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Incorporating Anthropometrics Data in Designing Driver's Seat for Malaysian Made Compact Cars

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ABSTRACT

This study investigated car seat design and its role towards driver's safety and comfort while driving a car. Past studies had found that users' feedback on driver seat comfort of two Malaysian made compact cars are in the range of 2.5 - 3.1 (i.e. "fulfilling the requirement" to "acceptable" scale) compared to Japanese made compact cars of similar class, which were rated between the range of 3.3 - 4.0 (i.e. "acceptable" to "commendable" scale) from a Likert scale of 1 to 5. The main objective of this study was to identify and investigate whether there are mismatches between driver's seat allowable comfort adjustment and the Malaysian anthropometry data. The study conducted detailed measurements of several existing Malaysian made car seat dimensions. Consequently, aninvestigation was carried out to find out whether the car seat dimensions lie in the comfortable ranges with respect to 90% of Malaysian anthropometric database developed from 1007 Malaysian male and female adults. It was found that Toyota Vios is the most comfortable car in terms of driver's seat condition and Proton Saga BLM is the most comfortable car for foot comfort among three chosen cars (Perodua MyVi, Proton Saga BLM, and Toyota Vios). The minimum and maximum values of Malaysian popliteal height are 369.95 mm (5th percentile female) and 503.88 mm (95th percentile male) lie between the minimum and maximum range of allowable horizontal movement of car seat adjustment for all the three cars. It can be concluded that all the three cars used in this study show that the car seats horizontal adjustment was able to accommodate 90th percentile of Malaysian population. However, the extreme population outside the majority of 5th and 95th percentile may experience some difficulties in achieving comfort.

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INTRODUCTION

Comfort is one of thewidely mentioned termsto consumers in product marketing. This includes from everyday use product, equipment, facilities and vehicles. Information on comfort area is crucial and important especially in vehicle study scope and the current available knowledge is quite limited (Fai*et al*., 2007; Vink & Hallbeck 2012). Consumers nowadays are looking for a car that can offer them comfort and safety features, thusevery car manufacturer has to consider these criteria closely in order to be ahead in the automotive industry (Franz *et al*., 2011; Schmidt *et al*., 2013; Zenk *et al*.,2012). As mentioned by Kolich and Taboun(2004), "comfortable seating nowadays is no longer considered a luxury but it is a requirement".

Ergonomic factors are one of the criteria that need to be incorporated in car design to ensure the comfort of the users (Darses& Wolf, 2006). Therefore, this study focuses on the drivers' car seat design because drivers' comfort needs to be considered closely and effectively because the controlling and maneuverability of the car depend on the driver (Mohamad *et al*., 2010). The two categories in ergonomic criteria assessment studies are the physiological and anthropometric factors. Examples of physiological factors are: objective measurement using pressure distribution(Andreoni *et al*., 2002; Porter *et al*., 2003), vibrationanalysis(Morioka & Griffin,

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2010; Okunribido *et al*., 2007; Rahmatalla & DeShaw, 2011; Wang & Rahmatalla, 2013;Xu *et al*., 2011),surface electromyography(Alizadehkhaiyat *et al*., 2011; Hashemi *et al*., 2013; Roman-Liu & Bartuzi, 2013)and temperature at seat (Diebschlag *et al*.,1988). As for anthropometric factors,they are mainly involved in human body measurement. Several past researches that focused on anthropometric factors in comfort design are studies done by Parkinson and Reed(2007),Reed *et al*.,(2005),Reed *et al*. (2000) andSeitz *et al*.,(2000).

Anthropometry is a study of human body measurements such as stature, reach, body length, circumference and many others. An appropriate use of anthropometric data in designing equipment, workstations, and vehicle design may improve human well-being, health, comfort and safety (Pheasant, 1998). There are many researchers who incorporated anthropometric data in their design stages such as Gragg *et al*.,(2012), Singh *et al*., (2012), Yang and Cho(2012) and Reed *et al*.(2005). Anthropometry is important in classifying dimension needed for certain population, for instance the development of car seat design as mentioned by Linder *et al*.(2013), because females and males have different anthropometry and mass distribution, which may influence the interaction of the upper body with seatback and head restraint, and consequently injury risks.

