

ORIGINAL ARTICLE

THE STUDY OF SEATING PRESSURE ON CAR SEAT BETWEEN TWO NATIONAL CARS

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ABSTRACT

The main objective of this research is to compare the seating pressure during the driving session between two different types of national cars. The objective of this research is to conduct object pressure distribution study on two different types of car seat using CONFORMat (model 5330) with system model CER2, compare and analyse the results based on object pressure between both car seat. Twelve respondents participated a driving session with TekscanCONFORMat (model 5330) setup using the same route for both national car. We select two types of national cars equipped with automatic transmission for this research. The seat pressure on the subject along the journey is recorded using TekscanCONFORMat Research 7.60 software. Later, comparison made with respect to the seat pressure experienced by twelve respondents. The results shows different values of back and seat pressure recorded among the twelve subjects. Lastly, the results are analysed and discussed at the end of this paper. Model B seat design has better ability to distribute evenly the pressure to both seat and back. However, results for Model A showed the pressure is more concentrated on the seat area.

Keywords: TekscanCONFORMat; Seating pressure; Ergonomic

INTRODUCTION

Automotive car seat provides driver comfortable driving experience especially long-term driving session¹. It is design to distribute object pressure evenly to reduce pressure focused on a specific area, which caused fatigue, pain, and ulceration². In order to design a car seat with good pressure distribution function: the weight of driver, car seat contour, seat backrest angle and car seat material must be considered²⁻⁵. To determine the object pressure exerted towards the car seat usually engineer used pressure sensor mat to obtain the accurate average object pressure distribute value⁶. On the other hand, automotive car seat also serves as support purpose, good car seat support reduces the risk of Musculoskeletal Disorders (MSDs) and compression of Ischial Tuberosity (IT)⁷. This study focused on comparing the seating comfort on car seat between two national cars using CONFORMat (Model 5330) with system model CER2 as a device to perform objective pressure measurement.

METHODOLOGY

Twelve respondents (six males and six females) selected to drive the two national cars with automatic car transmission. Those respondents with age between 21 to 25 years. This section consists of the overall research flow and the essential elements to conduct this study. Refer to Figure 1, it is brief flow for the planning of study which states the task will be carried out throughout of research. Furthermore, the

essential elements to conduct this study such as: the parameter used; equipment setup; test drive and data analysis is stated clearly. All these elements explained according to sequence. Apart from a chart, this section also showed the process of executes driving session.

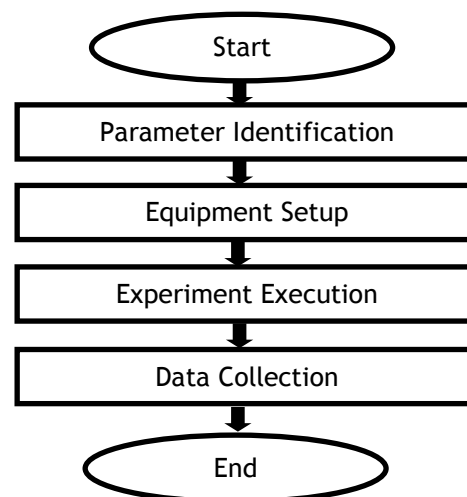


Figure 1 - Flow chart

Many types of parameters identification techniques are used.

Types of seats

First, identify the features of car seat for both selected national's car model. The car seat features' identified to study the difference between both car seats and their effects the drivers' seating pressure⁸⁻⁹. The car seat features

include the design, contour, material, height of the seat, length and width of the seat pan and, the height of backrest. Record and compare all these measurements.

Road Selection

The travel distance for every respondent is fixed; i.e. from the SPA highway roadside to Plaza Toll Tangkak Inbound, the overall route as shown in Figure 2. The starting and ending points of the route, fixed from the roadside of SPA highway after a left turn the T-junction of Jalan Autocity-TKB. After enter SPA highway, the driver will stop at the roadside for equipment adjustment then prepare for the journey.

