

PRELIMINARY STUDY ON THE ERGONOMIC DESIGN OF MOTORCYCLE SEAT FOR COMFORT USAGE

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ABSTRACT

Motorcycle seats undeniably provides good comfort to motorcyclists but there are some that offers less affirmation on ushering comfort, whilst some even results in harm to users, resulting in back pains, neck, shoulders, and other parts of the body over prolonged riding periods. This research aims to investigate the discomforts faced by motorcyclist and the best seat concept based on an ergonomic design, fit for the masses through a subjective evaluation. A study that includes a survey was conducted to study the subjective assessment against the motorcycle seat comfort. The study is divided into two parts, where in part 1, the anthropometric data were collected from a total of 100 respondents, representing 88 males and 12 females. Mean from the anthropometric data was used for two new seat redesigns, designated Seat A and Seat B. For part 2, sets of questionnaire were distributed to 130 respondents to measure their perception of seat design A and design B. Based on the results produced, 86.2% respondents suffered discomforts while riding a motorcycle. Most suffered discomforts at particular body areas: lower back, buttock and shoulder, while no discomfort reported around leg, feet and thigh. Results also proved that current seat designs needed an improvement with a majority of respondents opting an added backrest and to increase surface around buttock area. Based on the evaluation of designs, Seat B was selected as a better option as compared to seat A in terms of comfort usage.

Keywords: Motorcycle seat, ergonomic design, anthropometric, comfort, lumbar support

INTRODUCTION

Ergonomics is the process of designing or arranging workplaces, products and systems so that it fits the need of people who are directly involved with it. Ergonomics covers all aspects of a job, from the physical stresses it places on joints, muscles, nerves, tendons, bones and the like, which also includes environmental factors that could also affect hearing, vision, and general comfort and health^{1,2}. The importance of studies into Ergonomics is about ensuring a good fit between people and what they interact with.

Ergonomics should be considered in the design of every product, system and environment. Automotive ergonomics is the study of how the automotive industry has the technical ability to conjure up better designs for human comfort and ease of use. Motorcycles undeniably provides an important aspect towards the mobility of humans, the vehicle market as well as being one of the most important transportation mode among users worldwide. It is justifiably more useful to low-income earners as it has a lower cost advantage as compared to a car, but it is also a very hazardous vehicle type³. When riding a motorcycle, a motorcyclist typically wants the best comfort they could get with the motorcycle seat^{4,5}.

When it comes to ergonomics within motorcycles, there is a preconceived notion to increase efforts towards comfort and safety level for the motorcyclist, but there exist the inability of motorcycles to provide constant comfortability and shielded safety during the riding process, as compared to a car³.

The motorcycle seat is the main provider of comfort to all motorcyclist. However, over long extended periods, the motorcycle seat would eventually introduce discomfort, fatigue and could also cause lower back pains to the rider as well as to the passenger⁶. Comfort sitting is one important element that has to be given serious consideration. Due to increase exposures to seated postures, sitting comfort has become an important issue that demands adequate ergonomic inventions⁷.

Alleviating lower back pain is crucial in order for the motorcyclists to feel comfortable during the riding process. Sitting within a prolonged duration of time on top of a vehicle can cause great intradiscal pressure unto the lumbar region and consequent low back pain^{6,8}. The lumbar region is also one of the most vulnerable parts of the spine, as this part is suspended between the upper heavy parts of the body including the rib cage and the lower and the lighter part starting from the hip bone^{6,9}. So, this lumbar region needs a supporting backrest in order for the motorcyclist's

body to feel comfortable during the riding process. Based on a study ¹⁰⁻¹¹ which claims that having seats with lumbar support, is beneficial in reducing tensions in back muscle groups, buttocks and legs resulting from prolonged sitting activities.

