ORIGINAL ARTICLE

PRELIMINARY STUDY ON THE BEST WORKING POSTURE FOR MOTORCYCLING

[1] Muhammad Izzat Nor MA'AROF, [2]Abdul Rahman OMAR, [2]Zamalia MAHMUD, [3]Nasir SENIN

[1]Mechanical Engineering Department, Faculty of Engineering and Quantity Surveying, INTI International University, Persiaran Perdana BBN, Putra Nilai, 71800 Nilai, Negeri Sembilan, Malaysia
[2]Motorcycle Engineering Test Lab (METAL) of the Faculty of Mechanical Engineering, UniversitiTeknologi MARA, 40450 Shah Alam, Selangor, Malaysia
[3]Mechanical and Human Factor Department (MHFD), MIMOS Berhad, Technology Park Malaysia, Bukit Jalil 57000 Kuala Lumpur, Malaysia

ABSTRACT

Motorcycle riding posture has generally been documented to be ergonomically unfitting for human. This is because the human operator is mostly seated at static with minimal sitting support and without a backrest. Thus, it is emphasized that there is a link between motorcycling riding posture (motorcycle ergonomics) with motorcycle road accidents. The objective of this study was to identify the best riding posture for motorcycling based on a survey study. The significance of this study was to investigate the public perception on the best motorcycling riding posture. A survey research with 30 healthy motorcyclists (between the ages of 18 – 25 years old) from diverse backgrounds via questionnaire was conducted. The data was analyzed via the Statistical Package Service and Solution (SPSS) with the statistic for level of confidence at 95% (1.96), expected proportion (in proportion of one) at 0.5 and the precision (in proportion of one) at 0.1 (due to the limitation of resources). For greater grasp of understanding in regards to the results obtained, veteran motorcyclists (above 14 years of riding experience) were also consulted. The results summarized that the best riding posture for motorcycling is the upright riding posture. From the consultation, it was detailed that the particular riding posture was most probably selected due to the following reasons: i) being the most versatile/flexible riding posture, ii) capable of providing an acceptable level of motorcycling comfort, iii) propose minimal level of physical hazard. Even so, the results also highlighted by the consultants that other factors such as modes of travelling and riding styles would also influence in determining the best riding posture. Conclusively, based on the survey, the upright riding posture is the best riding posture. Nevertheless, the result is only limited to physical and psychological (perceptions) evaluations without examining the riding postures from the physiological perspective such as via the use of sEMG measurement.

Keywords: Motorcycle Ergonomics, Riding Posture, Working Posture

INTRODUCTION

Motorcycle is one of the mostly utilized two-wheeled vehicle in the Southeast Asian region. However, the riding posture has generally been documented to be ergonomically unfitting for human. This is because the human operator is mostly seated at static with minimal sitting support and without a backrest. Thus, it is emphasized that there is a link between motorcycling riding posture (motorcycle ergonomics) with motorcycle road accidents. What is the best sitting posture for human? Is the best sitting posture being characterized with reference to the shape of the spine? Or is it based on comfort? The objective of this study was to identify the best riding posture for motorcycling based on a survey study. This study was just a preliminary in exploring the ergonomics matters related to motorcycling riding posture. The result from this preliminary study will provide the information and serves as the fundamental in determining the optimal riding posture for motorcycling.

LITERATURE REVIEW

Experts have been in continuous debates on defining and determining the characteristics of the best sitting posture (O'Sullivan et al., 2012 and 2010; Openshaw and Taylor, 2006). From the ergonomics standpoint, the motorcycling working posture – or the riding posture, could be treated as a sitting posture. It is characterized as a sitting posture where the human operator is seated on a sitting platform with no full-backrest and the hands and feet are supported. Indeed, the motorcycling riding posture is similar to bicycling. Nevertheless, the working duties of a

motorcyclist are indeed slightly differ than a bicyclist in term of complexity. In general, a motorcyclist has to operate a more complex system of controls such as the throttle, brake and gear levers – among others. In addition, the human operator has to effectively, efficiently and safely manoeuvre and control the motorcycle with the used of synchronized fluid body motion (Ma'arof et al., 2012).

