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THE EFFECTIVENESS OF NEW MODEL OF MOTORCYCLE SEAT WITH BUILT-IN LUMBAR SUPPORT

Umi Kalsom Mohd Shafiei[a], Karmegam Karuppiah[a*], Shamsul Bahri Mohd Tamrin[a], Goh Yong Meng[b], Irniza Rasdi[a], Ayuni Nabilah Alias[a]

[a]Department of Occupational Health and Safety, Faculty of Medicine and Health Sciences, Universiti Putra Malaysia, 43400 UPM, Serdang, Selangor, Malaysia.
[b]Department of Veterinary Pre Clinical, Faculty of Veterinary Medicine, Universiti Putra Malaysia, 43400 UPM, Serdang, Selangor, Malaysia.

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*Corresponding author
megam@upm.edu.my

Abstract

Motorcycle is getting significant attention as it is already and will be an important mode of transport in the future. However, motorcycle is a hazardous type of vehicle mode and therefore requires more efforts to enhance their safety and comfort level. As compared to car drivers, motorcyclists are more exposed to sitting hazards during the riding process. Due to increased exposures to seated postures, sitting comfort has become an important issue that demands adequate ergonomic interventions. The purpose of this study was to evaluate the effectiveness of new model of motorcycle seat with lumbar support aimed at reducing muscle discomfort among male motorcyclists. This study was conducted among male motorcyclists at University Putra Malaysia (UPM). 94 subjects were participated, with 47 subjects for each control and experimental group. Each subject was asked to sit for 2 hours on motorcycle in two different sessions. At every 15 minutes interval, subjects were required to evaluate their discomfort level on Borg's scale CR-10 questionnaire. Results in this study found that lumbar support (prototype) shows a significant effect towards certain body parts particularly on the neck, shoulder, upper back, arms and also lower back. However, there were no significant effect were found on the buttock, thigh, knee, calf and ankles. In conclusion, this new model of motorcycle seat with lumbar support can help to reduce discomfort level towards motorcyclists especially during prolonged riding process.

Keywords: Motorcycle; prolonged riding; muscle discomfort; lumbar support

Abstrak

Motosikal semakin mendapat perhatian penting dan akan menjadi satu cara pengangkutan yang penting pada masa akan datang. Walau bagaimanapun, motosikal adalah sejenis cara kenderaan yang berbahaya dan oleh itu ia memerlukan lebih banyak usaha untuk meningkatkan tahap keselamatan dan keselesaannya. Berbanding pemandu kereta, penunggang motosikal adalah lebih terdedah kepada bahaya duduk semasa proses menunggang. Disebabkan peningkatan terhadap pendedahan postur duduk, keselesaan ketika duduk telah menjadi satu isu penting yang memerlukan intervensi ergonomik yang mencukupi. Tujuan kajian ini adalah untuk menilai keberkesanan model baru tempat duduk motosikal dengan sokongan lumbar yang bertujuan untuk mengurangkan ketidakselesaan otot di kalangan penunggang motosikal lelaki. Kajian ini dijalankan di kalangan penunggang motosikal lelaki di Universiti Putra Malaysia (UPM). 94 subjek telah mengambil bahagian, dengan 47 subjek bagi setiap kumpulan kawalan dan kumpulan eksperimen. Setiap subjek telah diminta untuk duduk selama 2 jam di atas motosikal dalam dua sesi yang berbeza. Pada setiap 15 minit, subjek dikehendaki untuk menilai tahap ketidakselesaan mereka pada skala CR-10 soal selidik Borg ini. Hasil kajian ini medapati bahawa sokongan lumbar (prototaip) menunjukkan kesan yang ketara terhadap bahagian-bahagian badan yang tertentu terutamanya di leher, bahu, bahagian atas belakang, lengan dan juga di bahagian bawah belakang. Walau bagaimanapun, tidak ada kesan yang ketara ditemui pada bahagian punggung, peha, lutut, betis dan buku lali. Kesimpulannya, model baru tempat duduk motosikal dengan sokongan lumbar ini boleh membantu untuk mengurangkan tahap ketidakselesaan terhadap penunggang motosikal terutama semasa proses menunggang yang berpanjangan.

