Assessment of Whole Body Vibration Exposure among Motorcyclist in Malaysia under Different Speeds and Different Road Profiles: A Preliminary Study


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BACKGROUND:
Whole body vibration (WBV) exposure has a significant influence on humans’ comfort, health and performance. Objective: The aim of this study is to evaluate the WBV exposure value experienced by the motorcyclist under different road profiles and speeds. Results: Research findings showed there are significant differences of the vibration exposed on the motorcyclist under different road profiles and different speeds. Conclusion: The VDV exposure is higher when riding at the higher speed and on the paved road. The necessary preventive measures and actions should be taken by the motorcyclists to prevent the vibration exposure risk to their health.

OBJECTIVE:
The aim of this study is to determine vibration value when riding a motorcycle under different speeds and road profiles.

INTRODUCTION

Motorcyclists are exposed to extreme riding discomfort due to engine inertial unbalances, improper structural design of the motorcycle and excitation of the road [1]. In fact, motorcycles are the major contributors to road fatalities in the country, with no signs of decline in the near future [2-5].

Riding a motorcycle raises concerns not only about traffic safety, but also about health issues related to WBV exposure. Past studies have identified several health issues such as low back pain and finger and shoulder symptoms among motorcyclists [6-7]. In addition, the health problem may cause significant increase in medical costs to the motorcyclists. Furthermore, the vibration exposure may also lead to fatigue and thus, may affect their riding performance [8-9]. Therefore, this problem should be address and the preventative measures should be taken.

In Malaysia, studies about motorcyclist safety and comfort still at the budding stage. Currently, Malaysian Institute of Road Safety (MIROS) is playing an active role conducting researches about motorcyclist. This study was conducted in the University campus and the respondents were senior undergraduate students. In general, majority of University students depends on motorcycles for their daily transportation due to economic reasons and the University regulations for not allowing undergraduate student to bring their car in the University compound. It is one of the main reasons this study was conducted. The main objective of this study is to evaluate the WBV exposure among motorcyclists. It was a preliminary study to identify the health risk that might be presence due to vibration exposure.

Research methodology:
Respondents and Motorcycle: Two male senior undergraduate students, at age of 22 years were recruited to participate in motorcycle riding tests. Each motorcycle rider had at least 3 years of motorcycle riding, and was familiar with the test route adopted in this study, which is in the university campus. Both respondents had used similar motorcycle (engine size of 125 cc, two stroke).

Equipment: The main objective of this study is to determine vibration value when riding a motorcycle under different motorcycle speeds and road profiles according to ISO 2631-1. A Quest VI-410 Advanced Analyser Vibration meter as shown in Figure 1 was used to collect the vibration data.
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Fig. 1: Quest VI-410 Advanced Analyser Vibration Meter.

Field Testing Procedure: Figure 2a and Figure 2b show the example of the tarmac road the paved road surfaces employed in this study. Each field test was conducted for 5 minutes on two different parameters:

i) Different speed (20-40 km/h and 40-60 km/h) with similar road profile (tarmac road) and

ii) Different road profile (tarmac and paved road) with similar speed (20-40 km/h).

Fig. 2a & 2b: The tarmac road and the paved road.

Based on past studies, the reaction time for the sense of motion had been found to be from 0.24 till 0.80 seconds. This is one of the main reasons that the comfort measurements are typically performed via integration over 1-second intervals [10]. Therefore, in this study, there were 300 units of data that need to be analysed for duration of 5 minutes.

Each test was performed when there is no disruption on the road such as the other road user and the weather. This is to ensure a consistent traffic conditions and to provide comfortable environment for the respondents as indicated by Chen [11]. Prior to the test, each respondent was given the detailed instructions and the riding procedure. The respondents need to ensure they do not move when riding and remain on the seat in order to avoid the data conflict. Chen [11] mentioned that the riding speed is associated to driver behaviour and the road conditions. Therefore, the respondents were also advised to take care of their riding speed because it can influence the final experiments results. For each riding task, the seat pad accelerometer was mounted on the seat beneath the respondent’s buttocks in accordance with ISO 2631-1 standard.