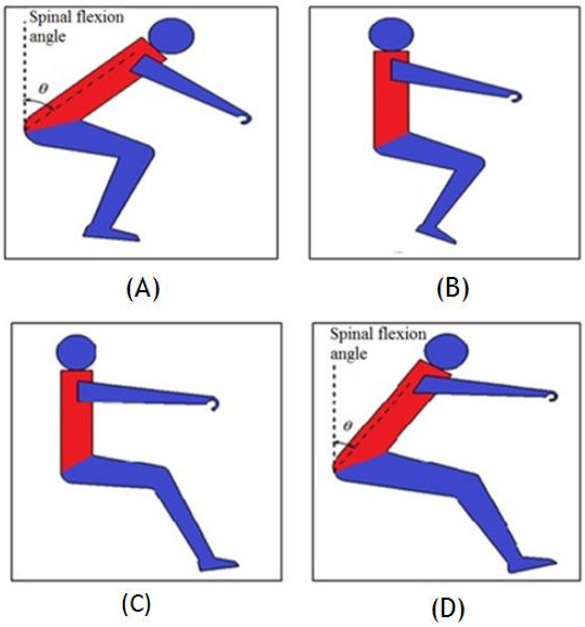


Figure 1. The four motorcycling riding postures (Ma'arof and Ahmad, 2012)

In their study, Ma'arof and Ahmad (2012) introduced the "Riding Posture Classification" system or the "RIPOC" system which classify motorcycle (irrespective of design and levels of performances) with respect to how the human operator would be seated on the motorcycle. According to the study, a riding posture is established when the human operator satisfies the riding posture establishment conditions. Ma'arof and Ahmad (2012) had designated 4 types of riding postures for motorcycling with each riding posture being distinctive to one another with respect to the trunk flexion angles and feet positioning characteristics. The riding postures designated by the "RIPOC" system are:

i. "RIPOC Type 1: Forward Lean Riding Posture" (coded as "A" for this study), the motorcyclist practices more than 20 degree of spinal flexion with both feet allocated underneath the knees.
ii. "RIPOC Type 2: Upright Riding Posture" (coded as "B" for this study) the motorcyclist practices less than 20 degree of spinal flexion with both feet allocated underneath the knees.
iii. "RIPOC Type 3: Seatback-Leg-Forward Riding posture" (coded as "C" for this study), the motorcyclist practices less than 20 degree of spinal flexion with both feet allocated ahead the knees.
iv. "RIPOC Type 4: Double Forward Riding posture" (coded as "D" for this study), the motorcyclist practices more than 20 degree of spinal flexion with both feet allocated ahead the knees.

Figure 1 shows the illustration of the riding postures introduced by Ma'arof and Ahmad (2012). Indeed, a motorcycle is a "unique" workstation on its own from view point of ergonomics as noted by Robertson and Minter (1996). However, this "unique" characteristic is more driven towards the negative side of ergonomics. Generally, motorcycles are built with the 'one size fits all' principle. Therefore, it is very difficult to accommodate the human operator who comes in different anthropometric characteristics (Stedmon, 2010). In addition, Robertson and Minter (1996) also noted that motorcycle is a "constrained" workstation where minimal adjustment could be made to aid in 'fitting' the workstation to the human operator. The main problem with motorcycling is that the working postures are "constrained, cramped, static and poor", and is therefore, 'unfitting' for a human operator (Ma'arof et al., 2012). Even so, the number of global human operators that used motorcycle as an alternative mode of transportation is increasing annually.

Motorcycle is one of the main alternatives to the four-wheeled road legal in the Asian region. Motorcycles are widely used in the congested cities of Kuala Lumpur, Taiwan, Bangkok and Jakarta. This is mostly due to its ease of usage in heavy traffic and even in the countryside (Chen and Chen, 2011). This study found that motorcycle is exceedingly celebrated most prominently since it is economically inexpensive and further coupled with its characteristics in being highly efficient in term of its mobility and convenience (Lin et al., 2008). The market and demand on motorcycle in the Asian region is predicted to blossom and new markets would mushroom as result from the global petroleum crisis (Young, 2013 and Shell.com, 2013). As of the year 2011, as much as 9,985,308 motorcycles were officially registered in Malaysia (Ministry of Transport, 2011) and based from this study's observation, the number has increased tremendously. However, the statistics of

motorcycle usage is parallel to the statistics of the motorcycle road accidents.

