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Incorporating Malaysian's Population Anthropometry Data in the Design of an Ergonomic Driver's Seat

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Abstract

An ergonomically designed driver's seat is crucial in ensuring quality, comfort and safe driving. The increase in road accidents every year is mostly linked to drivers' fatigue. Therefore, posture comfort is an important aspect in driver's seat design. The aim of this study is to design a driver's seat which is suitable for Malaysians. There are three main objectives in this study; firstly, to investigates the comfort level and safety system of the existing driver's seat, secondly, to identify and determine parameters which may affect comfort and the driver's seat safety system, and lastly, to develop and design an ergonomic driver's seat. Anthropometric data of drivers should be used during the driver's seat design stage. Critical dimensions of the driver's seat and anthropometric data must be taken into consideration in order to optimize the comfort level and safety of the seat. Previous studies showed that the evaluation of driver's seat discomfort should include both objective and subjective evaluations. The seat discomfort will negatively affect the driver's performance. All information pertaining to the driver's seat design was obtained through research on the related subjects. In the data collection phase, the objective evaluation method was used in determining the seat's dimension while subjective evaluation was used to gather information on the drivers' experience. Anthropometric data from 1405 male and female subjects were collected and stored in a database. Meanwhile, subjective evaluation on driver's seat discomfort was conducted on 100 male and female respondents. The SPSS software was used to analyse the data. Every parameter that affects the safety and comfort of the driver's seat were then used to design a new driver's seat. The parameters that were taken into account are backrest height, cushion width, cushion length and adjustability. These parameters were then matched with the Malaysian drivers' anthropometric data. Finally, the dimensions of the new driver's seat were determined: 520mm cushion width; 380mm cushion length, 480mm backrest width, 407.5mm backrest height and 180mm adjustability.

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Keywords: design, driver's seat, safety, comfort, paramter, anthropometry

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1. Introduction

Driver's seat is an important component in car manufacturing process. This is because every driver needs a seat to control their vehicle. Driver's seat comfort while driving needs to be differentiated from the comfort of sitting on a chair at home, in the office or at the workplace. This shows that driver's seat comfort in a car has distinctive comfort value compared to other types of seats (Andreoni et al., 2002).

Body posture when one sits and drives will determine a driver's comfort level. A driver's comfort level is determined by his body posture when he sits and drives. If his body posture is not in a comfortable level, it is natural that his body will feel pressured and burdened. Theoretically, to obtain driving comfort, we need a seat design that can accommodate our body posture. If a car seat could not accommodate a driver's body posture when driving, the perception on discomfort will arise by itself (Guenaelle, 1995; Gvi et al., 1998).

To create a driver's seat which gives comfort while driving, the design of the seat needs to take into account anthropometric data which differ according to the population that uses the seat. These anthropometric data will be used in determining the most suitable parameter of a driver's seat. Anthropometric data for a population is different from another and this can be seen in the slight difference in anthropometric data between drivers in the United Kingdom and Norway (Bolstad et al., 2001; Haslegrave, 1980). However, Malaysian population have smaller physical body size when compared to American and European, thus there is a big and significant difference with respect to their anthropometric data.

The ability and capability of human to design a product must be adapted to human features. When there is a mismatch between a product and human features, automatically the feeling of discomfort will arise in users of the product. Therefore, all products must be manufactured according to users' anthropometric data (Sagot et al., 2003). Comfort assessment can be evaluated objectively and subjectively. Objective evaluation is carried out based on the existing parameters of the driver's seat. Meanwhile, for subjective evaluation, the subjects were directly asked by using a survey questionnaire to rate their perception on driver's seat comfort. Indirectly, this reflects users' perception. Combination of both the objective and subjective methods will give better evaluation on discomfort (Deros et al., 2009).