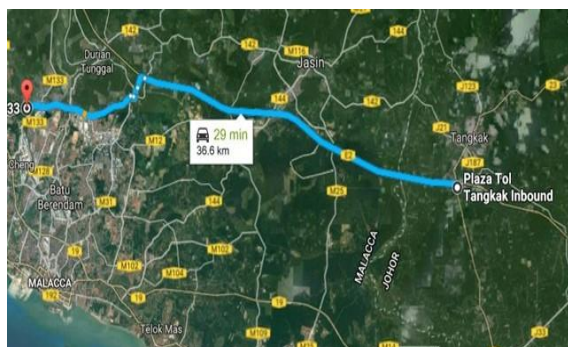


Figure 2 - Total distance for analysis

Respondent Selection

Twelve respondents (6 males and 6 females) selected from UTeM Industry campus to participate in this experiment. The weight of each respondent; measured and recorded using the weighing scale in the laboratory as shown in Figure 3. Calibration is done for each respondent to gather get the maximum body pressure distribution the numerical data extract using Microsoft Excel. Average maximum body pressure distribution; calculated, the value is being inserted as “calibrated pressure” in the CONFORMat Research 7.60 software.



Figure 3 - Weight scale

First, the weight of respondent is key-in into “Applied force” column. Then, press the “Start” button to start the calibration showed in Figure 4. Later, save the calibration file for each respondent, every respondent has gone through this CONFORMat system calibration before conduct the experiment.

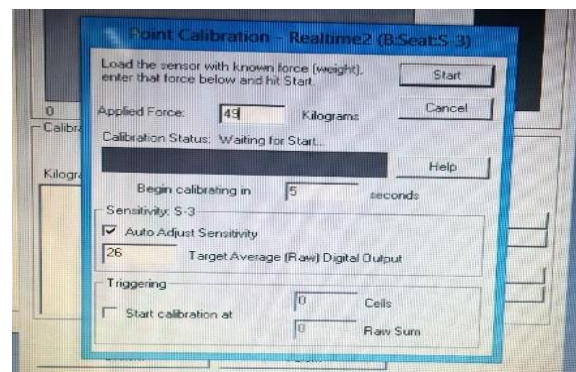


Figure 4 - Insert weight of respondent for calibration

The average calibrated pressure from 12 respondents can be obtain from the exported file from the CONFORMat Research 7.60; the results can be view using Microsoft Excel. Furthermore, the average value of calibrated pressure result is key-in to the “calibrated pressure” column shown in Figure 5.

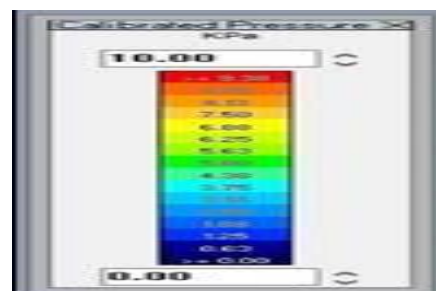


Figure 5 - Calibrate pressure column in the CONFORMat Research 7.60 software

The purpose of “calibrated pressure” column is to set the maximum pressure detected by the sensor. For example, if 10 Kpa is key-in to the “calibrated pressure” column, the real-time display will show pressure exerted to the CONFORMat in 2-D or 3-D display by using colour as differentiation of low and high-pressure area figure 6.

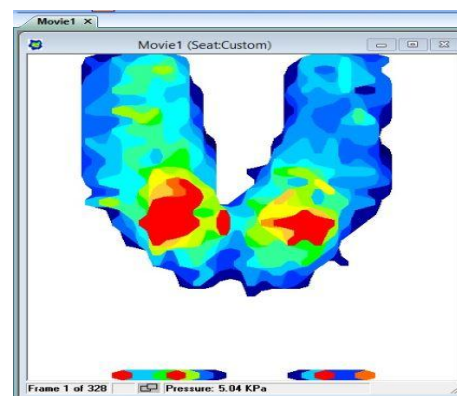


Figure 6 - Real-time display for CONFORMat. The red colour region signify high pressure according

to the value insert at the "calibrated pressure" column

Before setting up the CONFORMat on the car seat, the driver should enter the car and make an adjustment of the car seat to get an optimal and comfortable driving posture. Then, both of the sensor mat (CONFORMat), placed on the car seat pan and backrest respectively.