The International Traffic Safety Data and Analysis (2013) reported that from the year 2003 to 2011, Malaysia has shown an increment of motorcycle road accidents from 56% to 61%. The World Health Organization documented that other Asian region such as Thailand, Cambodia, Singapore and Indonesia have respectively reported 74%, 67%, 46%, and 36% percentage of fatal road accidents involving 2- and 3-wheeled vehicles. In short, the statistics are alarming. Henceforth, it could be concluded that the number of human operators at risk are high. With the annual increment of motorcycle road accidents, it raises questions such as whether motorcycle ergonomics is also a daunting contributor to such incident. Consequently, this study aims to identify the best riding posture for motorcycling via a survey research.

METHODS

The following research methodology was conducted:

Mode of study

This study performed a descriptive survey study via questionnaire data collection method with the objective to identify the best riding posture for motorcycling. The respondents were given bilingual questionnaires (English and "Bahasa Melayu").

The main research questions were as follow:

i. Which of the four riding posture is the best riding posture for motorcycling?
ii. Is the most comfortable riding posture is the best riding posture?
iii. Which of the four riding posture is the most uncomfortable riding posture?

Study location

The study was performed at the Faculty of Mechanical Engineering, UniversitiTeknologi MARA, Shah Alam, Selangor, Malaysia. The study was approved by the Ethics Committee of the Research Management Institute of the Universiti Teknologi MARA, Shah Alam, Selangor, Malaysia.

Subjects

The subjects comprising of male undergraduate students who fulfilled the inclusive criteria participated in this study. All 120 subjects volunteered to join. The subjects were briefed on the nature (but not the real research questions) and answering method of the questionnaire study. Prior to participating in the survey study, each subject was asked to fill a consent form. The subjects were informed that they could withdraw at any time and their participation will be kept confidential.

The inclusion criteria for the survey study are as follow:

i. Subjects are male student with more than 1 year motorcycling experience (motorcycle of any engine capacity). The main item here is the subject's experience. The motorcycle is only the workstation for the work to commence.
ii. Age between 18 – 25 years old.
iii. The respondents have no history of accident or physical trauma in the past one year.

Study variables

There were several variables in this study. The list is as follow:

Table 1: The independent and Dependent Variable(s) of this study

Independent variable	Dependent variables
Respondents' individual perception on motorcycling comfort and experience	The most comfortable riding posture
	The most uncomfortable riding posture
	Preferred type of riding posture
	The characteristics of the best riding posture

Pilot test

Prior to the survey study, a pilot study was performed with 30 subjects from the Faculty of Mechanical Engineering, Universiti Teknologi MARA, Shah Alam, Selangor, Malaysia. The subjects consist of undergraduate students, lecturer and a Professor. The average time to

complete the questionnaire was 4 minutes. Necessary amendments were made on the questionnaire after each pilot test based on the samples' feedbacks. In addition, discussion sessions with the subjects were also conducted to further improve the questionnaire.

Data Collection Instrument: Questionnaire Design and Likert's Scale Management

The questionnaire was developed based on the study by Basri et al., (2013), Karmegam et al., (2012), Kong et al., (2012) and Mehta and Tewari (2000). The questionnaire was divided into 2 sections which has a total of 10 questions. The detail on the question is given in Table 2.

Table 2: Details on questionnaire

Section	Details	Types of questions
A	Demographic details	All multiple response items (Total 4Qs)
B	Motorcycling details	All multiple response items (Total 6Qs)

Data Collection Procedure

The selected group of respondents was gathered together in a conducive laboratory at the Faculty of Mechanical Engineering, UniversitiTeknologi MARA, Shah Alam, Selangor, Malaysia. The respondents were given some briefing on the nature of the study. The data was collected in situ once the briefing has ended.

Data Analysis

The data was analyzed via the Statistical Package Service and Solution (SPSS) with the statistic for level of confidence at 95% (1.96), expected proportion (in proportion of one) at 0.5 and the precision (in proportion of one) at 0.1 (due to the limitation of resources).