MATERIAL AND METHOD

I. Subjective Rating:

The number of participants involved in this study was 45 Malaysian citizens, comprising of 19 females and 26 males. The participants' age ranged from 20 to 30 years old. Minimum driving experience required is one year to ensure the drivers have adequate experience in driving. As a token, the participants were given some incentives for their participation.The objective and procedures of the study were explained in detail to each participant and they are required to fillin their personal information in a form given to them. Having done that, participants will be required to sit on the driver's seat in their comfortable driving postures. Participants were then required to fill in the Likert scale form given to them in assessing the comfort of the driver's seat. The same procedure was repeated for the other two different cars chosen in this study.

The maximum and minimum values of seat adjustment horizontal sliding distance (SLD) were taken with the absence of participant on the seat. The sliding distance was measured from the Accelerator Heel Point (AHP) to the front of the drivers' car seat as illustrated in Figure 1. The measurement tools used consist of the basic L-shape ruler and a tape measurement. Data were recorded manually into the form provided. The seat adjustment measurements were taken from three different cars, PeroduaMyVi, Proton Saga BLM, and Toyota Vios. The cars chosen are from compact and entry midsize segment cars. These cars represent the highest, average and the lowest ranks of cars used in Malaysia according to the survey by Powers (2008).The selected cars shared equal features on the driver's seat such as manual adjustment of the seat track and the seat back, no armrest and standard fabric cover. It is important to ensure they shared similar features to minimize the aesthetic effects on the participants' subjective responses (Kyung & Nussbaum, 2008).

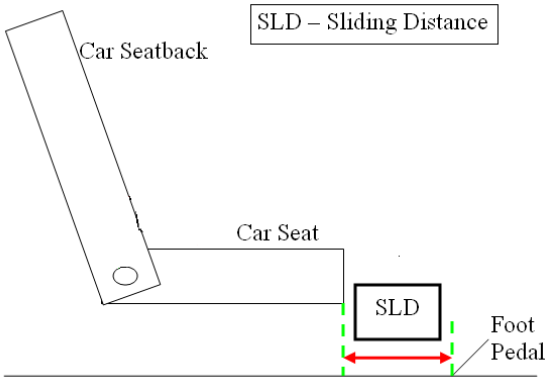

Fig. 1: Car seat horizontal adjustment measurement.

II. Anthropometry measurement:

For anthropometry data collection, 62 body dimensions were measured from 1216 Malaysian respondents. However for the purposes of this paper, only the popliteal height parameter was used. The participants' ages varied between 15 - 65 years old. The range of participants for collecting the anthropometric data came from all ages to fit the 95thpercentile of Malaysian citizens. The participants involved were gathered from all the Malaysian 14 states.All anthropometric data collected were based on MS ISO 7250 standard (2003). The equipment used in this study comprised of the anthropometric measuring tools such as the Human Body

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Measuring Kit and Anthropometer.The anthropometric data were measured and recorded in the data form before being transferred into the computerized anthropometric database.

RESULT AND DISCUSSION

The results found from the study are presented and discussed in this section. There are two parts of data analyses: first, from the subjective rating of 45 participants and second, the comparisons of car dimensions with anthropometry data of the 1216 participants.

I. Subjective Rating:

A descriptive statistical analysis was used to depict the percentage value of subjective rating gathered from each participant involved.Descriptive analysis was done on the participants comfort survey (subjective rating). The responses of the questionnaire were based on a five-point Likert scale with rating from 1 to 5. A percentage analysis of the questionnaire was done in order to enhance the interpretation of significant findings from the study. The percentages of comfort rating for all three cars involved in this study are shown in Table 1.

Table 1: Comfort Rating Percentage (n = 45).