To ensure the CONFORMat do not slip off from the seat and back rest, it is tightened by using string to the seat. Next, connect both of the sensors to the laptop with CONFORMat Research 7.60 software. When the devices are connected, CONFORMat Research 7.60 will show the real-time display for both seat front and back top sensor mat. Adjust both cameras to see clearly the road condition and driver posture after the respondent sitting inside the car. This is to record, if there is any significant pressure fluctuation along the travelled journey, video can act as a reference to find out the cause. When the setup is completed, "record" button will be press for both the camera and real-time display. The driver is required to maintain in the range of 80 to 100 km/h along the travel journey. Lastly, "stop" button will be press to save the recording for both camera and real-time display.

EXPERIMENT EXECUTION

Each selected respondent carry out the experiment. Respondent is required to drive a selected national car with the CONFORMat system in the car. Twelve respondents drive two types of national car at a separate time using the same route. Before the equipment being setup, respondent is required to enters the car and adjust the driver seat accordingly to achieve the most comfortable and optimal sitting position.

Next, CONFORMat system is setup onto the driver seat, use a string to hold both sensor mat and to avoid the sensor mat slip off from the actual position. After that, the respondent enter the car and drive to the starting point (SPA highway). Park the car at the roadside after passing the SPA highway traffic light. To obtain the real-time display view, connect the devices to the laptop. When the camera is ready, press the "Record" button to record the respondent seating pressure

throughout the whole journey. Furthermore, respondent required to stay on the left lane all the time except for over taking and use only the specific toll lane. Lastly, press the "Stop" button when respondent stops the car at the roadside before exiting from Inbound Plaza Toll Tangkak.

DATA COLLECTION

Saved all the recorded real-time data collected from each respondent as a recorded movie. The movie can be open in the CONFORMat Research 7.60 software. For each respondent, generate the graph for front seat and back top respectively. A sliding bar on the graph can assist in determining the pressure value, kPa on the graph. Furthermore, the generated graph is object pressure versus time; it shows the pressure exerted by the respondent towards the seat and back throughout the whole journey.

RESULTS

Record all the peak pressure on the graphs for each respondent in a table for further analysis. Generate a graph for all collected data to get a clearer picture of the overall trend of the pressure exerted on the car seat for both types of national cars.

Comparison

Compare the results obtained in terms of weight, gender, and type of car seat from different national cars. Generate the three different graphs separately for weight category, gender and type of car respectively to analyse the impact of these three elements towards object pressure exerted on the car seat.

RESULTS AND DISCUSSION

This section discuss the results obtained from twenty-four experiments conducted by the twelve respondents. Every trip has video recording to record road condition and driver's posture.

The results based on two genders driving two different cars and categorized into three different range of weight as shown in Table 1.

Table 1- The range of weight for both gender.

Weight	
Male	Female
< 60 kg	< 45 kg
61-79 kg	49 - 59 kg
> 80 kg	> 60 kg

For each category stated in Table 1 has two respondents, all respondents are requested to

drive both national cars. Furthermore, the collected results will be compared and analyse in

three different aspects which is range of weight, gender, and type of car.

RESULTS ANALYSIS

Extract the raw data from all the respondents from CONFORMat Research 7.60 software. Identify the shape of graph showed in Appendix Peak object pressure from each generated graph and compiled in Table 2.

Table 2 consists of object pressure gathered from approximately thirty minutes driving session from twelve respondents. All of them have executed driving session two times using the same route with two different national cars. In the table also shows the object pressure for back and seat respectively for both cars.

Data recorded only from the beginning point (roadside of SPA Highway) to the end-point (Tangkak Toll), the total duration is a range of 25-30 minutes. Divide the weight category into three categories for both male and female as stated in Table 3, each category has two subjects. In the graph, subjects 1 to 6 are male and 7-12 are female. The weight category starts from heavy to light for both genders. From the trend of the graph, it is obvious the shape of the graph is incline to right for subject 1-6 then 7-12. Overall, majority of the pressures exert to the driver car seat and partially towards their back. The maximum object pressure for the back of driver is 2 kPa for male driver and 1.7 kPa for female driver. Furthermore, the maximum object pressure on the driver seat is 4.7 kPa for male and 3.8 kPa for female.