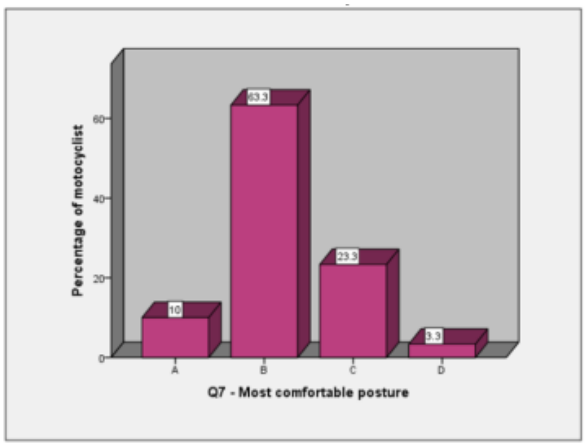
RESULT

The following are the result of the descriptive analysis of motorcyclist posture based on the survey research. Table 3 shows the median value for the demographic details.

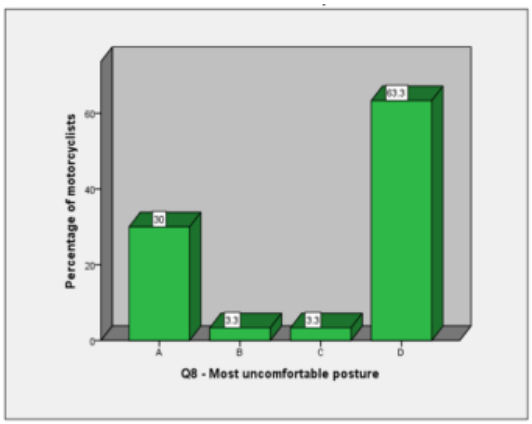
Table 3: Median values for demographic details

Questions	Median value (based on calculation)
Age	18.4 years
Height	163.3 cm
Weight	61.6 kg
Riding experience	5.8 years
Frequency of motorcycling per week	4.5 days
Total average riding duration per day	31.4 minutes

From the survey study, the majority of the respondents were between 18-20 years old. About 50% of the motorcyclists have a riding experience between 4-6 years followed by 30% between 7-9 years. Also, a majority of the motorcyclists (90%) have heights of between 161cm and 180cm. About 40% motorcyclists are in the range of weight between 51-60 kg. A slightly higher percentage (46.7%) of motorcyclists is in the range of weight between 61-80 kg. Finally, the average riding duration per day by majority of motorcyclists was between 31-60 minutes. The data collected and analyzed is tabulated in Table 4 and displayed in Figure 2 and Figure 3.

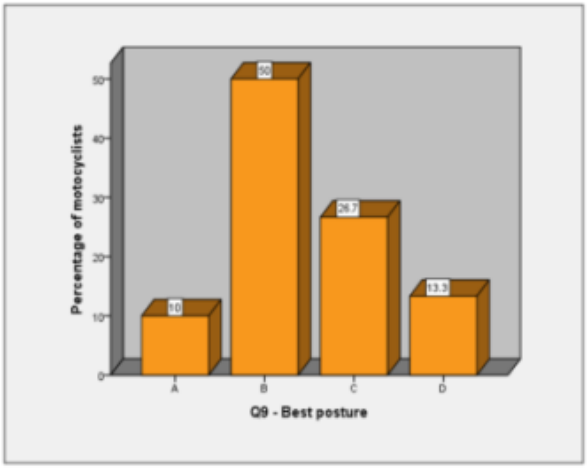


(a)

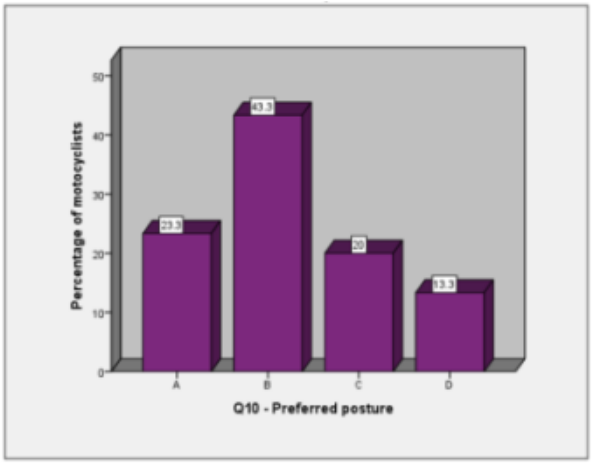


(b)

Figure 2. (a) Percentage of the 'most comfortable', and (b) the 'most uncomfortable' riding posture based on the survey study



(a)



(b)

Figure 3. (a) Percentage of the 'best posture', and (b) the 'preferred posture' based on the survey study

Figure 2 and 3 shows the results of the analysis of the percentage of the 'most comfortable'/ 'most uncomfortable' riding posture based on the survey study and the percentage of the 'best posture' and the 'preferred posture' based on the survey study respectively. Figure 2(a) shows that at 63.3%, the majority of the respondents indicated that posture B as the most comfortable riding posture. The second most selected was riding posture C at 23.33%, followed by A and D with both at 10% and 3.333% respectively. In short, riding posture B was unanimously voted as the most comfortable riding posture.