This research aims to determine the best seat design judged and based from an ergonomic perspective, in order to prevent any bodily harms occurring towards a motorcyclist. Hence, this study is to evaluate the parameters of currently available motorcycle seats and to develop an updated or improved design based on the produced analysis.

METHODS

This study identified the parameters of currently available seat designs and then redesigned the current seat based on the ergonomic ‘concept’ to increase the user comfortability. In this study, the anthropometric data of Malaysian motorcyclist were measured and collected from 100 respondents. After collecting the anthropometric data, the mean and standard deviation of the anthropometric data were calculated. Two conceptual designs were proposed according to the mean of the anthropometric data. Then, a set of developed questionnaire were distributed in order to determine the more superior design of the two that was proposed.

List below are the anthropometric data that was taken into consideration when making these crucial measurements. Figure 1 shows the measurement that had to be identified on body parts of the respondent. The anthropometric data are:

- Shoulder height, sitting (number 6)
- Hip breadth, sitting (number 5)
- Elbow height, sitting (number 7)
- Buttock-popliteal length (seat depth) (number 8)

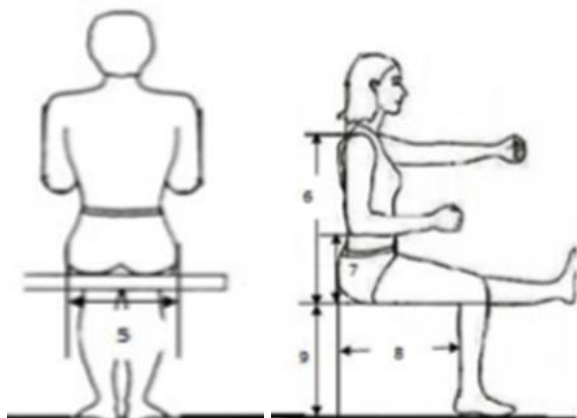


Figure 1. The anthropometric measurement for this study ³

These seat redesigned illustrations were developed using the latest Solidwork software which is the SOLIDWORKS® 2018 software. The result from the development of the redesigned seat will have two new designs which is labelled as Seat A and Seat B. The dimension of the redesign seats is based on the dimension of current motorcycle seats available in the Malaysian market.

RESULTS

I. Anthropometric Data

Prior to creating the new designs, creating a collection of the correct measurements of the human the body is important. Anthropometric data is important in this study in order to create a seat design which will be more suitable for the rider and towards reducing the feeling of discomfort when riding a motorcycle. These measurements involve four parts on the human body. These measurements are connected to the parameter of the motorcycle seat design, which goes toward improving the design based on shape and design criteria. The four anthropometric data are; (Shoulder height, sitting), (hip breadth, sitting), (Elbow height, sitting) and (Buttock-popliteal length). As a requirement to obtain these four anthropometric data, we had targeted at least 100 respondents ¹⁶⁻¹⁷ representing 88 males and 12 females starting from ages of 18 - 34 years old with different figures to measure their anthropometric data. The mean and standard deviation of the anthropometric data is shown in Table 1. This data was used to redesign the motorcycle seats in order to improve the comfort level based on an ergonomic interpretation.

Table 1. Mean and standard deviation anthropometrics data measurement

No.	Measurement	Study group (n=100)	
		Mean	Standard Deviation
1.	Shoulder height, sitting	60.81	4.04
2.	hip breadth, sitting	35.28	5.43
3.	Elbow height, sitting	23.04	3.89
4.	Buttock-popliteal length	44.67	4.60

II. Improvement of the Seat Designs

There is a need for a concerted effort towards redesigning a particular seat that can prevent and be able to decrease problems in relation to discomfort and lumbar pain (lower back pain). It should also be able to provide more comfort to

riders for short or longer journeys fitted onto current models available to the mass market and being useable to all desiring riders.

Thus, two designs, Seat A and Seat B were proposed based on the anthropometric data collected.