Table 2 - Object pressure from 12 respondents for both national car

Subject	Car Type			
	Model A		Model B	
	Back Top	Seat Front	Back Top	Seat Front
1	1.9	4.5	1.8	4.7
2	1.6	4.3	1.4	4.7
3	1.7	4.4	0.9	4.7
4	1.4	3.4	1.4	4.5
5	1.5	3.1	1	3.7
6	2.0	2.7	1.2	2.8
7	1.5	3.6	1.1	3.8
8	1.5	3.3	1.5	3.4
9	1.7	2.8	1.1	3.2
10	1.4	2.6	1.2	3.2
11	1.6	2.1	1.6	2.8
12	1.5	2.3	1.3	2.4

Figure 7 showed the weight range has a slight effect on the object pressure exerted on the car seat. The trend of object pressure on seat for subject 1 to 6 and 7 to 12 are in the decreasing trend because the weight is decreases from subject 1 to 6 and 7 to 12. It is obvious that greater weight respondent exerted greater pressure towards the car seat. For the back of car

see, it does not affect much by the weight of a person but it helps to distribute and reduce the seat pressure of driver when driving the car. Therefore, the object pressure for back is not consistent and it depends on the habit or posture of driver. Besides that, the incline angle that pre-set by driver may also affect the object pressure of drivers exerted on their back.

Table 3 - Back pressure for both national cars

Subject	Back Pressure for Both National Cars			
	Model A	Back Top	Model B	Back Top
1		1.8		1.9
2		1.4		1.6
3		0.9		1.7
4		1.4		1.4
5		1.0		1.5
6		1.2		2.0
7		1.1		1.5
8		1.5		1.3
9		1.1		1.7
10		1.2		1.4
11		1.6		1.6

12

1.3

1.5

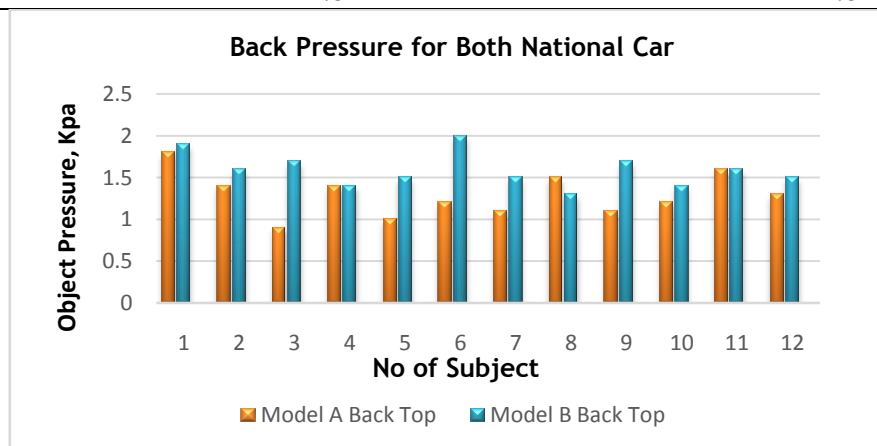


Figure 7 - Graph of back pressure for both national cars

Table 4 - Seat pressure for both national cars

Subject	Back Pressure for Both National Cars	
	Model A Back Top	Model B Back Top
1	4.7	4.5
2	4.7	4.3
3	4.7	4.4
4	4.5	3.4
5	3.7	3.1
6	2.8	2.7
7	3.8	3.6
8	3.4	3.3
9	3.2	2.8
10	3.2	2.6
11	2.8	2.1
12	2.4	2.3

