

Driving Posture Measurement using 3D Scanning Measuring Technique

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ABSTRACT

Driving posture measurement is essential for the evaluation of a driver workspace and for improved seat comfort design. This study captures the comfortable driving postures for Koreans using a handheld portable Artec L™ 3D scanner. Subjects consisted of 20 healthy individuals (10 males and 10 females) ranging in age from 20 to 40 years and grouped as three weight groups (<59 kg, 60-79 kg and >80 kg). Eighteen land markers were attached (car seat: 9 markers; subject: 9 markers). From the 3D scanned data, the angles (neck, back, headrest, seat back, wrist, elbow, knee, and ankle) and distances (head to headrest, seat height, and seat back and forth) between the land markers were extracted in the Rapidform XOR software. The body pressure distribution was measured using two pressure mats from 17 body part regions. The measured pressure data were analyzed for average pressure, contact area, and body part pressure ratio. A questionnaire was provided to the participants to determine seating comfort of the automobile seat. The questionnaire showed that all three weight groups were satisfied with the overall comfort of the seat. Significant differences were found between left- and right-side pressure distribution in both seat pan and seat back regions. Even though the subjects adopted their preferred driving posture and were satisfied with the overall comfort of the seat, their pressure distribution results showed discomfort. Therefore, the seat manufacturers need to consider preferred driving posture with pressure distribution when designing new automobile seats.

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INTRODUCTION

Automotive seats play an important role in improving the comfort and work of a driver and passengers [1]. An ergonomically designed automotive seat can prevent many painful disorders, including low back pain, which is typical of bad posture [2]. Driving posture is essential for the evaluation of driver workspace and for improved comfort. Various research regarding driving posture has been conducted to design an ergonomic driver seat.

Many researchers use body pressure measurement to develop a comfortable seat. The measurement of body pressure distribution is used for the objective evaluation of the user's discomfort or fatigue level [2, 3]. The measurement of pressure distribution is a means to express the stresses acting at the contact interface between the human and the seat. The interface pressure measurements are relevant to physiological factors that induce comfort. Several studies found which measurements of interface pressure should be compared to establish a comfort or discomfort rating [4]. There was a study showing a statistical correlation between the uniformity of interface pressure distribution and local discomfort [5]. Body pressure ratio is used to analyze the overall seating comfort of automobile seats [3]. When a prototype of a new seat is developed, the vehicle

manufacturers have opted to rely on subjective assessments as the indicator of seat comfort [6]. The subjective evaluation questionnaire directs occupants to assign a feeling of discomfort to a specific region of the seat. Both objective and subjective evaluations play an important role in the development of seating systems [2].

The body segments observed by the three-dimensional motion analysis system, and the driving posture monitoring system are employed to trace the seat adjustment level for driving comfort [1]. Digital human models are used to analyze the preferred range of joint angles (neck, shoulder, elbow, wrist, torso, hip, knee, and ankle angles) [7]. Data on occupant posture and body dimensions are generally obtained using portable coordinate measurement equipment [8], optical motion capture equipment [9], infrared depth sensors [10], and a posture monitoring system [1]. Nowadays, a number of 3D scanners are available on the market, which are mainly used to enable anthropometry in an entirely new way. However, the study on driving posture measurement using a 3D scanning technique is limited. The external geometry of the human models is acquired from the 3D whole-body laser scanner in a driving position [11]; however, the 3D scanned model was used for simulation purposes. Therefore, we considered using a 3D scanner to capture the occupant driving posture and to extract body dimensions and joint angles.

The purpose of this study is to capture the comfortable driving posture for Koreans using a 3D scanner and to evaluate the comfort of an automobile seat by comparing subjective seating comfort with objective evaluation.

METHOD

Subjects

Subjects consisted of 20 healthy individuals (10 males and 10 females), ranging in age from 20 to 40 years and carefully selected to include three different weight groups (< 59 kg, 60–79 kg and > 80 kg). The subjects' driving experience levels ranged from 2 months to 156 months, with a mean of 76.35 months. The purposes and procedures of the study were explained in detail and the subjects gave their informed consents. For the experiment, each participant wore tight-fitting exercise tights.