Design 1: Seat A

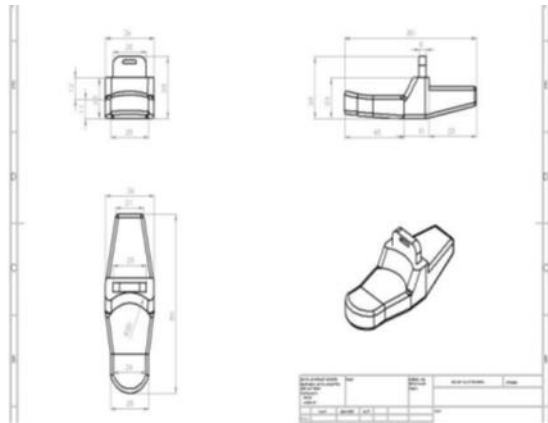


Figure 2. Two-dimensional design of Seat A

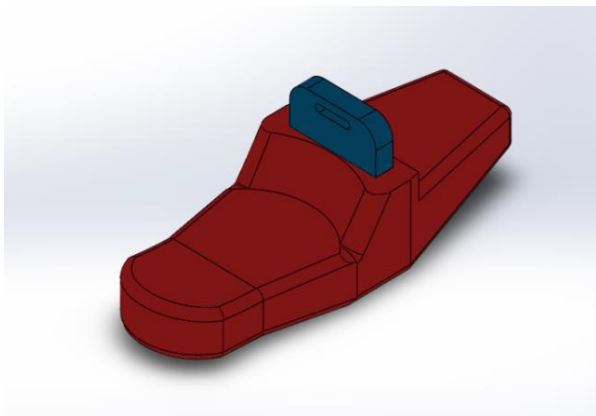


Figure 3. Three-dimensional design of Seat A

Figure 2 and Figure 3 show the two-dimensional design and three-dimensional design for seat A. The base dimension of the seat A is taken from the current seat design dimensions from Honda Ex5 Dream model motorcycle. The full length of the seat manually measured is 80cm and the length is maintained at 80cm. The length is divided into three parts; the front part being 45cm in length which is for the rider. 10cm is for the height increase and 25cm is for the passenger. The front length for rider is based on the anthropometric data, Buttock-popliteal length mean. The width of the seat is increased around the buttock area of the rider at 36cm and this also increases the cushioning around the buttock cushion area of the rider seat, after a noticeable lack of cushion volume was found of the current motorcycle seat. The width increase area is based on the mean of the anthropometric data collected which is the hip breath measurement during sitting. Other

improvements of the Seat A, were the height of the seat had been increased to 12cm around the rider buttock area in order to provide support to the lumbar part. The seat then will be installed with a back rest which is of 12cm in size, which would also be able to be pulled out, and pushed in depending on the needs of a particular rider. So the total height will now be 24cm, which should support the back area of the rider, thus will decrease the back pain during prolonged riding periods. However, there will be no back rest provided for the passenger. The dimension change of the seat height is following the anthropometric data mean, elbow height, sitting.

Design 2: Seat B

Figure 4 and Figure 5 show the two-dimensional design and three-dimensional design of Seat B. The base dimension of Seat B follows the current seat which is at 80cm. The rider length is 45cm and the increased height is 10cm, while the passenger length is set at 25cm. The front length for rider is based on the anthropometric data, Buttock-popliteal length mean. The buttock cushion area of the rider is increased to 36cm which is based on the anthropometric data, hip breath, sitting mean. This is due to the finding that current seat design has less cushion area around the rider's buttock.