2. Methodology

The purpose of this study is to suggest a driver's seat design, which fulfil the anthropometric population in Malaysia based on comfort level and safety of a driver's seat. There are two evaluations made that is the objective and subjective evaluations before developing a driver's seat design. Data collection was initiated with the collection of population anthropometric data from 1405 subjects to match dimensional design of a driver's seat using traditional method (i.e. ruler, measuring tape and vernier callipers). A total of 100 male and female subjects were involved in the subjective evaluation survey. The survey questionnaire used in this study was adopted from Deros et al. (2009). In subjective evaluation, data were collected based on respondents' perception towards the parameters which influenced the design of the driver's seat. Meanwhile, for the objective evaluation, data were collected based on existing driver's seat dimensions of two car models labelled PM1 and PS1.

Data collected through subjective evaluation were analyzed using the Statistical Package for Social Sciences (SPSS) Version 21. Results from both objective and subjective evaluations were utilized in proposing a driver's seat design using 3-D Digital Human Modeling (DHM) software, CATIA.

3. Results and Discussions

3.1. Subjective Evaluation

Anthropometric data of the 1405 Malaysian population were collected from 795 male and 610 female subjects. In this study, the anthropometric data were simplified in the form of 5th, 50th (mean), 95th percentile values and standard deviation. The eight related dimensions were selected for analysis; they are: standing height, sitting height, popliteal height, interscye breadth, hip breadth, and shoulder height in sitting position, length of buttocks to popliteal and cervical height for the male, female and overall data are shown in Table 1, Table 2 and Table 3.

Table 1. Anthropometric data of 795 male subjects (mm)

Dimension	50th Mean (mm)	Standard Deviation (mm)	5th Percentile (mm)	95th Percentile (mm)
Standing Height	1687.24	64.66	1580.00	1790.00
Sitting Height	860.97	67.39	750.00	950.00
Popliteal Height	446.78	32.17	401.80	508.40
Interscye Breadth	379.87	76.93	306.80	480.00
Hips Breadth	366.26	60.85	300.00	480.00
Shoulder height in sitting position	568.74	65.51	480.00	652.00
Length of buttocks to popliteal	473.22	43.07	415.00	560.00
Cervical height	650.67	72.92	530.00	740.00

Table 2. Anthropometric data of 610 female subjects (mm)

Dimension	50th Mean (mm)	Standard Deviation (mm)	5th Percentile (mm)	95th Percentile (mm)
Standing Height	1566.15	60.79	1475.55	1670.00
Sitting Height	794.46	79.03	665.50	890.00
Popliteal Height	422.32	42.39	360.00	500.00
Interscye Breadth	358.15	124.53	275.00	440.00
Hips Breadth	385.23	71.10	291.65	520.00
Shoulder height in sitting position	518.20	67.56	407.75	600.00
Length of buttocks to popliteal	450.61	47.59	380.00	528.90
Cervical height	598.74	71.05	502.75	680.00

Table 3. Anthropometric data of all 1405 subjects (mm)

Dimension	50th Mean (mm)	Standard Deviation (mm)	5th Percentile (mm)	95th Percentile (mm)
Standing Height	1634.67	87.01	1495.00	1770.00
Sitting Height	832.09	79.78	710.00	931.70
Popliteal Height	436.16	38.88	378.60	503.50
Interscye Breadth	370.44	100.86	290.00	468.50

Hips Breadth	374.47	66.14	295.00	500.00
Shoulder height in sitting position	546.80	70.96	450.00	643.50
Length of buttocks to popliteal	463.40	46.45	395.00	545.00
Cervical height	628.13	76.01	520.00	732.10

The anthropometric data collected were used to determine the correlation between the parameters that influenced safety level and driving comfort. Later, 100 subjects were selected to take part in the subjective evaluation using a survey questionnaire. Analysis on the driver's seat design awareness which influenced the perception of drivers' comfort and discomfort is shown in Table 4. The comparison on the level of awareness of the driver's seat design showed that almost all subjects (85%) admitted that they are aware that seat design will influence their perception on the level of comfort or discomfort. Following are the difference in the awareness level of the subjects.

