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The Requisite for Motorcycle Personal Protective Clothing: Malaysia's Perspective

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Abstract – *Nearly 1.3 million people are killed and up to 50 million people are injured on the world's roads every year. Approximately 30% of road deaths involve motorcyclists especially in the ASEAN region. In Malaysia, the number of motorcycle accidents is consistently increasing in parallel with the rising number of registered motorcycles. Motorcyclists are categorized under vulnerable road users (VRUs) due to their disadvantages in terms of safety. It is believed that personal protection equipment (PPE) is able to mitigate and minimize motorcyclist injuries resulted from road crashes. The most basic PPE for motorcyclist is the helmet which is made mandatory in many Southeast Asia countries due to its effectiveness in reducing head injuries. Other than that, protective clothing is also vital to protect human body parts from trauma. This study attempts to explore the effectiveness of motorcycle protective clothing performance available in Malaysia. Selected motorcycle protective clothing was tested using anthropometric test device, calibration equipment and instrument. In addition, a market survey was conducted to explore and examine the types and trends of motorcycle protective clothing available. This study finds that motorcycle protective clothing with protector i.e. padding and airbag can provide potentially reduced neck and chest injury in contrast with those with no protection. Furthermore, the result reveals that 55% of the protective clothing available is made of synthetic material. The overall results provide significant information that is useful in the development of countermeasures to improve motorcyclists' safety.*

Keywords: Motorcycle protective equipment, motorcycle jacket

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1.0 INTRODUCTION

Every year, approximately 1.35 million people are killed while another 50 million are injured due to road traffic accidents. From the number of fatalities, almost half of all road deaths involve vulnerable road users (VRUs) namely pedestrians, cyclists and motorcyclists (WHO, 2018). In addition, road traffic injuries have been identified as the leading cause of death for

young people aged 15-29 and the eighth leading cause of death globally (WHO, 2015). Even more worrying, road traffic deaths and injuries have mainly occurred at low- and middle-income countries where 90% of the world's road traffic fatalities have taken place. The highest proportion of road traffic deaths in Southeast Asia is largely due to motorcycle accidents with about 34% (UNECE, 2017).

Road traffic crashes involving motorcyclists accounted for the highest proportion of all road deaths in Malaysia (Abdul Manan & Várhelyi, 2012; RMP, 2017). The prevalence of motorcycle accidents remains a major challenge in the country. The number keeps increasing in parallel with the rising number of registered motorcycles (RMP, 2017). Nevertheless, the motorcycle is still the most popular mode of transport in Southeast Asian countries for various purposes including courier service, fast food delivery, commuting to work and others (Md Isa et al., 2013). Due to less protection to both rider and pillion passenger, the motorcycle is considered a dangerous type of road vehicle. It has been noted that motorcyclists are 30 to 35 times more likely to die in a road crash compared to car occupants (Ivers, 2012).

Due to its disadvantages in terms of safety, the best way for motorcyclists to mitigate or minimize the risk of injuries and death in a motorcycle accident is by wearing currently available personal protective equipment (PPE). The most basic and proven PPE for motorcyclists is the motorcycle helmet. Wearing a helmet while riding is made mandatory in Malaysia since 1973. In addition, there is a specific standard used in Malaysia which refers to Malaysian Standard No. 1; and it is illegal for motorcyclists to wear non-standard helmets while riding. Evidence shows that wearing a proper helmet significantly improve the chances of surviving an accident (Deutermann, 2004; Hamzah et al., 2014; Ramli & Oxley, 2016; Abdul Manan et al., 2018).