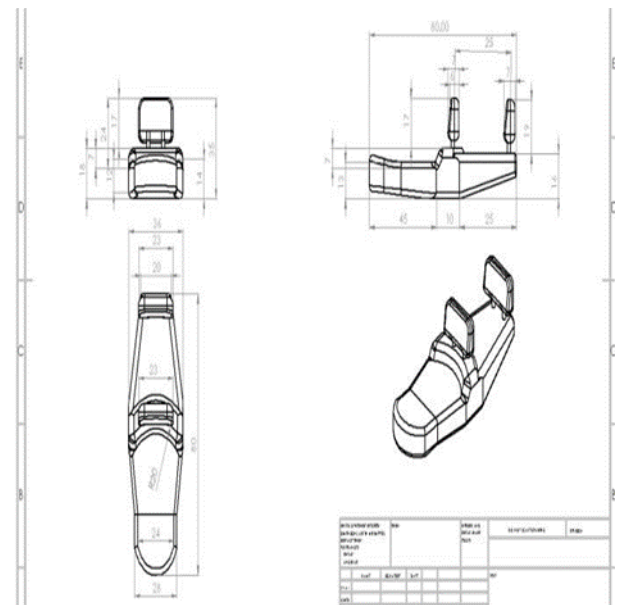


Figure 4. Two-dimensional design of Seat B

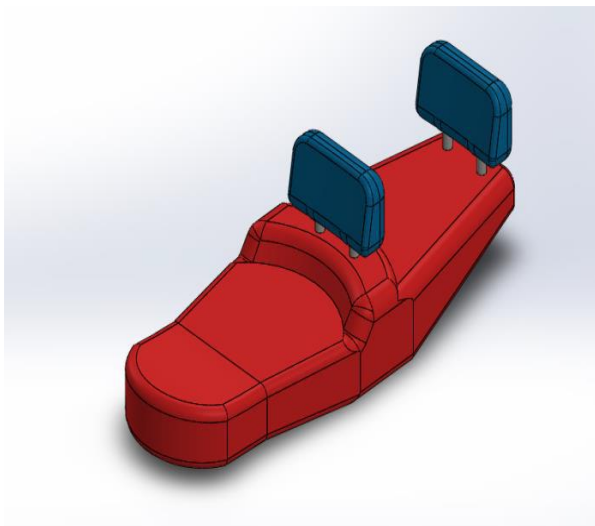





Figure 5. Three-dimensional design of Seat B

By increasing the buttock cushion area, it should prevent any discomforts to the rider during long distance riding. The height of the seat is then increased by around 7cm. Seat B is also designed with a back rest, but is now being fitted for both passenger and rider. The height of the back rest is 17cm for the rider and 19cm for the passenger. The seat height adjustment is based on the elbow height, sitting mean from the anthropometric data collected. Additionally, the back rest is portable; it can be assembled or disassembled according to the rider’s intention. The rider can assemble the back rest when riding for long journeys or be removed for shorter rides.

Table 2 shows the summary of seat design features in comparison between the original seat, Seat A and Seat B. The table shows the characteristic of all seat designs.

Table 2. Comparison of Design Features

Dimension	Original Seat (Honda EX 5 Dream)	Seat A	Seat B
			
Length	80cm	80cm	80cm
Width center seat	30cm	36cm	36cm
Width back seat	28cm	28cm	28cm
Height center seat	16cm	23cm	18cm
Width front seat	24cm	28cm	28cm
Characteristics	<ul style="list-style-type: none"> ➢ Hard cushion ➢ Does not have backrest ➢ Small buttock surface area. ➢ Causes discomfort and back pain during riding. 	<ul style="list-style-type: none"> ➢ Have a back rest. ➢ Back rest can be pull out and push in. ➢ Wider buttock surface area. ➢ No back rest for passenger. ➢ Single rider seat recommendation. 	<ul style="list-style-type: none"> ➢ Have back rest for both passenger and rider. ➢ Portable back rest can be plug and play. ➢ Wider buttock surface area for rider. ➢ Recommendation for long journey ride.