Next, in referring to Figure 2(b), at 63.3% it was indicated that riding posture D as the most uncomfortable riding posture as shown in. A close second for this category was riding posture A at 30%, while both riding posture C and D were at 3.333%. Based on this result, it was clearly evidence that riding posture D is voted as the most uncomfortable riding posture.

With respect to Figure 3(a), at 50% majority, riding posture B was also selected as the best riding posture for real world motorcycling. Nevertheless, riding posture C at 26.667% was voted second, then followed by riding posture A and D with 10% and 13.333% respectively. Thus, riding posture B was clearly selected by the respondent as the best riding posture for real world motorcycling.

Finally, from Figure 3(b), it was indicated that at 43.333% majority, the respondents selected riding posture B as the preferred riding posture for motorcycling. Riding posture A came in second at 23.333%, before closely followed by riding posture C at 23% and finally, riding posture D at only 13.333%. Therefore, from the survey, riding B was unanimously voted as the most comfortable, the best riding posture for real world motorcycling and also the most preferred riding posture for motorcycling. It should be highlighted that a riding posture could be noted as 'the best', yet, it does not mean that it is preferred to be practice since the riding posture could be uncomfortable. For example, the riding posture A is the best or ideal for travelling at high velocity, yet, it is not preferred much for other modes of travelling since it presented certain degree of physical stress to the motorcyclist. Nevertheless, being preferred could covers simultaneously for both being ideal and favoured to be practiced; which in this case showed that riding posture B was noted as such.

DISCUSSION

The objective of this study was to identify the best riding posture for motorcycling from a survey research. The data was analyzed via the

Statistical Package Service and Solution (SPSS) with the statistic for level of confidence at 95% (1.96), expected proportion (in proportion of one) at 0.5 and the precision (in proportion of one) at 0.1 (due to the limitation of resources). In addition, veteran motorcyclists (above 14 years of riding experience) were also consulted for greater grasp of understanding in regards to the results obtained.

Based on the survey, it was evidence that the best riding posture for motorcycling is the riding posture B i.e. the upright riding posture – or "Type 2" based on the RIPOC System. Upon consulting the experts, critical analysis was made on the result. It was anonymous that with respect to how the human operator is positioned on the motorcycle during real time motorcycling, it came to no surprise that this particular posture was selected. From the consultation, it was agreed by the experts that: i) the upright riding posture has the highest level of versatility in term of real world motorcycling, ii) the upright riding posture provides acceptable level of motorcycling comfort to the motorcyclist, iii) upon practicing, controlling and holding the upright riding posture, the motorcyclist is experiencing minimal levels of physically and physiologically hazards.

Firstly, the upright riding posture shows the highest level of versatility in term of real world motorcycling because the riding posture provides the flexibility to deal with various real world motorcycling conditions such as commuting in congested cities/urban areas and long distance motorcycling. The particular postures provide the motorcyclist with the capacity of having a good physical range of motions (e.g. spinal flexion and extension) and the flexibility in varying the upper body limbs variables (e.g. elbow flexion and extension). Since the motorcyclist is seated upright, this posture allows for the arms and shoulders to be free from significant static loading provided by the upper body mass. Therefore, the elbows could be flexed or extended with much ease. This would ultimately grant the upper body limbs higher level of mobility to efficiently, effectively and safely perform the necessary motorcycling duties such as steering through small moving spaces. Adding to this, the upright riding posture also provided the motorcyclist with good neck and head positioning. This helps to ensure that the motorcyclist's head and neck are aligned with the spinal column. Therefore, no stress is placed on the upper trapezius muscles during motorcycling. Hence, the motorcyclist has adequate line of vision without the need for neck extension. Adding to this, with the upright riding posture could also be varied by the motorcyclist if the situation arises. For instances during off-road motorcycling, the motorcyclist could stand-up on the foot-pegs to manoeuvre through difficult terrain such as mud, dirt and scrubs. The versatility criteria given by the upright riding posture are advantageous for manoeuvring the motorcycle in wide ranges of roads and traffic conditions, be it on-road or off-roads.