After the field test, the respondents were interviewed whether they felt any discomfort at any of their body parts based on the Body Part Discomfort Survey. This survey was developed based on past studies [12-14]. After the experiment and the interview, the vibration data collected were analysed using the Quest Professional II software for further analysis. The VDV was used in the analysis of this study. The VDV can provide useful information about the effect of road particularly when the motion of the vehicle includes shocks or impulsive velocity changes. High VDV levels indicate the presence of shocks or jolts and jars in the ride. This can occur even if the frequency weighted acceleration (root mean square, r.m.s.) level is not high [15]. It gives a measure of the total exposure to vibration, taking into account the magnitude, frequency, and exposure duration [16]. The VDV was calculated using the formula as shown in Equation 1:

$$ VDV = \left( \int_0^T a(t)^4 \, dt \right)^{1/4} $$

where \( a(t) \) is frequency-weighted acceleration and \( T \) is the period of time over which vibration occurs. Overall VDV_{xyz} can be calculated by using Equation 2:

$$ VDV_{xyz} = \sqrt[4]{(VDV_1^2)^4 + (VDV_2^2)^4 + (VDV_3^2)^4} $$

(1)
RESULTS AND DISCUSSIONS

Vibration Measurement: The vibration experiment was conducted to gather the information WBV experienced by respondents while riding on two types of roads; tarmac and paved. The vibration measurement results in Table 1 show that there are significant differences of the vibration exposed on the motorcyclist under different road profiles and different speeds.

Table 1: Result of vibration measurement on the motorcycle

<table>
<thead>
<tr>
<th></th>
<th>Different speed + Similar road profile</th>
<th>Same speed + Different road profile</th>
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<tbody>
<tr>
<td></td>
<td>20-40 km/h Tarmac</td>
<td>40-60 km/h Tarmac</td>
</tr>
<tr>
<td>Mean VDV (m/s^2)</td>
<td>0.424</td>
<td>0.649</td>
</tr>
<tr>
<td>Peak VDV (m/s^2)</td>
<td>0.960</td>
<td>1.707</td>
</tr>
</tbody>
</table>

Effect of Riding Speed and Road Profile: With regards to Table 1, the VDV at the higher speed on the similar road (tarmac road) is higher than the lower speed (20-40 km/h). This result is in-line with the study conducted by Chen [11] and Ismail [17] where the authors mentioned that a slower riding speed may lowered the vibration exposure. In addition, the VDV for the paved road is clearly higher than the tarmac road. This is due to the paved road condition which is bumpier, uneven and harsh compared to the tarmac road [18-22]. According to Gillespie [22], road roughness is one of the main factors contribute to the higher vibration value.

Subjective Evaluation - Body Part Discomfort: Both of respondents agreed that they had experienced a slight discomfort at the back, buttock and the hand. In addition, both respondents mentioned that they always felt a lot of discomfort at the back, buttock and the hand particularly when riding for a long journey.

Conclusion:
The findings from this study showed that applying different road parameters may lead to different conclusion about WBV exposure. From this study, a slower riding speed and an even road such as the tarmac road may lead to lower VDV. In addition, VDV is a good indicator to evaluate the ride roughness and was found to correlate very well with riders’ subjective feedback. Based on the interview, it can be concluded that both respondents had experienced a slight discomfort at the back, buttock and hand. Therefore, more studies are required to understand a clear relationship between the vibration exposure and motorcyclist discomfort. The necessary action should be taken by the motorcyclist to prevent any risk to their health. Furthermore, the evidence on the association between WBV and musculoskeletal disorders are needed particularly involving motorcyclist in Malaysia. It should involve more targeted respondents for conducting this particular study.

REFERENCES