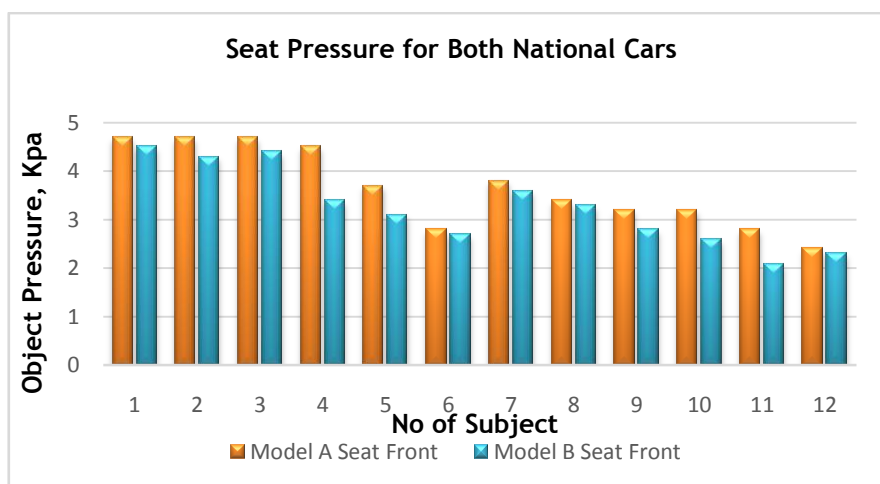


Figure 8 - The graph of seat pressure for both national cars

Figure 7 and 8 are object pressure exerted on back and seat of car seat respectively for both national car Model A and Model B. Figure 7, showed the overall back pressure for Model A is lower compared to Model B. Driver exerted lesser pressure towards back, but more on the seat. Apart from that, only respondent 8 experienced higher pressure on back for Model A. Figure 8, Model B shows lower pressure on seat compared to Model A. Respondent 4 showed the

largest difference of object pressure (i.e. 1.1 kPa) for seat between the two national cars.

DISCUSSION

For several male respondents, their weight has less effect on the pressure change as they are able to reach the sensor panel without lifting their body from the sensor mat, whereas for all female respondents, their weight has contributed

topressure changes on the seat and back sensor mat. Examples are shown in Figure 9 and Figure 10.

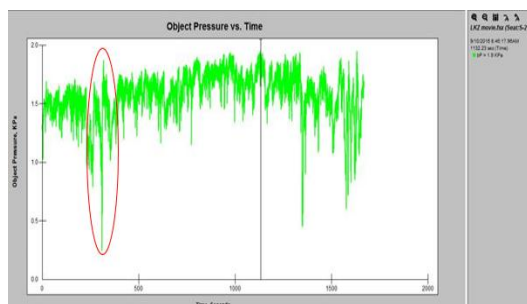


Figure 9 - Graph of back top sensor mat object pressure versus time for subject 1 when driving Model B

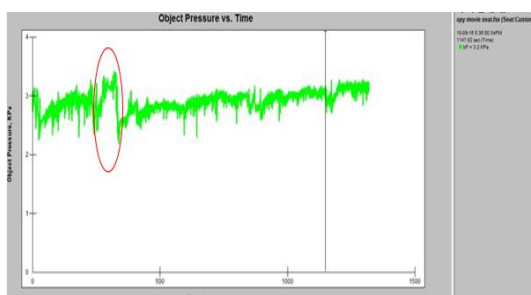


Figure 10 - Graph of seat front sensor mat object pressure versus time for subject 9 when driving Model A

Moreover, each respondent who conducted the driving session can adjust the seat back rest. The backrest angle is not fixed; every driver can adjust the comfortable and optimal angle before starting the driving session. However, the incline angle is according to the driver's habit, the pressure exerted by driver towards car seat might affect by the car backrest angle. There is study stated larger incline angle caused higher pressure. The object pressure for back showed inconsistent value from all the respondents, it does not depend on the weight of an individual, it may affect by the backrest angle and driver posture.

From the results gathered, every respondent has exerted different pressure value towards the car seat and back. One of the reason is the weight that alters the pressure value of respondent, another will be the preferred sitting posture portrayed by each driver. Individual may use to different back incline angle the incline angle will affect the pressure acted on the car seat. The posture preferred by each driver can affect the result.

Furthermore, in the graph shows greater weight individual exerted higher pressure towards the car seat⁹. The difference of object pressure between seat and back for Model A is greater as respondents exerted most of their pressure

towards the seat instead of the back. For Model B, most respondents experienced higher pressure on their back compared to Model A but less pressure contributed to the seat area. From this phenomenon, seat design for Model B is more encouraging for the driver as it distributed weight evenly compared to the seat design of Model A.