Secondly, the upright riding posture also provides acceptable level of motorcycling comfort for the motorcyclist. This study noted it as 'acceptable comfort level' because the riding posture is still a seated posture without the availability of sufficient backrest. Therefore, it could not provide the needed spinal support for a comfortable sitting. Even so, the upright riding posture could still provide the motorcyclist with the capability to maintain the natural shape of the spine. This is a very important aspect to achieve comfortable sitting (O'Sullivan et al., 2012 and 2010; Berry, 2009; Openshaw and Taylor, 2006; Dul and Weerdmesster, 2003). Therefore, a working posture such as the upright riding posture aids in ensuring the motorcyclist to keep a healthy working posture (Health and Safety Executive, 2013; Bosch Rexroth AG, 2012; Travail Sècuritaire, 2011; Ergonomics Guideline for Manual Handling, 2010). This is also closely associated with the final criteria, where upon practicing, controlling and holding the upright riding posture.

Finally, in regards to practicing, controlling and holding the upright riding posture the motorcyclist is experiencing minimal physically and physiologically hazards. By keeping the riding posture as close as possible to the natural shape of the human physical system; the motorcyclist is experiencing only minimal physical and physiological hazards such as various episodes of musculoskeletal disorders. Examples of the minimally experienced or minimally avoided musculoskeletal disorders are the ulnar artery aneurism and thoracic outlet syndrome.

Nevertheless, although the arguments aids in enlightening that the upright riding posture in a positive shade, this study would like to stress that over time, the upright riding posture would still causes various forms of discomforts (not limited to physical and physiological discomforts) to the motorcyclist. In holding and controlling

the upright riding posture, although not on the arms and wrists, the motorcyclist will still experience certain amount of static loading (originating from the upper body mass) to the spinal column (Rohlmann et al., 2011 and 2001). Since the spinal column is perpendicular with respect to the sitting surface, upper mass would be radiating through the spinal column before going down the pelvis and buttocks. In addition, in keeping the spinal column erected and maintaining the natural shape of the spine, the motorcyclist is needed to exert certain degree of muscular activation (Mörl and Bradl, 2012; O'Sullivan et al., 2012; Caneiro et al., 2010; Masani et al., 2009; Corlett, 2008). This would eventually result in physical discomforts and even spinal injuries and/or disorders to the motorcyclist such as spinal shrinkage, high disc pressure and disc degeneration (Kingma et al., 2009; Claus et al., 2008; van Deursen et al., 2000; and Magnusson and Pope, 1998) if motorcycling is performed in prolonged continuous session. Even so, the argument is that no working posture shall be maintained in prolonged session. Varying the working posture through time is important as noted in various studies such as Peeters et al., (2013), O'Sullivan et al., (2012), Rohlmann et al., (2011) and Seidel et al., (2011).

Moreover, this study also wanted to note that Stedmon (2010) have highlighted that other factors such as modes of travelling (example: cruising, speeding) and riding styles (example: aggressive riding, leisure riding) would play significant roles among motorcyclists in determining and selecting the best riding posture for motorcycling. The study further added that the types of motorcycle and the anthropometric characteristics of the motorcyclist would also determine the individual preferred type of riding posture. Also, the result of this study was only within the scope and limitation of this study – such as the research method and the population size selected. The selection of the best riding posture for this study was made with respect to the perception made by the public.

CONCLUSION

Conclusively, based on the survey research, the upright riding posture or the "Type 2" (Ma'arof and Ahmad, 2012) is the best working posture for real world motorcycling. Upon analyzing the posture with the consultants, it was evidence that in comparison with the other riding postures, the upright riding posture was selected due to the following: i) the upright riding posture provides the motorcyclist with the highest level of upper body physical versatility and flexibility in term of real world motorcycling, ii) the upright riding posture provides acceptable level of motorcycling comfort to the motorcyclist, iii) upon practicing, controlling and holding the upright riding posture, the motorcyclist is experiencing minimal physical and physiological hazards. Even so, this study stresses that there are other factors that could lead to the selection of the best type of riding posture according to the public. These factors according to Stedmon (2010) are modes of motorcycling, types of motorcycle and also the ever apparent variations in anthropometric characteristics. In addition, motorcyclists would also tend to determine the best working posture for motorcycling based on their personal preferences and qualitative judgment. The results is only limited to physical and psychological (perceptions) evaluations without examining the riding postures from the physiological perspective such as via the use of sEMG measurement. For future survey study, perhaps, the numbers of respondent is being increased to more than 30 participants.