I. Survey Analysis

In this survey, we gather data on the respondent’s experience, discomfort level and the design chosen based on two designs provided in this study. 130 respondents were chosen to answer this survey questions.

a. Respondents Discomfort during Riding Motorcycle

In figure 6, it is found that 112 respondents chose “Agree” with the percentage of 86.2% having said that they felt discomfort during rides on their motorcycle as compared to 18 respondents whom had chosen “Disagree” with a percentage being 13.8%. Based on the data analysis, most respondents are experiencing discomfort levels on their body during rides. This proves that current seat design gives discomfort to the riders and needs an improvement ¹².

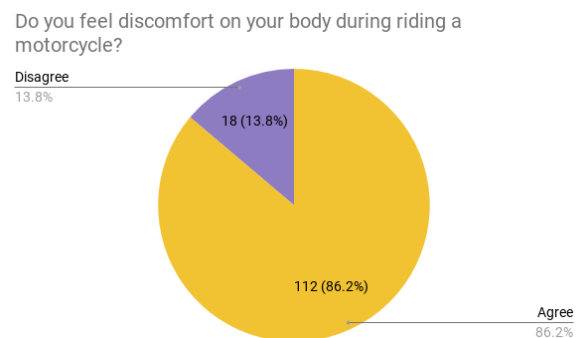


Figure 6. Respondent Opinion Regarding Motorcycle Seat Comfort

b. Part of Body that Feel Discomfort during Riding Motorcycle

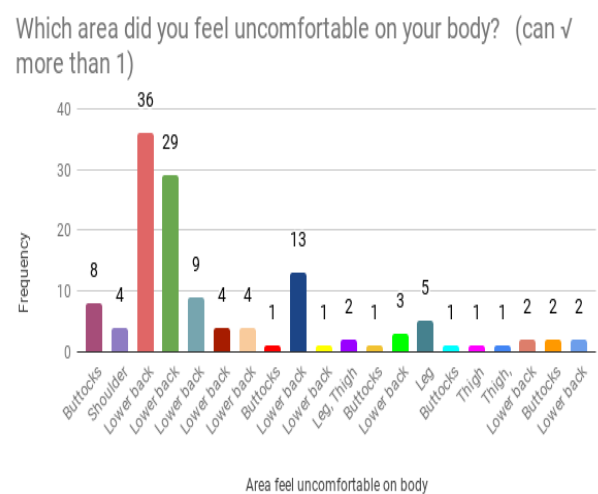


Figure 7. Respondent’s body parts that feel discomfort first during riding process

In figure 7, above, a majority of the respondents suffered discomfort at both the Lower back (29.5%) and Bottom areas (17.8%). The Lower back area also showed a higher percentage of discomfort level at 15.5%. Based on the data analysis, the results showed that a majority of respondents would initially suffer discomfort on their Lower back and Buttock during rides on their motorcycle. Then the pain will eventually reverberate at other parts like the Shoulder, Elbow and Hips as these parts also suffers discomfort, as mentioned by respondents of their riding experience. This result proves that current motorcycle seats does not offer adequate comfortability levels to its user. The respondents pointed that main areas that discomfort occurs are strongest at the Lower Back and Buttock area. This can be proved by the result of past studies¹², which had stated that majority of motorcyclist mainly experienced discomfort at upper body parts such as low back, buttock and shoulder. Motorcyclist experienced no discomfort at the lower body parts such as leg, thigh and feet.

c. Respondent Opinion on the Improvement of Seat Design

Referring to Figure 8, majority of the respondent choose “Both” (bigger seat dimension and add back rest) rather than choosing the options of bigger seat dimension only and add back rest only. The data recorded that 56.9% for the answer “Both”, 28.5% of respondents chose ‘Added Back Rest Only’ and 14.6% chose “Bigger Seat Dimension only”.