Table 1. Participants' group classification

Gender	< 59 kg	60–79 kg	>80 kg	Total
Male	4	3	3	10
Female	4	3	3	10

Driver Posture Measurement

Data on drivers' posture and body dimensions were captured using a handheld portable 3D scanner from Artec (Model: Artec L™). Eighteen land markers were attached (car seat and structure: 9 markers; and participant: 9 markers) as shown in Fig. 1. The 3D scanned data were processed in the Artec studio (version 9.2) software, in which the scanned data were aligned, fused, smoothed and finally exported into one of several 3D formats. From the 3D scanned data, the angle and distance between the land markers were extracted in the Rapidform XOR software (3D systems Corporation). The angles measured from the seat and participant were neck, back, headrest, seat back, wrist, elbow, knee, and ankle. The distances measured were head to the headrest, seat height, and seat back and forth.

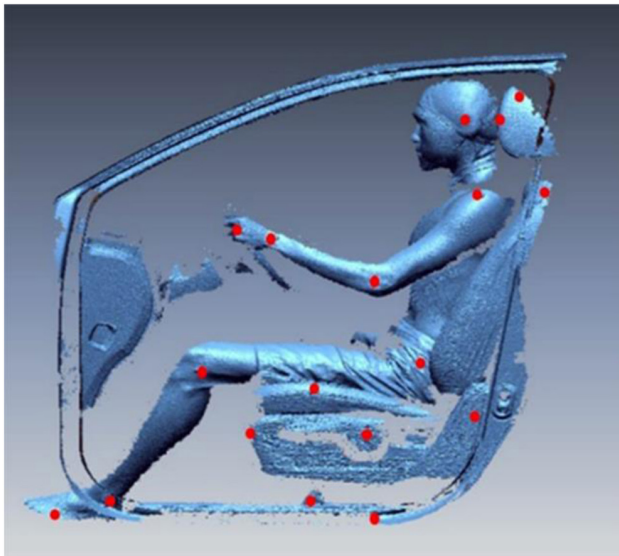


Figure 1. Seat and participants land markers locations highlighted

Pressure Measurement

Many design weaknesses of seats can be detected by the measurement of the seat pressure distribution [3, 22]. In addition, the pressure distribution between the body and seat surface was used to evaluate seating comfort [12]. Two pressure mats were used to measure the interface pressure from the seat pan and seat back regions. The pressure mats (Fig. 2) are from Xsensor (Model: PX100:36.36.02) with: high-resolution (12.7 mm pitch), 1,296 sensing points, sensing area (45.7 cm × 45.7 cm), and 0.06 cm sensing area thickness. The pressure range is 0 to 220mmHg. The sample rate is 3,157 frames per minute. The pressure distribution was measured from 17 [13] body part (9 seat back, 8 set pan) regions separately as shown in Fig. 3. The measured pressure data were analyzed using Xsensor's X3 Pro v5.0 software.

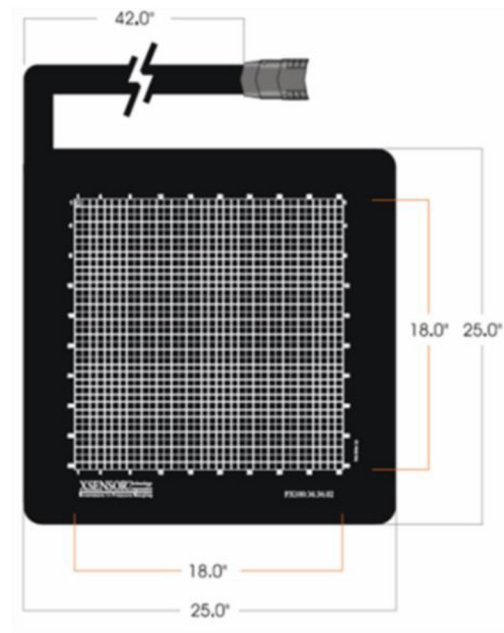


Figure 2. Pressure mat (PX 100:36:36.02) from Xsensor

The average body pressure demonstrated during sitting in the preferred driving posture checked through the average pressure (mmHg) measurement. In addition, the contact area (m²) was calculated using Eqn. 1 from the seat pan and seat back region. Finally, to obtain the body pressure ratio, each body part pressure value was divided by total body pressure value (Eqn. 2).

$$\text{Contact area (m}^2\text{)} = \text{cell size (m}^2\text{)} \times \text{number of nonzero cell elements} \quad (1)$$

$$\text{Body pressure ratio (\%)} = \frac{\text{Each body part pressure}}{\text{Total body pressure}} \times 100 \quad (2)$$