Current Journal of Applied Science and Technology

Volume 42, Issue 5, Page 12-18, 2023; Article no.CJAST.96596
ISSN: 2457-1024
(Past name: British Journal of Applied Science & Technology, Past ISSN: 2231-0843, NLM ID: 101664541)

Rapid Upper Limb Assessment among Malaysian Multi-Purpose Vehicle's Driver

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/CJAST/2023/v42i54067

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/96596

Original Research Article

Received: 17/12/2022
Accepted: 22/02/2023
Published: 15/03/2023

ABSTRACT

Conditions of comfort driving may be perceived differently by drivers with different physical built or gender where right sitting position plays a big element in maintaining body health. Therefore, the objective of this paper is to analyze anthropometric data of Multi-Purpose Vehicle's (MPV) driver using Rapid Upper Limb Assessment (RULA) technique. RULA was performed on various MPVs seats. The outcome of this study indicated that seating posture among the Malaysian MPVs driver are not fully fit into the MPVs driver's seat and required further investigation. This outcome suggested for further advanced research be conduct in the future.

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Keywords: Rapid Upper Limb Assessment (RULA); Multi-Purpose Vehicle's (MPV); anthropometrics; Musculoskeletal Disorder (MSD).

1. INTRODUCTION

Driver's seat is an important component in car manufacturing process. This is because every car driver has his / her own preferred driving position that may vary from each other. Discomfort sitting condition tend to make one to modify sitting position [1] or take timely sitting break [2]. Sitting posture and musculoskeletal disorder (MSD) are considered serious issues by researchers in wide-range of industries and activities such as agriculture [3], emergency medical surveillance [4], lifting process [5] etc. A safe and comfortable driver's seat plays a very important role in car seat design and fabrication. Today, drivers are more concerned with their driving safety and comfort, thus they perceived that comfort must have the same level of importance as with functional and aesthetic design of automobile. Therefore, ergonomically designed driver's seat is important because it could enhance drivers' safety and comfort while they are driving and controlling the car [6]. Driver's seat comfort while driving needs to be differentiated from the comfort of sitting on a chair at home, in the office or at the workplace. This shows that driver's seat comfort in car has distinctive comfort value compared to other types of seats. Driving posture discomfort can contribute to MSD problem injuries, lumbar pain, and fatigue. The MSD problem is a condition where a part of musculoskeletal system is injured over time. The disorder occurs when a body part is continually used to work hard, stretch farther, impact more directly or functions at a greater level then it is supposed not to. The MSD impact could be either acute or chronic where in both conditions could cause damage on a joint, muscle and bone. However, others area can be strained and their response to that trauma may be an injury.

In order to choose the best driver's seat, consideration of several criteria is required. These including whether it is comfortable, easy to use, and adjustability in sitting condition. An ergonomics driver's seat can be a particular seat designed to reduce stress and strain on a body while drivers sitting to control vehicle. Long trip spends a lot of time on driver's seat. This condition could cause repetitive stress disorder, an injury to a part of the body due to overusing or exerting too much stress on that body part. This repetitive stress disorder leads to MSD. Car seat comfort has a strong relationship with the postural support characteristic to the driver's. Therefore, it is important to design a car seat that can contribute towards comfort and seating adjustability. Discomfort and lower back pain are frequent complaints reported by drivers. Drivers tend to experience pain more often as it is more difficult to shift body positions while driving. Low-frequency whole-body vibration in moving cars can contribute to effects on the lower back. The shape of the vehicle seat itself may put pressure on selected parts of the legs, back, and buttocks. This contact can lead to pain or discomfort at pressure points and may affect blood flow to the legs and feet. Therefore, the objective of this research is to analyze sitting posture among Multipurpose Vehicle's (MPV) driver using Rapid Upper Limb Assessment (RULA) method. MPV is selected due to this vehicle are commonly used for long journey. This study is limited to Malaysian MPVs drivers only. It hopes that this study could alleviate the MSD among drivers.

2. METHODOLOGY

In order to achieve the objective of this research, an orderly approach was drawn. This approach including main parts of data collection and analysis. Flow chat illustrated below simplified methodology implemented in this research in order to complete research objective.