Table 4. Subjects' awareness level on driver's seat design

Information on Subject	Level	Number	Percentage (%)
Awareness level	Aware	85	85.0
	Not Aware	7	7.0
	Indifferent	8	8.0

Analysis on the parameters with respect to Figure 1 showed 98% of subjects perceived that seat 'Adjustability' as the most influential parameter in determining driver's seat comforts. The second highest (97%) is Cushion followed by Back Rest at 91%. Other parameters which were perceived to influence seat comfort are Cushion material (86%), Cushion width (84%), Head Rest (83%) and Cushion length with (82%).

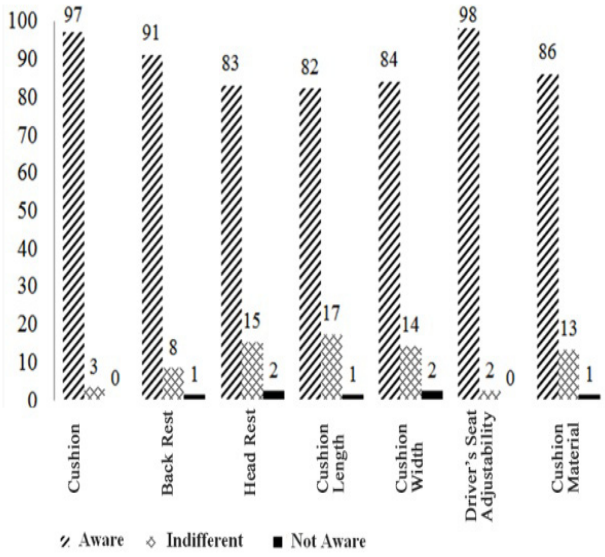

Fig.1. Parameters that influence driver's seat comfort

Subjects were asked to name factors which they think affect the driver's seat comfort. Figure 2 showed that 94% of the subjects cited driver's seat adjustability as the most influencing factor, followed by softer cushion material at 82%. The subjects also cited other factors which they perceived may provide more comfort to the driver's seat such

as the curvature of the head rest (78%), wider cushion (70%) wider back rest (69%), longer cushion length (59%) and finally taller back rest at 52%.

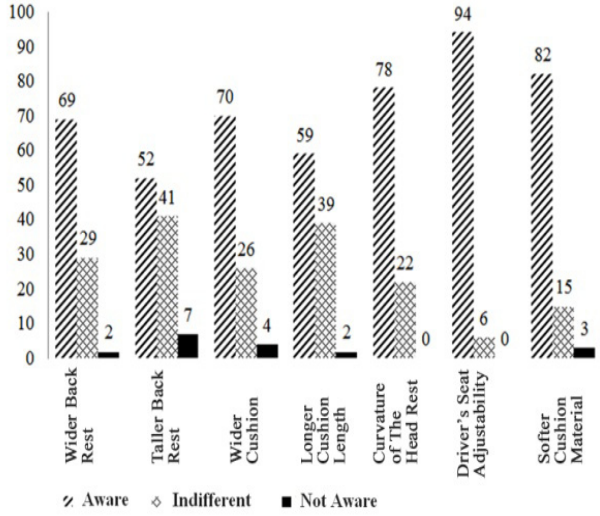

Fig.2. Comparison of proposed parameters that influence driver's seat comfort

Referring to Figure 3 and Table 5, there is 4 types of driving postures were introduced to the subjects. Type B posture is the most preferred of driving posture adopted among the subjects (59%) followed by Type C (23%) and Type D (15%). Type A (3%) was least preferred driving posture used by the subjects.