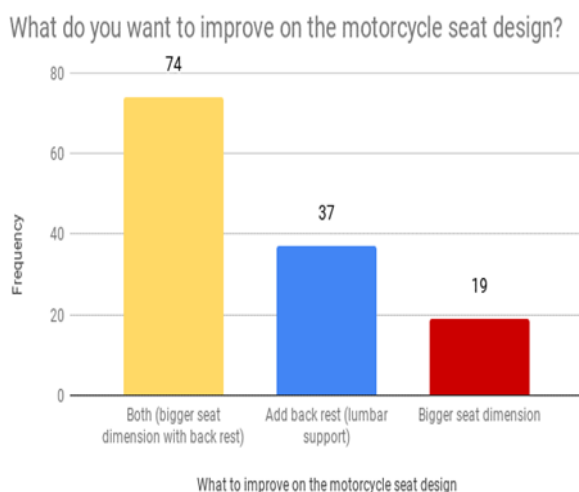


Figure 8. Respondent Opinion on What to Improve on Seat Design

The question required the respondent to state reason on why they had chosen the answer. Majority of respondents who selected “Both” as their answer stated that when improving both (added back rest and bigger seat dimension), they felt strongly that the seat will be more comfortable. Respondents also opined that if it is

applied during a motorcycle riding session, it should provide a hindrance towards having any back pain and pain to the buttock area. Other reasons stated, were to avoid any possible MSD issues and to provide better posture while riding motorcycles. This finding collaborates with past studies by^[10] which claimed that seats with lumbar support is beneficial in reducing tensions in back muscle groups, buttocks and legs resulting from prolonged sitting activities.

Based on the two designs proposed in this study, 96% of the respondents agreed that a redesign of the current seat will give greater effect towards the comfortability level during rides on the motorcycle especially for longer durations of travelling. Referring to Figure 9, design of seat B (77%) showing higher preferences from the respondents as compared to design A (23%).

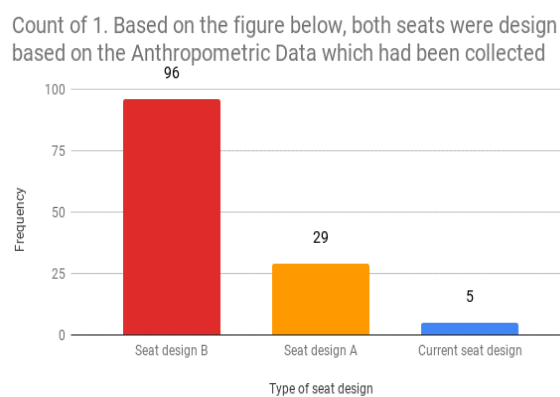


Figure 9. Preferable Seat Design

DISCUSSION

Based on the study of seat dimensions, it has been identified that the surface area under the rider’s buttock is fitted with a lower cushion height. The front seat cushion is also often rounded in shape and offers a negative effect to the rider, mainly due to the awful conditions of Malaysian roads. Thus, a typical motorcyclist will unwittingly experience mechanical vibration from the seat. This mechanical vibration will then transfer a force directly to the vertebra (back side) and lumbar parts of a motorcyclist, so it travels more quickly from the seat due to the small area of buttock cushioning that is available. There are identifiable hazards coming from these mechanical vibrations such as musculoskeletal disorder, lower back pain and whole body vibration (WBV). By increasing the buttock cushion area, the problem can be alleviated and diagnosed based upon the diameter of the hip breath and sitting length; deduced upon the collected anthropometric data from the respondents. The redesigned seats with alterations involving the buttock cushion area is only slightly increase by about 6cm, thus it does

not affect the motorcycle frame. When the surface area at the bottom increases, the vibration should reduce and the lower back will have more comfort. The fatigue and stress levels will decrease in the lumbar part. Hence, the motorcyclist will feel a significant difference and would be able to ride the motorcycle with increased safety and higher comfort.