Other than the helmet, protective clothing is another vital item to protect the human body from injuries. A number of researchers have concluded that effective injury prevention is most likely to come from protection systems worn by the motorcyclist (Craig et al., 1983; Nordentoft et al., 1984; Ouellet et al., 1987; Sporner et al., 1990; Ariffin et al., 2016). Although less attention has been paid to the injury reduction benefits of motorcycle clothing, there is evidence that a significant proportion of motorcycle injuries may be reduced or prevented through the use of effective protective clothing (Schuller et al., 1986; EEVC, 1993; Otte et al., 2012; ACEM, 2004; de Rome et al., 2011). Table 1 shows the distribution of injuries by body region in fatal and non-fatal accident cases in 2016. In fatal accident cases, the most commonly injured body region was the head which accounted for 56% for riders and 54.9% for those riding pillions (RMP, 2017). This is followed by multiple injuries among riders and pillion passengers with 29.2% and 32.8%. respectively. The neck and back/hip back accounted for the lowest with less than 3% each.

However, Table 1 also shows the different focus in terms of the most common body parts injured in non-fatal accident cases. For non-fatal cases, the most common body part was low extremity (from the hip to the toes) which accounted for 34% for riders and 30.2% for pillion passengers. This is followed by multiple injuries among riders and pillion passengers with 29.4% and 31.2% respectively. Furthermore, the table shows a significant increment of injury among riders and pillion passengers at the chest and back in non-fatal cases in contrast with fatal case. In summary, it is indicated that the highest attention should be given to head protection. However, vulnerability of other body parts should not be taken for granted as they are equally important. With proper riding equipment, the number of serious injuries in non-fatal accident cases can be potentially reduced. In fact, prevention strategies should also

provide better protection for vital parts in the chest, abdomen, and spine, as emphasized in previous related studies (Ankarath et al., 2002; Kraus et al., 2002).

Table 1: Distribution of injuries by body region (RMP, 2017)

Body Region	Fatal		Non-fatal (Serious + Minor)	
	%		%	
	Rider	Pillion	Rider	Pillion
Head	56.5	54.9	16.4	15.8
Neck	2.2	2.9	0.8	2.1
Chest	8.4	2.0	2.4	1.9
Arms	0.8	1.2	13.0	13.6
Back	0.0	0.7	3.2	3.6
Hip	0.5	1.7	0.8	1.6
Leg	2.4	3.7	34.0	30.2
Multiple	29.2	32.8	29.4	31.2
Total	100.0	100.0	100.0	100.0

According to the injury pattern, protection is more vital for motorcyclists as opposed to passenger vehicle occupants who are protected in a 'shell' with additional safety features such as seatbelt and airbags. Many researchers agree and believe that motorcycle protective clothing can potentially reduce injuries (Hell & Lob, 1993; Otte et al., 2012; ACEM, 2004). Their research findings mostly reveal that protective clothing can prevent or reduce injuries such as cuts and abrasion, exhaust pipe burns, friction burns and the stripping away of skin and muscle. With regard to the body region which needs to be protected, a study by Phan et al. (2008) reported that the upper body part requires more protection than the lower body part. A study conducted in Australia also agreed that protective clothing fitted with body armour can reduce the risk of severe injury to the upper body (de Rome et al., 2011, 2012). Even though protective clothing cannot completely shield a person from injury during a major impact, it can reduce injury severity. In other established researches carried out, it was revealed that protective clothing can provide better protection in low speed collision (de Rome et al., 2011).

Besides for body protection, motorcycle protective clothing can be worn for different purposes such in rainy and windy situation. With additional features such as waterproof material, it can keep motorcyclists dry. The reflective material for motorcycle protection clothing is also an alternative to increase motorcyclist visibility during night time. However, a study conducted by de Rome et al. (2011) revealed that the main cause of riders not wearing protective clothing is due to hot weather; with most of them in the younger age group and in the moped group.

This study aims to explore the effectiveness of motorcycle protective clothing that is available in Malaysia. Nevertheless, due to budget constraint, the experiment can only include a few types of motorcycle protective clothing for testing. The tests are conducted by using dummy calibration equipment and instrument.