Kata kunci: Motosikal; menunggang berpanjangan; ketidakselesaan otot; sokongan lumbar

1.0 INTRODUCTION

Economic status in Malaysia has growing rapidly and most of people in Malaysia afford to have private vehicles. Due to this situation, the vehicle population in Malaysia has increased tremendously and causing extremely congested roads with all types of vehicle and passengers which travelling at different speed [1]. Nevertheless, motorcycle has become one of the main individual vehicle choices for mobility in Malaysia. Previous study done in Malaysia has found that motorcycle has becomes the best mode of transportation compared to other types of vehicles due to serious traffic congestion problem in Malaysia. It also has been mentioned that motorcycle contributes over 50% of all traffic distributions on Malaysia roads [2].

It is undeniable that motorcycle is a useful mode of transportation and the costs are relatively lower than cars but it is also a hazardous type of vehicle mode. In terms of ergonomic, motorcycle requires more effort to enhance their safety and comfort level because motorcycle does not provide comfortability towards motorcyclists during riding process [3]. Previous study also has stated that riding a motorcycle can cause fatigue due to maintain body posture and produce the required force to control the motorcycle [4]. Besides that, another study done in Malaysia found that more than 50% of male and female motorcyclists were complaining of discomfort when riding the motorcycle [3]. Thus, ergonomic intervention has to play an important role to provide sitting comfort due to increased exposures to seated postures [5].

As an effort to help reducing discomfort among motorcyclists, a study done by Karuppiah *et al.* [3] had proposed a new prototype of lumbar support to improve level of discomfort among motorcyclists. The new model of the prototype (lumbar support) is introduced to provide back support towards motorcyclists during the riding process. However, the researcher stated that the proposed design required some further field testing to enhance its capability in providing support to lumbar region during riding. Thus, this study with the permission obtained from the previous researcher, intended to evaluate the effectiveness of the new model of motorcycle seat with lumbar support aimed at reducing muscle discomfort among motorcyclists during the riding process in a trial section.

2.0 EXPERIMENTAL

2.1 Study Design

The study design employed was an experimental study. Subjects in this study were randomly assigned into two groups (experimental and control group). The subjects in experimental group received lumbar support intervention during the experimental session while the subjects in control group were not received lumbar support intervention. This study required pre and post study. Pre study was considered as a baseline data and post study was the effect of the intervention given. The differences of the outcome between pre and post studies represent the effect of lumbar support intervention.

2.2 Subjects

This study was conducted among male motorcyclists at Universiti Putra Malaysia. Among them, the selections of the respondents were based on the purposive sampling. Motorcyclist that met the inclusion criteria which were male, age between 18-35 years old, normal body mass index (BMI) of 18.5-24.9, motorcyclists for a motorcycle of 150 cc and below, have more than one year riding experience, have no history of accident or injury in the past one year and no immediate complaint of low back pain were selected in this study. For those who had inadequate sleep and taking medication prior to experiment were excluding out from this study.

2.3 Experimental Procedure

Each respondent required to attend experimental session on two different days (with a minimum three day interval between them). During the session, each respondent was asked to sit on the static motorcycle for two hours in a controlled room environment. Respondent in intervention group received pre and post interventions (with and without lumbar support) while respondents in control group received pre and post intervention without lumbar support. The simulator was played during the experimental session and the experimental situation was similar to a real ride on road although this experiment was performed in the laboratory. At 15 minute intervals, respondents were told to evaluate their discomfort level on the Borg's CR-10 questionnaire (Figure 4).

2.4 Instruments

2.4.1 Motorcycle Seats

Two types of motorcycle seat (with and without lumbar support) were used to determine the discomfort level of motorcyclists as shown in Figure 1 and Figure 2. Subjects in experimental group were used the prototype (lumbar support) during the experimental session while subjects in control group were not received the intervention. This prototype was patented in year 2013 and the patent application number is PI 2013701235.

Figure 1 Motorcycle seat with lumbar support

Figure 2 Motorcycle seat without lumbar support (prototype)

2.4.2 Borg's Scale Discomfort Ratings

An adapted Borg CR-10 scale was used to assess the degree of subjective discomfort on each body parts. The discomfort ratings were recorded throughout the experimental session with measurements taken at times 15, 30, 45, 60, 75, 90, 105 and 120 min. A rating was given for each of 10 regions of the body parts including neck, shoulder, upper back, arm and hands, low back, buttocks, thighs, knees, calf and feet. This scale produces rating ranges from 0 (nothing at all) to 10 (extremely strong) (see Figure 3 and Figure 4).