2.1 Data Collection

Total of 32 males MPVs driver in Malaysia participated in this study and this total sample size participants should be statistically accepted [7]. This minimum sample size regards to limitation of statistical anthropometrics database available at Malaysia with respect specific population [8]. Participants age ranged from 20 to 60 years old. They were healthy with no injury or experiencing cumulative trauma disorder (CDT). Dimensions in related to sitting posture were gathered. Those including stature (body height), sitting height, lower leg length (popliteal height), hips breadth buttock-popliteal length (seat depth) and sitting eye height. All dimensions performed while participants sitting on various model of MPV. Those sitting posture are as the following diagram noted 1,2,4,5,7 and 10 accordingly.

Data collected were analysed using SPSS software. Data could also be manually approximated using the following formula.

k^{th} percentile = $x \pm z\sigma$

Where:

k^{th} = Population percentile

z = Constant

$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n}$ = Mean

$\sigma = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}}$ = Standard deviation

***k*th percentile**	10 or 90	5 or 95	2.5 or 97.5	1 0r 99
***z* value**	± 1.28	± 1.64	± 1.96	± 2.33

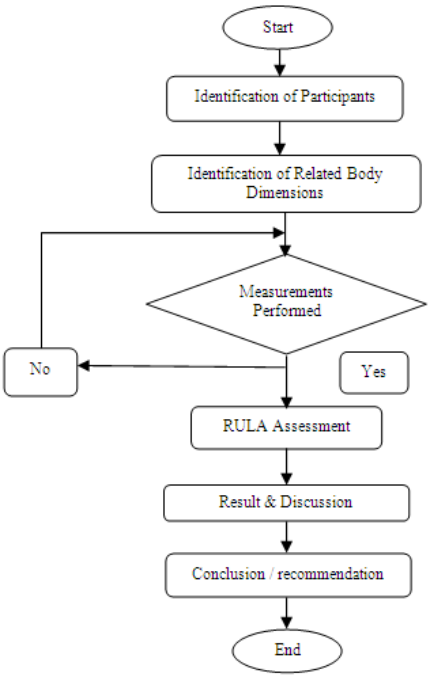

Fig. 1. Experimental flow chart

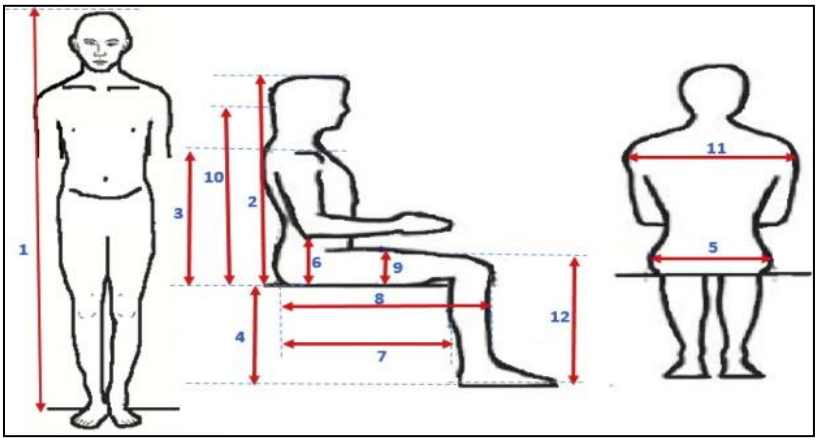

Fig. 2. Body dimensions in related to sitting posture collected .All dimensions are related to sitting posture

The percentiles values obtained by multiplied constant z value and added or subtracted accordingly to the mean / average. The above simplified formula in the form of percentile values and standard deviation are commonly applied by many researchers to categorized anthropometric data accordingly [9-12].

2.2 RULA Assessment

RULA assessment aim to identify driver's sitting position using anthropometric data. This assessment was performed using the above statistical data. RULA assessment was performed in order to identify body segments that experiencing posture related problem which need to be improved. RULA assessment performed using CATIA V5, an engineering and design leading software which capable of designing, simulating and analyzing prior to the actual products manufacture in range of industries including aerospace, automotive, consumer goods, industrial machinery and etc. where actual shape of parts designed could be assembled and viewed. CATIA V5 also capable of performing ergonomics ergonomic design & analysis. Alternatively, other relevant software such as Ergo-Fellow 2.0 by FBF SISTEMAS could also perform RULA [13]. Steps of RULA assessment including preparation CAD model of components and 3D scenario, manipulating manikin, changing the anthropometric variables, creating links between manikin & geometry/components and human activity analysis. RULA assessment resulted to RULA score of 1 to 7 with specific color and comment reported. Scale 1 noted the least concerned and 7 noted the most concerned accordingly. The summary of scale indicated is as the following Table 1.