2.0 METHODOLOGY

The aim of the study is to identify the many choices of motorcycle protective clothing available in Malaysia and also to assess their performance to reduce injury on a dummy that is worn with

the selected motorcycle protective clothing. In order to meet the objectives of this study, two methods have been used. A market survey approach was carried out to investigate and observe the types and trend of motorcycle protective clothing available in Malaysia. An online market survey was conducted by searching the motorcycle protective clothing sold in popular online stores to obtain such information. In addition to the information, a series of market survey was conducted only for motorcycle protective clothing sold in the Klang Valley area, with the targeted areas divided into spare part and motorcycle shops.

For the protective jacket evaluation, the researchers bought four types of popular jackets which were available in the market for a reasonable price. This study was conducted to evaluate the performance of jackets available in the market. The item for evaluation was the rider protection performance against impact according to the specified test configuration – chest (Figure 1) and neck impact (Figure 2). It should be noted that the evaluation is based on a test conducted by Japan Automobile Research Institute (JARI) in 2011. Table 2 shows the specifications of the tested jackets.

Table 2: Specifications of the tested jackets

No.	Type/Model	Material Type	Front Padding	Rear Padding	Water Proofing
1	Jacket 1*	Mesh	Yes	No	Yes
2	Jacket 2	Synthetic (polyurethane)	No	No	Yes
3	Jacket 3	Denim	Yes	No	No
4	Jacket 4**	Mesh	Yes	Yes	No

*Came with neck protection **Airbag jacket

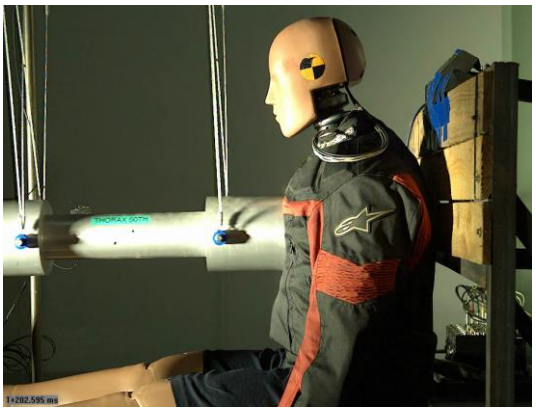

Figure 1: Chest impact configuration

Figure 2: Neck impact test configuration

3.0 RESULTS

3.1 Market Survey

The local market provides a variety of motorcyclist protective gear including motorcyclist protective clothing. A store generally exhibits a range of motorcyclist protective clothing in terms of different types of padding, wind and water proofing, colour and reflectivity, material and also price. In term of pricing, the motorcyclist protective clothing ranges between RM170 and RM2,200. Approximately 68% of the price on the online store is below RM500. It should be noted that the survey did not include protective pants for riding.

The type of material plays an important part to protect the motorcyclist from serious abrasion during a road accident. Various types of material are used for motorcyclist protective clothing such as cotton jeans type, leather, Kevlar, and mesh. Also, synthetic material is widely used such as polyurethane leather, nylon, fully polyurethane type or a combination of two or more syntactic materials. Besides the brand of the clothing, the type of material determines its price. In this survey, 55% of the motorcyclist protective clothing was made of synthetic material, 13.3% was made of full leather and 2.2% was made of Kevlar. In addition, 22.2% was made of unknown material. Different types of material gave different results in terms of tear and abrasion strength. Studies in other countries reveal that leather and Kevlar are the best material for protective clothing due to their durability, tear/cut, burst and abrasion on pavement resistance (de Rome et al., 2012).

Besides the material, additional features of the motorcyclist protective clothing are also important to reduce injury severity. Usually a thin cushion material is added to the cloth. The purpose of the padding is to enhance protection on elbows, back, shoulder and neck. The common material for padding is foam and reinforced plastic. Statistics shows that 91% of the clothing surveyed was equipped with padding whereby 21% was of removable type. In addition to providing protection, the design also takes rider's comfort into consideration. Based on the survey, 71% of the protective clothing was of air mesh or breathable type. This means that air can flow into the jacket and provide comfort to the rider without compromising its main purpose. Another feature of the protective clothing is water proofing. Statistics shows that 33% of jacket is not waterproof and therefore unsuitable to be used as a rain jacket.