ACKNOWLEDGEMENT

The authors would like to acknowledge the Ministry of Education (MOE) Malaysia for funding this research through the Fundamental Research Grant Scheme (FRGS/1/2014/TK01/UITM/02/3). The authors would like to express their utmost gratitude to Muhammad Fauzi Mohd Talib, Muhammad Firdaus Azhar, Muhammad Hafizudin Kamal, Wan Muhammad Syahmi Wan Fauzi, Mohd Afham Azmi, Muhammad AdzriAdzman, the staffs of the Faculty of Mechanical Engineering and the Institute of Graduate Studies in UniversitiTeknologi MARA and the Human Factors and Ergonomics Society Malaysia who have, directly or indirectly, contributed to this research.

REFERENCES

1. Basri, B., and Griffin, M. J. (2013), "*Predicting discomfort from whole-body vibration when sitting with an inclined backrest*", Applied Ergonomics 44, pp. 423-434.

2. Berry, C., McNeely, A., Beauregard, K., Dickens, H., Geddie, J. E. (2009), "*A Guide to Ergonomics, Occupational Safety and Health Division*", NC

Department of Labor, pp. 1-26.

3. Bosch Rexroth AG, (2012), "Ergonomics Guidebook for Manual Production Systems", Bosch Rexroth AG 2012, pp. 1-16.

4. Caneiro, J. P., O'Sullivan, P., Burnett, A., Barach, A., O'Neil, D., Tveit O., and Olafsdottir, K. (2010), "*The influence of different sitting postures on head/neck posture and muscle activity*", Manual Therapy 15, 2010, pp. 54-60.

5. Chen, C. F. and Chen, C. W. (2011), "*Speeding for fun? Exploring the speeding behavior of riders of heavy motorcycles using the theory of planned behavior and psychological flow theory*", Accident Analysis and Prevention 43, pp. 983-990.

6. Claus, A., Hides, J., Moseley, G. L., Hodges, P. (2008), "*Sitting versus standing: Does the intradiscal pressure cause disc degeneration or low back pain?*", Journal of Electromyography and Kinesiology, pp. 550-558.

7. Corlett, E. N. (2008), "*Sitting is a hazard*", Safety Science, Vol. 46, pp. 815-821.

8. Daniel, WW. (1999). "*Biostatistics: A Foundation for Analysis in the Health Sciences*". 7th edition. New York: John Wiley & Sons, cited in Naing, L., Winn, T., Rusli B.N. (2006), "*Practical Issues in Calculating the Sample Size for Prevalence Studies*", Archives of Orofacial Sciences 2006; 1, pp. 9-14.

9. Dul, J. and Weerdmesster B., (2003), "*Ergonomics for Beginners A Quick Reference Guide Second Edition*", Taylor and Francis e-Library, 2003, pp.5-41.

10. Health and Safety Executive, Ergonomics and Human Factor At Work, HSE, 2013, pp. 1-3.

11. International Traffic Safety Data and Analysis. (2013), "*Road Safety Annual Report 2013*", pp. 296, 429, 441.

12. Karmegam K., Ismail, M. Y., Sapuan, S. M., Ismail, N., Shamsul Bahri, M. T. (2012), "*Evaluation of motorcyclist's discomfort during prolonged riding process with and without lumbar support*", Annals of the Brazilian Academy of Sciences, pp. 1169-1188.

13. Kingma I., and van Dieën, J. H. (2009), "*Static and dynamic postural loadings during computer work in females: sitting on an office chair versus sitting on an exercise ball*", Applied Ergonomics 40, pp. 199-205.

14. Kong, Y-K., Kim, D-M., Lee, K-S., and Jung, M-C., (2012), "*Comparison of comfort, discomfort, and continuum ratings of force levels and hand regions during gripping exertions*", Applied Ergonomics 43, pp. 283-289.