Table 1. Level of MSD indicator

Score	Level of MSD Risk
1-2	negligible risk, no action required
3-4	low risk, change may be needed
5-6	medium risk, further investigation, change soon
6+	very high risk, implement change now

3. RESULTS AND DISCUSSION

Data taken were analysed and summarized accordingly as of Table 2.

From statistical data obtained, RULA assessment was performed using CATIA software. An example of RULA analysis performed among average male MPVs driver shows as of the following Fig. 3(a) and (b).

The final RULA assessment results noted on problematic postures at different percentile value summarized on Table 3.

It was noted that problematic posture of the upper arm, forearm, muscle and wrist and arm need to be further investigated.

As the RULA assessment result obtained, further investigation made by comparing anthropometrics data of other population to data obtained in this research. Simple comparison made was on the average and standard deviation values are as the following Table 4.

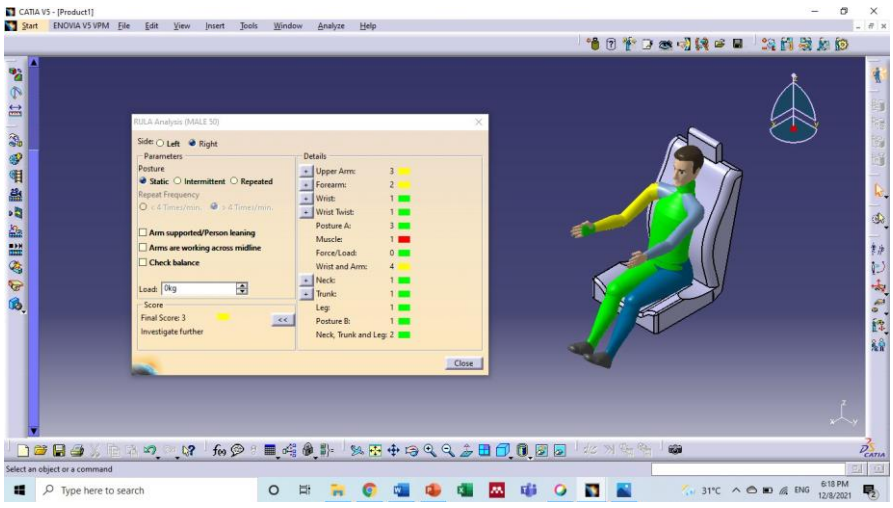

Fig. 3(a). RULA score for 50th percentile of male participant. (Isometric view)