	NC (%)	LC (%)	MC (%)	C (%)	VC (%)
PeroduaMyVi					
Driver's Seat Condition	0	0	26.7	71.1	2.2
Foot Comfort	0	6.7	22.2	62.2	8.9
Proton Saga BLM					
Driver's Seat Condition	0	0	46.7	51.1	2.2
Foot Comfort	0	2.2	33.3	53.3	11.1
Toyota Vios					
Driver's Seat Condition	0	0	20	62.2	17.8
Foot Comfort	0	2.2	24.4	64.4	8.9

* NC = Not Comfortable, LC = Less Comfortable, MC = Medium Comfortable, C = Comfortable, VC = Very Comfortable

Table 1 shows that the driver's seat conditions for Toyota Vios scored the highest with 17.8% of participants voted as the seat as very comfortable compared to PeroduaMyVi and Proton Saga BLM,which scoredonly 2.2% at very comfortable level. This result correlates positively with the study done by Mohamed andYusuff (2007) that showed the participants preference towards the Toyota Vios in term of car seat adjustability.

As for the foot comfortable evaluation, Proton Saga BLM achieved the highest very comfortable percentage of 11.1%, followed by PeroduaMyVi and Toyota Viosat 8.9%. The preference towards the Proton cars is maybe due to theirlarger legroom as compared to the Toyota Vios (Mohamed&Yusuff, 2007).

II. Anthropometric Comparisons:

As for anthropometric data comparison, the parameter of popliteal height was chosen to be compared with the maximum and minimum horizontal allowable seat adjustments in each car.Table 2 shows the anthropometric data measurement of popliteal height of 1007 participants.

Table 2: Anthropometric data Measurement (n=1007).

	Male				Female			
	Mean	SD	5%tile	95%tile	Mean	SD	5%tile	95%tile
Popliteal Height	436.88	40.61	369.88	503.88	436.82	40.53	369.95	503.69

*all data in mm

The car seat horizontal adjustments (sliding distance) for all three cars involved are depicted in Table 3.

Table 3: Value of car seat horizontal adjustability.

Cars	Minimum	Maximum
PeroduaMyVi	360	570
Proton Saga BLM	370	580
Toyota Vios	320	530

*all data in mm

From the data in Table 2, the minimum value of popliteal height taken from the 5^{th} percentile female is 369.95 mm. While for the maximum value of popliteal height of 95^{th} percentile male is 503.88 mm. Both of these values lie within the minimum and maximum allowable range of horizontal car seat adjustment for all the three cars as shown in Table 3. This means that the horizontal design of car seat adjustability for all three cars involved are able to satisfy a majority of 90% of Malaysian population.

However, 10% of the Malaysian maximum and minimum range population that lie outside of this may experience some difficulties in terms of car seat horizontal comfort adjustability. For a shorter individual, he may face more difficulties to sit comfortablyin a Proton Saga BLM as the minimum value is on the highside compared to PeroduaMyVi and Toyota Vios. This means that, he may have to sit slightlyfarther in his car seat in order to able to control the steering wheel.

On the other hand, for a taller individual, the Toyota Vios may restrict its horizontal car seat comfort because the value for the maximum adjustment is quite low compared to PeroduaMyVi and Proton Saga BLM. In this case, a driver may possibly need to raise his knees a bit in order to be able to sit properly in his car seat without obstructing his foot placement on the pedal.

Conclusion:

This study has investigated and found the comfort subjective ratings and preference in three different driver's car seats. It has made comparisons of anthropometric data with the car seat horizontal adjustability. The subjective rating results showed that the Toyota Vioswas found to be the most comfortable car in terms of seat adjustment while Proton Saga BLM was better in terms of spacious legroom for feet comfort. All the three cars studied showed that their car seat horizontal adjustments are able to accommodate 90 % of car drivers from the Malaysian population. However, the extreme population i.e. 5^{th} percentile and 95^{th} percentile outside the majority may experience some difficulties in achieving comfort.It is recommended that a more in depth investigation needs to be done in the future in order to clearly identify the possible explanation from the results found in this study. However these data must be interpreted with caution because the results are based on individual comfort perception and the sample size was small. As a suggestion, more researches on this topic need to be undertaken before the relationship between the car seat design and drivers comfort can be clearly understood.

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