CONCLUSION

In conclusion, concludes the findings gathered from all driving session conducted by 12 respondents using 2 types of national cars. Besides that, explained the compared results further to relate it to the objectives set at the beginning of the research. From the study that has been conducted on two types of national cars Model A and Model B, object pressure for twelve respondents has been successfully recorded and extracted using TekscanCONFORMat system for both seat and back. Furthermore, record every driving session by using action camera with respect to road conditions and driving posture.

During the driving session, some issues are cannot be avoided like depletion of battery for both action camera and laptop. Solve these issues by using inverter for car or power bank. Another issue is the action camera holder cannot hold tightly onto the windscreen. The double-sided tape has become not sticky after repeated usage. The camera dropped off from the windscreen a few times during driving session. Therefore, some interruption occur on the videos. Save all the recorded movies, later convert them into graph of object pressure verses time to obtain the peak object pressure from the generated graph.

By comparing the object pressure in terms of weight, it is obvious that greater weight has contributed higher pressure onto the car seat. The incline angle of backrest and driver posture also affect the pressure exerted towards car seat. From the analyse graph, male respondents with greater weight has higher pressure compared to female respondents. Besides that, there are 2 females (subject 7 and 8) is heavier than 2 males (subject 5 and 6) based on the weight category in this study, the results showed the object pressure for subject 7 is higher than both males. It also shows greater weight contribute greater pressure towards the car seat.

In terms of car seat comfort, all respondents experience lower pressure on Model B seat but higher results on Model A seat. However, respondents' experienced lower pressure on back for Model A compared to Model B. From this phenomenon, generate a graph of difference of object pressure between seat and back for both car. Seat and back object pressure for Model B car seat is overall lower than Model A. This

showed Model B seat design has better pressure distribution ability because the pressure was distributed evenly to both seat and back but for Model A the pressure is more concentrate on the seat area.

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REFERENCES

1. Grujicic, M., Pandurangan, B., Xie, X., Gramopadhye, A.K., Wagner, D. and Ozen, M. Musculoskeletal computational analysis of the influence of car-seat design/adjustments on long-distance driving fatigue. *Journal of Industrial Ergonomics*, 2010; 40(3): 345-355.
2. Chen, J.C., Chang, W.R., Chang, W. and Christiani, D. Occupational factors associated with low back pain in urban taxi drivers. *Occupational Medicine*, 2005; 55(7): 535-540.
3. Deros, B.M., Hassan, N.H.H., Daruis, D.D.I. and Tamrin, S.B.M. Incorporating Malaysian's population anthropometry data in the design of an ergonomic driver's seat. *Procedia- Social and Behavioral Sciences*, 2015; 195: 2753-2760.
4. Nawayseh, N. Effect of the seating condition on the transmission of vibration through the seat pan and backrest. *International Journal of Industrial Ergonomics*, 2015; 45: 82-90
5. Sakakibara T, Kasai Y and Uchida A. Effects of driving on low back pain. *Occupational Medicine*, 2006; 56(7): 494-496
6. Park, S.J., Min, S.N., Subramaniam, M. Lee, H., Shin, Y.K., Jang, C.H. and Hwang, S.H. Driving posture measurement using 3D scanning measuring technique. *SAE International Journal of Passenger Cars-Mechanical Systems*, 2015; 8(2): 600-605.
7. European Agency for Safety and Health at Work (EU-OSHA). E-fact 9-Work-related musculoskeletal disorders (MSDs), 2007; An introduction. EU-OSHA, Bilbao, Spain. <https://osha.europa.eu/en/publications/e-facts/efact09/view/>. (Accessed 21 Nov 2017)
8. Lee SH, Park JS, Jung BK and Lee SA. Effects of different seat cushions on interface pressure distribution: A pilot study. *Journal of Physical Therapy Science*, 2016; 28(1): 227-230.
9. Mohamad, D., Deros, B.M., Daruis, D.D.I., Norhidayah, F. and Sukadarin, E.H. Comfortable driver's car seat dimensions based on Malaysian anthropometrics data. *Iranian Journal of Public Health*, 2016; 45(1): 106-113.
10. Smith, J., Mansfield, N., Gyi, D., Pagett, M. and Bateman, B. Driving performance and driver discomfort in an elevated and standard driving position during a driving simulation. *Applied Ergonomics*, 2015; 49: 25-33.