Another finding based on this study, a backrest which supports the lumbar part of the motorcyclist as well as the passenger is crucial for long journey riding. Most small motorcycle does not have a backrest; this can lead to variable postures for the motorcyclist. Motorcyclist will be naturally inclined to find the best posture to get the best comfort. Without a back rest, the motorcyclist will eventually experience fatigue and tiredness and would also feel muscle discomfort around the lumbar part. Thus, the new designs must come with a back rest to support this crucial part, which is the lumbar area. This should help to greatly reduce the back pains or back discomforts being faced by motorcyclist. They would be able to ride longer journeys without having to feel the pain around the lumbar part.

Based on the feedback received, "Seat design B" was selected due to the reason that both passenger and rider would experience heightened comfort by having a back rest as a support mechanism. They stated that rider and passenger would be able to rest their backs while riding over long periods of travelling. This finding also supports past studies by [10] which claimed that seat with lumbar support is beneficial in reducing tensions in back muscle groups, buttocks and legs resulting from prolonged sitting activities. They also stated that Seat Design B should give more comfort to the passenger and rider and many respondents had chosen design B because it is deemed being more suitable for longer journeys. This statement satisfies claims by previous studies that had been undertaken. [9,13] which stated that by applying lumbar support it will reduce levels of discomfort for motorcyclist during a riding period. This shields rider and passenger from feelings of numbness or discomfort of their backs. The rider and passenger would also be able to maintain a good posture while riding. In addition to that, they stated that as the back rest is portable, it provides convenience to the user to either use or have it removed when not needed. The respondent also stated that Seat Design B has an increased comfort and provides better support.

CONCLUSION

There are many justifications in believing the objectives had been met. The reasons can be appropriated from the results of the data collection. Based on the research findings and using survey questionnaires, it can be concluded

that motorcyclist nowadays is suffering back pains and discomforts during motorcycle rides. Motorcyclist suffers pain at particular areas such as the lumbar part and around the buttocks area. Current seat built also needs an improvement in order to provide good comfortability to the user for shorter journeys as well as for longer planned journeys.

Based on the research findings, it can be concluded that by introducing a lumbar support or a back rest, it should provide a protective mechanism in which the seat enables for good posture positioning of the lower back bone to the motorcyclist. By applying a back rest and by having this support, back pains will decrease due to a lesser vibrational transfer towards the lumbar area. Another advantage, an ideal riding posture for the motorcyclist is best supported here and is capable in providing a perfect posture as well as enhancing the comfortability for a motorcyclist during the riding process. Also, by increasing the surface area around the buttock should increase higher comfort to the motorcyclist during all rides. This happens because by increasing the surface size at the buttock area, the seat in turn reduces vibrational impact flows to the lumbar area, in which back pain or lower back pain should decrease. Hence, this increases comfortability of those seats when being heavily utilized by the motorcyclist.

A majority of respondents choose Seat Design B because they deemed that not only the rider but the passenger too desires the advantages of having a back rest. A back rest is crucial for the passenger and the rider for short journey riding and especially so for longer journeys. Respondents also stated that by adding a back rest to the motorcycle seat, a good posture would be maintained and this will ensure the body having the ability to feel higher comfortability during rides. Nevertheless, it is recommended that further research on enhanced seat designs should be done, towards ensuring an optimum level of comfort is achievable for motorcyclist. Future seat designs should have the ability to offer a more pleasant comfort and satisfaction level. So, it is imperative that vehicle manufactures proceed to develop more innovative seat designs that caters to the interest of users and buyers. By doing this, Malaysian motorcyclist can reap substantiated benefits from these seating designs and should enjoy lesser or minimum vibrational transfers to their lumbar area during their rides on Malaysian roads.

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COMPETING INTERESTS

There is no conflict of interest.