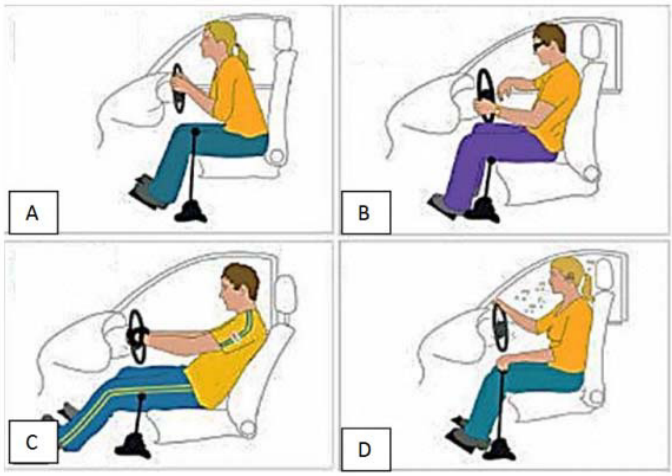

Fig.3. Types of driving posture

Table 5. Results of Driving Posture

Item		Number of subject	Percentage (%)
Posture Position	A	3	3.0
	B	59	59.0
	C	23	23.0
	D	15	15.0

3.2. Objective Evaluation

In this study, the dimensions of two types of existing driver's seat from two different model of compact cars manufacturers, code name: PM1 and PS1 were taken. Later, the authors have analysed the dimensions of driver's seat PM1 and PS1. Table 6 showed that both models, PM1 and PS1 have different design dimensions. The difference in dimensions of both models showed the inexistence of commonly accepted standards for driver's seat in Malaysia. At present driver' seat designs are found to be incompatible with the body dimensions of drivers which may lead to discomfort while driving.

Table 6. Driver's seat dimension of PM1 and PS1

	Parameter	Dimension	
		PM1 (mm)	PS1 (mm)
a	Cushion width	510	500
b	Cushion Length	490	530
c	Backrest width	490	550
d	Backrest Length	580	550
e	Adjustability	195	205

Table 7 suggest the proposed driver's seat dimension values were taken from Table 1, Table 2 and Table 3. These dimensions were based on the objective and subjective evaluations conducted which were then matched with the anthropometric data, a new driver's seat with dimensions suited to the Malaysian population is proposed. The dimension parameters of the driver's seat were determined using the method used by Matthew (2000) and were applied during the design stage of the driver's seat. This was done to accommodate at least 90% of the Malaysian driver's population by omitting less than 5^{th} percentile of the small physical size subjects and also the more than 95^{th} percentile of the larger physical size subjects in the population from the standard design for the mass produced driver's seat. This was done because these subjects may only represent a very small portion of potential users with respect to the population normal distribution.

Table 7. Proposed dimensions for driver's seat

Parameter	Proposed dimension (mm)
a. Cushion width	520.00
b. Cushion length	380.00
c. Backrest width	480.00
d. Backrest height	407.75
e. Adjustability	180.00

Figure 4 showed a new design of driver's seat was developed based on the five parameters cited by the respondents as having the most influence on the safety and comfort level of the driver's seat. The parameters used in the design are cushion width; cushion length, backrest width, backrest height and driver's seat adjustability.

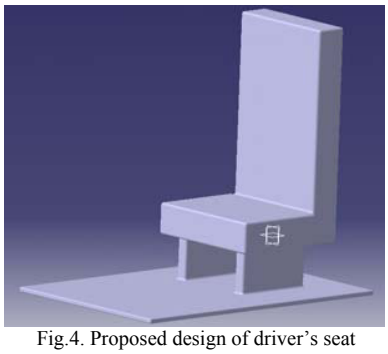

Fig.4. Proposed design of driver's seat

The design developed was simulated to match the body dimensions of the Malaysian population. Following are the simulations of body dimensions for normal (i.e. 5th and 95th percentile values) male (Figure 5) and female (Figure 6) drivers on the proposed driver's seat design.