0	Nothing at all
0.5	Very, very slight (just noticeable)
1	Very slight
2	Slight (light)
3	Moderate
4	Somewhat severe
5	Severe (heavy)
6	
7	Very severe
8	
9	
10	Very, very severe

Figure 3 Borg CR-10 scale

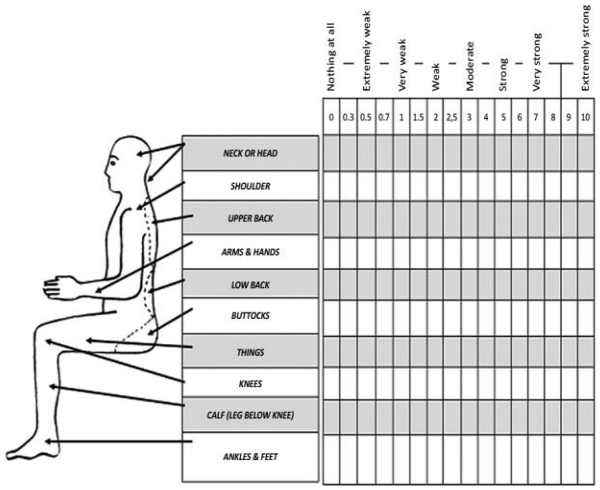

Figure 4 The body chart discomfort using Borg's CR-10 scale

3.0 RESULTS

3.1 Study Background

Table 1 shows the mean values of age and physical parameters (height, weight and BMI) of the control and experimental group.

Table 1 Descriptive statistic of subjects

Characteristics	Control group (n= 47)			Experimental group (n= 47)		
	Mean (SD)	Min	Max	Mean (SD)	Min	Max
Age (years)	23.30 (3.11)	20	33	22.80 (1.80)	21	27
Weight (kg)	63.22 (5.33)	50	76	63.19 (6.91)	48	75
Height (cm)	170.54 (6.10)	158	185	170.22 (5.46)	155	184
BMI (kg/m^2)	21.72 (1.65)	18.82	24.03	21.89 (1.67)	19.03	24.77

3.2 Discomfort Ratings on Each Body Parts

The results of Borg's scale discomfort ratings by the respondents are presented through bar graph. The graphs represent the rating of discomfort level on each of the body parts (neck, shoulder, upper back, arms, lower back, buttock, thighs, knees, calf and ankles) during 2 hours testing with and without the prototype (lumbar support) between control and experimental group. The graphs show that the respondents experience slightly discomfort on their body parts during 2 hours riding process. However, level of discomfort on each body parts among experimental group respondents were reduced after using the lumbar support prototype (based on the comparison of the bar graph in Figure 5). Neck and arms show the biggest differences in scores between control and experimental group while thigh indicates very small difference in scores compared to other body parts. Based on the results, this shows that lumbar support prototype could help reducing the discomfort level of motorcyclists on their body parts especially during prolonged riding.

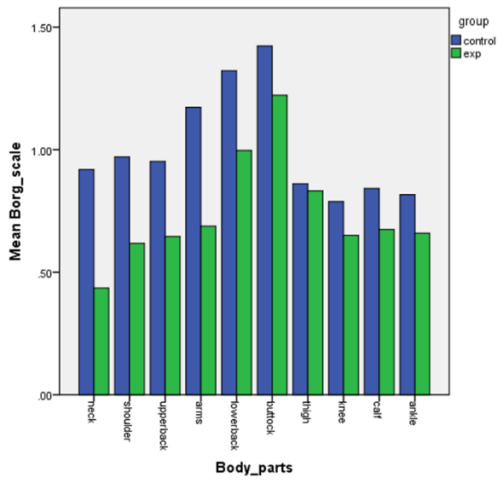

Figure 5 Borg scale discomfort ratings on each body parts for control and experimental group

3.3 Classification of Effect Size

The Cohen's effect size result show that the medium effect size was found on the neck while the other body parts only show small effect size which were below than 0.50. Effect size indicates the strength of the relationship between two variables. It can be classified as small: 0-0.2, medium: 0.5-0.7 and large: 0.8-2.0. The large effect size indicates that the lumbar support increase the comfort level towards motorcyclists. As shown in Table 2, the overall score at buttock, thigh, knee, calf and ankles did not significantly change.