15. Ma'arof, M. I. N., Ahmad, I. N., Abdullah, N. R., Karim, S. A. (2012), "*Motorcycling Riding Issues: Understanding the Phenomenon and Development of Ergonomics Intervention in Improving Perceived Comfort for Prolonged Riding*", *iDECON*, 2012.

16. Ma'arof, M. I. N., and Ahmad, I. N. (2012), "*Proposed Standardized Method for Motorcycle Nomenclature System*", Southeast Asian Network of Ergonomics Societies Conference (SEANES), Road User Ergonomics, Paper 60.

17. Magnusson M. L. and Pope, M. H. (1998), "*A review of the biomechanics and epidemiology of working postures (it isn't always vibration which is to blame!)*", Journal of Sound and Vibration 215(4), 1998, pp. 965-976.

18. Masani, K., Sin, V. W., Vette, A. H., Thrasher, T. A., Kawashima, N., Morris, A., Preuss, R., Popovic, M. R. (2009), "*Postural reactions of the trunk muscles to multi-directional perturbations in sitting*", Clinical Biomechanics 24, pp. 176-182.

19. Mehta, C. R. and Tewari, V. K. (2000), "*Seating discomfort for tractor operators - a critical review*", International Journal of Industrial

Ergonomics *25*, , pp. 661-674.

20. Ministry of Transport Malaysia, (2011), "*Transport Statistic*", pp. 28.

21. Mörl F., and Bradl, I. (2012), "*Lumbar posture and muscular activity while sitting during office work*", Journal of Electromyography and Kinesiology, 2012, Article in Press.

22. O'Sullivan, K., O'Dea, P., Dankaerts, W., O'Sullivan, P., Clifford A., and O'Sullivan, L. (2010), "*Neutral lumbar spine sitting posture in pain-free subjects*", Manual Therapy *15*, pp. 557-561.

23. 'Sullivan, K., O'Sullivan, P., O'Sullivan, L., and Dankaerts, W. (2012), "*What do physiotherapists consider to be the best sitting spinal posture?*" Manual Therapy, pp. 1-6.

24. Openshaw, C., Taylor, E. (2006), "*Ergonomics and Design A Reference Guide*", Allsteel Inc., pp.15.

25. Organization, World Health. (2013) *"Global Status Report on Road Safety 2013 - Supporting A Decade of Action: World Health Organization"*.

26. Peeters, GMEE (G.), Burton, N. W., and Brown, W. J. (2013), "*Associations between sitting time and a range of symptoms in mid-age women*", Preventive Medicine 56, pp. 135-141.

27. Robertson S. A., and Minter, A. (1996), "*A study of some anthropometric characteristics of motorcycle riders*", Applied Ergonomics, Vol. 27, No. 4., pp. 223-229.

28. Rohlmann, A., Arntz, U., Graichen, F., Bergmann, G. (2001), "*Loads on an internal spinal fixation device during sitting*", Journal of Biomechanics 34, pp. 989-993.

29. Rohlmann, A., Zander, T., Graichen, F., Dreisharf, M., Bergmann, G. (2011), "*Measure loads on a vertebral body replacement during sitting*", The Spine Journal 11, pp. 870-875.

30. Sècuritaire, T. Ergonomics, (2011), "*Guidelines for Manual Material Handling 2nd Edition*", WorkSafeNB, pp. 1-18.

31. Seidel, D., Hjalmarson, J., Freitag, S., Larsson, T. J., Brayne, C., and Clarkson, J. (2011), "*Measurement of stressful postures during daily activities: an observational study with older people*", Gait and Posture 34, pp. 397-401.

32. Shell, "Shell Responds To Boom In Asian Motorcycle Market". Retrieved on 22nd August 22, 2013 from Shell Global official website: http://goo.gl/bXADNe

33. Stedmon, A. (2010), "*HMI: Human-motorcycle interaction*", Centre for Motorcycle Ergonomics & Rider Human Factors, Department of Mechanical, Materials, Manufacturing Engineering (M3), University of Nottingham, pp. 1-18

34. van Deursen, D. L., Goossens, R. H. M., Evers, J. J. M., van der Helm, F. C. T. (2000), "*Length of the spine while sitting on a new concept for an office chair*", Applied Ergonomics 31, pp. 95-98.

35. Young, E. (2013), "Petrol Price: Why are they rising?" Retrieved on 22nd August 22, 2013 from BBC News Official Website: http://www.bbc.co.uk/news/business-21547684.