedure and relevant details. Informed consent was obtained from all participants, and the Ethics Committee of Chang Gung Memorial Hospital approved this study (No. 98-3633A3). The mean (standard deviation, SD) age, height, and body mass of the participants were respectively 20.7 (4.4) years, 175.6 (7.3) cm, and 66.7 (10.5) kg for the males, and 21.4 (3.8) years, 158.9 (4.1) cm, and 52.6 (5.8) kg for the females.

The EITW measurements of the participants were made using the impress and seated pressure methods. Data from our trials (2 methods × 2 measurements) were collected for each participant. The measurement of each method was repeated once to examine the intra-subject reliability, and the average of the repeated measurements was calculated for further analysis.

During the experiment, the participants were required to wear sportswear and thin tight pants. The measuring procedure of the seated pressure method was relatively simple, resistant to the influence of human factors, and has been commonly used by previous studies[5, 6]. The mFLEX pressure mapping system (Type 5E, Vista Medical LTD., Netherlands) was adopted for the seated pressure measurement (Fig. 1a). For implementing the impress method, this study referred to and revised the method used by Potter et al[4]. The measuring procedure proceeded as follows: (1) A large, round plastic basin was placed on the ground. (2) The bottom of the basin was filled with clay, and the surface of the clay was evened and smoothed. (3) The clay was covered with a layer of plastic wrap to keep it moist and malleable. (4) The participants slowly sat on the clay in a squatting posture, and an experimenter gently applied downward pressure on the shoulders of the participant so that the shape of the ITs was fully imprinted in the clay (Fig. 1b). (5) The participants carefully stood and examined the two concavities in the clay, placing a small steel ball at the bottom of each concavity to provide a measuring mark, and the distance between the two balls was measured using a vernier caliper and recorded.

The EITW measurements obtained through both methods were analyzed using SPSS Version 19.0, with the level of significance set at $\alpha = 0.05$. This study used the paired and independent t test to determine the reliability of the repeated measurements and to confirm the difference in the ETIW measurement values between the two methods.

RESULTS

This study used the intraclass correlation coefficient to examine the male and female EITW values obtained using the two methods. The results show that the reliability of the repeated measurements of the participants, regardless of gender, were higher than 0.9 (male: 0.940; female: 0.945), indicating satisfactory consistency.

Table 1 presents the paired t test results for the EITW values obtained by both methods. The two methods varied significantly in the males' EITW values ($p < 0.001$), whereas little variation was observed in the females' EITW values. Additionally, the females' EITW values were significantly higher than those of the males when the impress method was used ($p < 0.001$), which is in agreement with the results of Sauer et al[7].

Table 1 also contains a comparison between the EITW data of the present study and those of Sauer et al[7]. It shows that, regardless of the measurement method, the female EITW values exhibited relatively higher consistency (13.30–13.52 cm), whereas the male EITW values estimated using the pressure mapping system were non-significantly higher than those obtained by the other method or those of Sauer et al.

Table 1. Comparison of EITW measurements (this study vs. a previous study)

	Impress method	Seated pressure method	Differences	Sauer et al.[7]
Male	N = 15 11.96 (1.24)	N = 15 13.42 (1.42)	−1.46*	N = 12 11.65 (1.6)
Female	N = 15 13.52 (0.83)	N = 15 13.30 (0.91)	0.22	N = 14 13.49 (0.92)

*$p < 0.001$

Table 2. Coefficients of variation derived from the two EITW measurement methods compared with those from a previous study

	Impress method	Seated pressure method	Sauer et al.[7]
Male	10.4%	10.6%	13.7%
Female	6.1%	6.8%	6.8%

DISCUSSION

In the analysis, the reason for the pressure mapping system yielding comparatively higher male EITW measurement values remains undetermined; however, because the mFLEX system relies on weight-induced pressure distribution, the heavier weight of the males may be a major cause. In contrast, the impress method depends on the outer contour of the ITs, which were measured by impressing the participants' buttocks on the relatively soft clay. Moreover, the gender differences in buttock fat pads and soft tissues might have mutually influenced the measurements of the two methods.

Table 2 presents a comparison of the coefficients of variation of the EITW measurements in the present study and those of a previous study. The coefficient of variation is obtained by dividing the standard deviation of a data set by their average. Generally presented as percentages, this type of coefficient is a measure of relative variation and an indicator of the data distribution. In the table, all coefficients of variation of the male EITW measurements are greater than 10% (10.4–13.67%), whereas those of the female EITW measurements are lower than 7%. According to Tague on the morphological differences of male and female pelvises[8], the variation among female pelvises is significantly less than that among male pelvises, which would explain the aforementioned results.

By using the two measurement methods, this study preliminarily investigated the gender differences in EITW. The impress method developed in previous studies is an effective method for collecting EITW measurements. The measurement data obtained in the present study were similar to those reported in previous studies, whereas higher EITW values were obtained for males using the seated pressure method. This might have been due to the effects of gender differences in the adipose and muscle tissues of the buttocks on the EITW measurements of the two methods. Also, the impress method uses relatively soft clay to obtain the outer shape of subjects' buttocks, whereas a hard pad is used in the seated pressure method. Investigators must be careful when using these EITW data because different degrees of seat surface softness (e.g., office chair vs. bicycle saddle) should be considered. In summary, we propose that 12.0 and 13.5 cm should be respectively used as the design parameters for male and female EITWs in Taiwan, while noting that 13.5 cm might be more appropriate for male EITW for relatively hard seat or saddle conditions. Additionally, different thigh-torso angles, body sizes, and maneuvers performed in experimental procedures (e.g., pressing duration and clay flexibility) may influence EITW measurements, an aspect of measurement that requires further investigation.

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