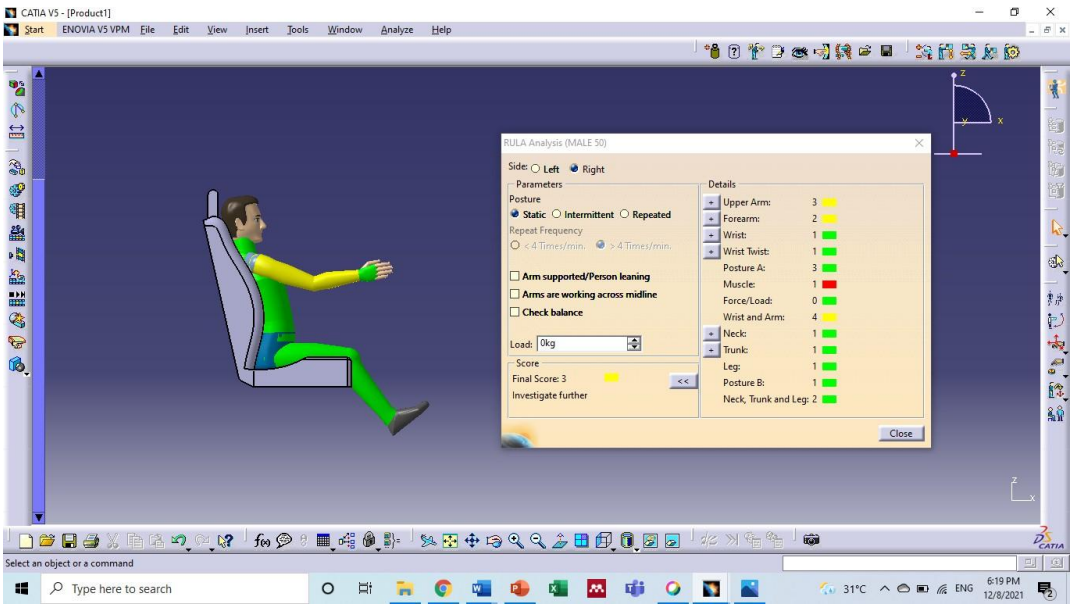

Fig. 3(b). RULA score for 50th percentile of male participant. (Left view)

Table 2. Summary of anthropometrics data

Dimensions (cm)	Mean	Std. Deviation	Min	Max	Percentiles		
					5th	50th	95th
Standing height :(1)	160.2	9.4	139	175	143.6	160.2	175.0
Sitting height :(2)	82.7	5.9	70	90	70.0	82.7	90.0
Popliteal height :(4)	42.6	2.5	36	47	37.9	42.6	46.4
Hips breadth :(5)	43.1	6.3	29	60	32.9	43.1	56.1
Length of buttock to popliteal: (7)	45.6	3.4	38	50	38.7	45.6	50.0
Sitting eye height: (10)	71.5	10.7	24	83	48.1	71.5	82.4

Table 3. RULA assessment result for related posture

Problematic Posture	Population Percentiles	Score	Color Code	Indicator
The upper arm, forearm, muscle, wrist and arm	5th	3		Investigate Further
	50th	3		Investigate Further
	95th	3		Investigate Further

Table 4. Comparison on selected anthropometric data among races: means and standard deviations

Dimension	Popliteal height		Length of buttock to popliteal	
	Mean	Std. Dev.	Mean	Std. Dev.
	cm		cm	
Malaysian [@]	42.6	2.5	45.6	3.4
United States	45.0	2.8	52.4	4.0
United Kingdom	44.9	2.7	51.7	3.5
China	41.0	2.3	45.2	2.9
Brazil	42.5	2.4	48.0	2.9
India	41.5	2.1	46.5	1.8

[@] *(Bridger, 2018)*

From the comparison made, it is noted that the largest and the smallest mean and standard deviation values represented by the United States and China population respectively. The Malaysian dimensions obtained comparatively range in between those values. Therefore, human variability does influenced RULA assessment result in this paper as MPVs seat design are meant for universal population. Human variability are due to genetics differences, molded environment and behavioral adaptation [14]. It is also noted from other source that, *"On the basis of these differences, if a piece of equipment was designed to fit 90 % of the male U.S. population, it would fit roughly 90 % of Germans, 80 % of Frenchmen, 65 % of Italians, 45 % of Japanese, 25 % of Thai, and 10 % of Vietnamese."* [15].

4. CONCLUSION AND RECOMMENDATION

In this paper, the objective of RULA assessment using anthropometric data of Malaysian MPV's drivers are achieved as this assessment could detect problematic MPVs drivers' postures. Based on the results obtained, most of the participants did not fit to the correct ergonomic sitting posture of the MPVs seat as the overall RULA assessment indicated yellow in color, suggesting further investigation are required. This could be concluded to several clarifications. Firstly, the Malaysian male drivers are not fully fit into the MPVs driver's seats as seat design are intended for universal population and therefore human variability does influence the result. As an example, popliteal height and length of buttock to popliteal distance influence the drivers distance to foot and brake pedal. The human variability features are explained on the result and discussion section above. Secondly, data taken may not be accurate as simple measurement was performed. Thirdly, MPVs driver may not practice to the correct sitting position. Therefore, it is suggested further research be conducted such as gathering more data of Malaysian MPVs driver and using more advance techniques such as vehicles motion comfort [16]. This is very important as future result obtained would be useful for future references to re design MPVs seat as the right sitting posture contributed an important factor in maintaining the body health.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/96596