REFERENCES

1. M, Dileep & S Govindarajo, Normala & Ismail, Noor Azizi. Instrument-Ergonomic Issues (IEI) Integrating Mixed Mode of Research in Instrument Construction. *Man in India*. (2014), 94. 52-72.
2. Ebe K, Griffin MJ. Quantitative prediction of overall seat discomfort. *Ergonomics*. 2000; 43(6):791-806.
3. Karuppiah, K., Salit, M. S., Ismail, M. Y., Ismail, N., & Tamrin, S. B. M. Evaluation of Motorcyclist's Discomfort during Prolonged Riding Process with and without Lumbar Support. *Anais Da Academia Brasileira de Ciencias*, (2012). 84(4), 1169-1188.
4. Khamis, N. K., Deros, B. M., & Nuawi, M. Z. Understanding The Effect of Discomfort Level Towards Motorcycle Riders Among Teenagers: A Preliminary Study. *Applied Mechanics and Materials*, (2014), 663: 480-484.
5. Law, T. H., Umar, R. S. R., Zulkaurnain, S., & Kulanthayan, S. Impact of the effect of economic crisis and the targeted motorcycle safety programme on motorcycle-related accidents, injuries and fatalities in Malaysia. *International Journal of Injury Control and Safety Promotion*, (2015), 12(1), 9-21.
6. Mathurkar, S. R. Design of Test Rig For Motorcycle Seat For Human Comfort, (2016) 891-898.
7. Kyung, Gyouhyung, Nussbaum, Maury A, & BabskiReeves, Kari. Driver Sitting Comfort and Discomfort (Part I): Use of Subjective Ratings In Discriminating Car Seats And Correspondence Among Ratings. *International Journal of Industrial Ergonomics*. (2008), 38(5): 516-525.
8. Behm, D. G., Anderson, K., & Curnew, R. S. Muscle force and activation under stable and unstable conditions. *The Journal of Strength and Conditioning Research*, (2002),16(3), 416-422.
9. Shafiei, U. K. M., Karuppiah, K., Tmrin, S. B. M., Meng, G. Y., Rasdi, I., & Alias, A. N. The effectiveness of new model of motorcycle seat with built-in lumbar support. *Jurnal Teknologi*, 77(27), (2015), 97-103.
10. Ng., D., Cassar, T., & Gross, C. M. Evaluation of an Intelligent Seat System. *Applied Ergonomics*. (1995) 26(2): 109116.
11. Na, S., Lim, S., Choi H, S. & Chung, K. Evaluation of driver's discomfort and postural change using dynamic body pressure distribution. *International Journal of Industrial Ergonomics* (2005),35:1085-1096.
12. K. Karmegam, M.Y. Ismail, S.M. Sapuan, N. Ismail, M.T. Shamsul Bahri, S. Shuib & P. Seetha. A Study on Motorcyclist's Riding Discomfort in Malaysia *Engineering, e-Transaction*, Vol. 4, No. 1, (June 2009), pp 39-4.
13. Mohd Hafzi, M. I., Rohayu, S., Noor Faradila, P., Wong, S. V. Prevalence and risk factors of musculoskeletal disorders of motorcyclists. (2011), *Malaysian Journal of Ergonomics*.
14. Almselati, A. S. I., Rahmat, R. A. O. K., & Jaafar, O. An Overview of Urban Transport in Malaysia. *Social Sci*. (2011) 6: 24-33.
15. Balasubramanian, V. and Jagannath, M. Detecting motorcycle rider local physical fatigue and discomfort using surface electromyography and seat interface pressure', *Transportation Research Part F: Traffic Psychology and Behaviour*, 22, (2014), pp. 150-158.
16. Shafiei, U. K. M., Karuppiah, K., Tmrin, S. B. M., Meng, G. Y., Rasdi, I., & Alias, A. N. The effectiveness of new model of motorcycle seat with built-in lumbar support. *Jurnal Teknologi*, 77(27), (2015), pp 97-103.
17. Izzat, M., Ma, N., Omar, A. R., & Mahmud, Z. Preliminary Study on the Best Working Posture for Motorcycling, *Malaysian Journal of Human Factors and Ergonomics* 2016, Vol. 1(2): 39 -47.