Table 2 Overall score at 10 body parts

Body parts	Study Group	Mean (SD)	Effect size
Neck	Control	0.92 (1.27)	0.54
	Experimental	0.44 (0.50)	
Shoulder	Control	0.97 (1.22)	0.35
	Experimental	0.62 (0.75)	
Upper back	Control	0.95 (1.10)	0.32
	Experimental	0.65 (0.75)	
Arms	Control	1.17 (1.43)	0.43
	Experimental	0.69 (0.79)	
Lower back	Control	1.32 (1.25)	0.30
	Experimental	1.00 (0.88)	
Buttock	Control	1.42 (1.54)	0.14
	Experimental	1.22 (1.25)	
Thigh	Control	0.86 (1.07)	0.03
	Experimental	0.83 (0.93)	
Knee	Control	0.79 (1.05)	0.15
	Experimental	0.65 (0.76)	
Calf	Control	0.84 (1.11)	0.17
	Experimental	0.68 (0.77)	
Ankle	Control	0.82 (1.06)	0.09
	Experimental	0.66 (0.73)	

Note: Effect size classification; Small (0.20 to 0.50), medium (0.50 to 0.80) and large (0.80 and above).

3.4 Effect of Group on the Discomfort Ratings of Each Body Parts

A one way multivariate analysis of variance (MANOVA) was performed to investigate the effect of lumbar support in discomfort ratings on each body parts. Ten dependent variables were used: neck, shoulder, upper back, arms, lower back, buttock, thigh, knee, calf and ankles. The independent variables was group: control and experimental. Preliminary assumption testing was conducted to check for normality, linearity, univariate and multivariate outliers, homogeneity of variance-covariance matrices and multicollinearity.

The overall one-way MANOVA shows there is a statistically significant difference between control and experimental group on discomfort ratings at each body parts, Wilks' Lambda = 0.831, F (10, 741) = 15.095, $p < 0.001$. The univariate ANOVA shows there is a significant difference between control and experimental group on neck [F (1, 750) = 44.05, $p < 0.001$], shoulder [F (1, 750) = 23.45, $p < 0.001$], upper back [F (1, 750) = 17.68, $p < 0.001$], arms [F (1, 750) = 44.29, $p < 0.001$], and lower back [F (1, 750) = 19.89, $p < 0.001$] after Bonferroni correction.

Table 3 Adjusted mean and 95% confidence interval of the effect of group on the discomfort ratings of each body parts

Variables	Adjusted mean (95% CI)	F statistics (df)	P value
Neck:		44.05 (1, 750)	<0.001‡
Control	0.92 (0.82, 1.02)		
Experimental	0.44 (0.34, 0.53)		
Shoulder:		23.45 (1, 750)	<0.001‡
Control	0.97 (0.87, 1.07)		
Experimental	0.62 (0.52, 0.72)		
Upper back:		7.68 (1, 750)	<0.001‡
Control	0.95 (0.86, 1.05)		
Experimental	0.65 (0.55, 0.74)		
Arms:		44.29 (1, 750)	<0.001‡
Control	1.17 (1.06, 1.29)		
Experimental	0.69 (0.57, 0.81)		
Lower back:		19.89 (1, 750)	<0.001‡
Control	1.32 (1.21, 1.43)		
Experimental	1.00 (0.89, 1.11)		
Buttock:		7.56 (1, 750)	0.050
Control	1.42 (1.28, 1.57)		
Experimental	1.22 (1.08, 1.37)		
Thigh:		0.15 (1, 750)	0.697
Control	0.86 (0.76, 0.96)		
Experimental	0.83 (0.73, 0.93)		
Knee:		3.55 (1, 750)	0.040
Control	0.79 (0.70, 0.88)		
Experimental	0.65 (0.56, 0.74)		
Calf:		5.24 (1, 750)	0.017
Control	0.84 (0.75, 0.94)		
Experimental	0.68 (0.58, 0.77)		
Ankle:		4.68 (1, 750)	0.018
Control	0.82 (0.73, 0.91)		
Experimental	0.66 (0.57, 0.75)		

‡ $p < 0.005$ (Bonferroni correction)

4.0 DISCUSSION

Prolonged motorcycle riding have previously been identified as a potential source of motorcyclists' discomfort due to reasons of improper structural motorcycle design, imbalance of engine inertial and also due to road excitation [6]. It is also supported by Walker, Stanton & Young [7], which claimed that motorcyclist will dangerously affected with direct exposure from environment, noise and vibration.

Also, they are not only exposed to road accident but they might be exposed to other kinds of hazard such as whole-body vibrations (WBV), physical load and stress. All these hazards can have an adverse effect on their musculoskeletal system [8]. As we all know, riding a motorcycle is far more physically and mentally demanding rather than driving a car butonly a few studies are aware to explore about motorcyclists' discomfort.