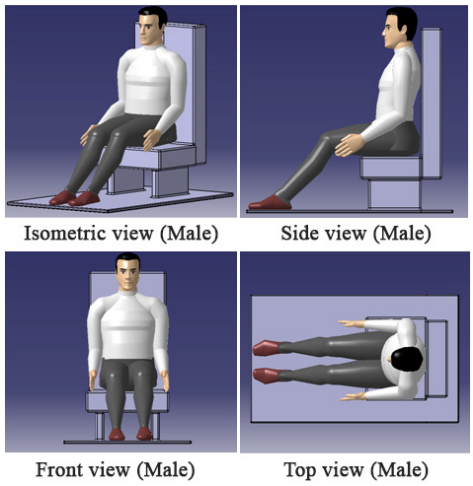

Fig.5. Digital Human Modelling (DHM) for male subjects

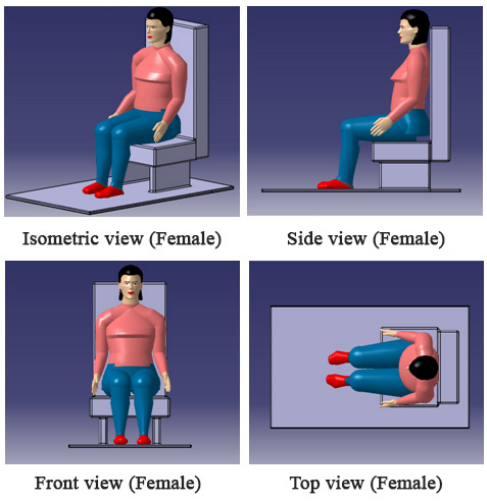

Fig.6. DHM for female subjects

Table 8 presents the comparison of PM1 and PS1 driver's seat dimension against the proposed driver's seat dimensions.

Table 8. Driver's seat dimension

	Parameter	Dimension		
		PM1 (mm)	PS1 (mm)	Proposed dimension
a	Cushion width	510	500	520
b	Cushion Length	490	530	380
c	Backrest width	490	550	480
d	Backrest Length	580	550	407.75
e	Adjustability	195	205	180

4. Conclusion

In general, this study investigates the comfort and safety level of the present driver's seat by identifying and determining parameters which influence the comfort level and safety system of the driver's seat. Consequently a new ergonomically designed driver's seat was developed so as to improve the safety and comfort level. Parameters that influence the safety and comfort level must be considered in designing the driver's seat. The adjustability of the driver's seat was the most cited parameter as having the most influence on safety and comfort level. It is clear that the respondents used the adjustability function to alter their sitting posture. The second most cited parameter is the seat followed by parameters of backrest; cushion material, cushion width, headrest and cushion length. Based on the results and findings of this study, a new driver's seat design was developed with the following dimensions of the five selected parameters; cushion width 520.00 mm, cushion length 380.00 mm, backrest width 480.00 mm, backrest height 407.50 mm and adjustability 180.00 mm.

References

Andreoni G., Santambrogio G.C., Rabuffetti M., Pedotti A. (2002). Method for the analysis of posture and interface pressure of car drivers. *Applied Ergonomics, 33 (6)*, 511–522.

Bolstad, G., Benum, B., Rokne, A. (2001). Anthropometry of Norwegian light industry and office workers. *Appl. Ergon, 32 (3)*, 239–246.

Deros, B.M., Daruis, D.D.I. & Nor, M.J.M. (2009). Evaluation of car seat using reliable and valid vehicles seat discomfort survey. *IEMS. 8(2)*, 121-130.

Guenaelle P. (1995). One methodology to evaluate Automotive Seat Comfort. In: Proceedings of the Third International Conference on Vehicle Comfort and Ergonomics, Bologna, Italy, 29–31 March, 231–240.

Gyi D.E.,Porter J.M., Robertson N.K.B. (1998). Seat pressure measurement technologies: consideration for their evaluation. Appl. Ergon. 27 (2), 85–91.

Haslegrave, C.M. (1980). Anthropometric profile of the British car drivers. *Ergonomics, 23*, 437–467.

Jackman E. (2014). How to Adjust your seating position while driving. Retrieved: January, 8, from http.www.eddiejackman.com

Matthew P.R. (2000). Survey of auto design recommendations for improve comfort, April, From http://mreed.umtri.umich.edu/mreed/pubs/Reed

Sagot J. C., Gouin V. & Gomes S. (2003). Ergonomics in product design: safety factor. *Safety Science, 41*, 137–154.