A new prototype of lumbar support has been introduced in order to improve level of discomfort among motorcyclists. The proposed design is intended to provide back support for the motorcyclists during the process of riding. Thus, in this study, the effectiveness of new model of motorcycle seat with lumbar support was explored by examining the discomfort ratings on each body parts (neck, shoulder, upper back, arms, lower back, buttock, thigh, knees, calf and ankles) of the motorcyclists.

Generally, the trends of Borg's scale discomfort rating in bar graph (Figure 5) showed that motorcyclists in experimental group (lumbar support intervention) experienced a great reduction in their discomfort level during 2 hours riding process compared to control group. This indicates that lumbar support did provide a positive effect on comfort towards motorcyclist's body parts. This finding was consistent with findings of past studies by Ng *et al.* [9] which claimed that seat with lumbar support is beneficial in reducing tensions in backmuscle groups, buttocks and legs resulting from prolonged sitting activities.

Nevertheless, according to Cohen's effect size, this present study found that only medium effect size was seen on the neck region while other body parts show a small effect sizes. Here it can be said that, even small changes of discomfort ratings on each body parts was found but it may be beneficial in the long run. Besides that, this lumbar support prototype also show a significant effect towards certain body parts particularly on the neck, shoulder, upper back, arms and also lower back. However, there were no significant effect were found on the buttock, thigh, knee, calf and ankles. It is possible that the effect of the lumbar support may be greater on upper body muscles compared to lower body muscle. Previous research also has shown that lumbar support provided the utmost effects on low back and upper back body parts in both male and female motorcyclists [3]. Hence, this study suggests that by introducing this lumbar support prototype, it may help to reduce muscle discomfort experienced by motorcyclists during process of riding.

5.0 CONCLUSION

This study was carried out to determine the effectiveness of using a lumbar support in reducing motorcyclists' riding discomfort on their each body part. Based on the findings in the present study, it can be concluded that the application of lumbar support towards motorcyclists might help them reducing the discomfort level and preventing them from muscle fatigue during prolonged riding process. Thus, with the usage of lumbar support, the comfortability level of motorcyclists will be improved as well.

Based on the findings of this study, it is recommended that further research might investigate the observed difference in terms of subjective and objective measurements between male and female motorcyclists. There is little or none of the previous studies deal with subjective measurement correlated with objective results, especially in the evaluation of muscle discomfort among motorcyclists. Future research also should be concentrating on improving the lumbar support design because there is some limitation with the current design that need to be improved from time to time in order to provide comfortability at the optimum level.

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References

[1] Almselati, A. S. I., Rahmat, R. A. O. K., & Jaafar, O. 2011. An Overview Of Urban Transport In Malaysia. *Social Sci.* 6: 24-33.

[2] Law, T. H., Radin Umar, R. S., Zulkaurnain, S., & Kulanthayan, S. 2005. 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*. 12(1): 9-21.

[3] Karuppiah, K., Salit, M. S., Ismail, M. Y., Ismail, N., &Tamrin, S. 2012. Evaluation Of Motorcyclist's Discomfort During Prolonged Riding Process With And Without Lumbar Support. *Anais da Academia Brasileira de Ciências*. 84(4): 1169-1188.

[4] Velagapudi, S. P., Balasubramanian, V., Babu, R., & Mangaraju, V. 2010. *Muscle fatigue due to motorcycle riding (No. 2010-32-0100)*. SAE Technical Paper.

[5] Kyung, Gyouhyung, Nussbaum, Maury A, & Babski-Reeves, Kari. 2008. Driver Sitting Comfort And Discomfort (Part I): Use Of Subjective Ratings In Discriminating Car Seats And Correspondence Among Ratings. *International Journal of Industrial Ergonomics.* 38(5): 516-525.

[6] Khamis, N. K., Deros, B. M., & Nuawi, M. Z. November 2014. Understanding The Effect Of Discomfort Level Towards Motorcycle Riders Among Teenagers: A Preliminary Study. *Applied Mechanics and Materials* 663: 480-484.
[7] Walker, G. H., Stanton, N. A., & Young, M. S. 2006. The Ironies Of Vehicle Feedback In Car Design. *Ergonomics.* 49(2): 161-179.
[8] Behm, D. G., Anderson, K., & Curnew, R. S. 2002. Muscle Force And Activation Under Stable And Unstable Conditions. *The Journal of Strength & Conditioning Research*. 16(3): 416-422.
[9] Ng., D., Cassar, T., & Gross, C. M. 1995. Evaluation Of An Intelligent Seat System. *Applied Ergonomics*. 26(2): 109-116