3.2 Protective Jacket Evaluation – Neck Impact Test

The dummy was set in the targeted and adjusted impact position so that the upper end of the impactor impact face would come as close as possible, to but not in contact with the rear lower end of the helmet. In this study, the neck impact test was only conducted for the airbag jacket type and the jacket with neck protection. Additionally, a reference test dummy only was also conducted as a comparative study. Table 3 shows the result of the neck impact test. The result showed that the protective clothing with neck protection (MJT 08 – Jacket 1) receive lower force in forward direction as opposed to the reference test.

Table 3: Neck impact test result

Test Number	Protection Type	Maximum Force X (Forward Direction) (N)
MJT 07	Airbag jacket	1,324
MJT 08	Jacket 1 with neck protection	1,100
MJT 09	None (reference)	1,391

3.3 Protective Jacket Evaluation - Chest Impact Test

A fixed wall was set against the back of the dummy so that the impact from the impactor would be received almost totally by the front side of the dummy's chest. The dummy was set in the targeted impact position so that the impactor would hit on the longitudinal and transverse centre of the dummy's ribs. The results indicated that in the chest deflection test, all test protective clothing with chest protection (MJT 02, MJT 04, MJT 05 and MJT 06) show a reduction in chest deflection by not more than 4mm as compared to not wearing any protective clothing. However, the test result for protective clothing with no chest protection (MJT 03) indicated high chest deflection in contrast with the dummy wearing no protective clothing.

Also, prediction of an Abbreviated Injury Scale (AIS) injury in this test result was compared with the estimated injury curve proposed by NCAP (Prasad et al., 2010). When the dummy wore no protective clothing (MJT 01), the AIS 3 probability stood at 32%. This probability was reduced to 17.18% by putting a protective clothing equipped with chest protector on the dummy (MJT 02). Although the airbag jacket (MJT 06) recorded 1.73mm less than the reference test, the airbag jacket absorption characteristics in terms of time is faster than the other types of tested jacket. Moreover, the airbag jacket reached the maximum chest defection earlier than the other types of tested jacket. Table 4 shows the chest impact tests.

Table 4: Chest impact tests and probability of AIS

Test Number	Protection Type	Impact Speed (m/s)	Maximum Chest Deflection (mm)	Probability of AIS >=3(%)
MJT 01	None (reference)	6.68	62.25	32.0
MJT 02	Jacket 1 with protection	6.67	56.23	26.5
MJT 03	Jacket 2 – no protector	6.69	63.79	32.5
MJT 04	Denim with protector	6.69	59.64	29.8
MJT 05	Jacket 4 – with protector	6.70	62.00	31.7
MJT 06	Airbag	6.73	60.52	30.0

4.0 DISCUSSION

In Malaysia, motorcyclists must wear a protective helmet that complies with one of the following manufacturing standards – MS 1; and this is the only compulsory protective equipment required when riding a motorcycle. Even though helmet wearing is high among riders, there is a small percentage of pillion passengers who do not properly wear helmet (unbuckled chinstrap) (Abdul Manan et al., 2018). Although the law does not require additional protection such as protective clothing, glove, protective pants and other equipment, the contribution of such equipment is significant to reduce motorcyclist injury especially in lower speed collision.

According to statistics in Malaysia, the most commonly injured body regions leading to death include the head which accounted for 56% for riders and 54.9% for pillion passengers. This is followed by multiple injuries among riders and pillion passengers with 29.21% and 32.84%, respectively. The neck and back/hip back are the lowest with less than 3.0% each. Results from this study showed that motorcycle clothing with additional neck protector can decrease the force to the neck which will result in neck extension. According to a report by Melvin and Lighthall (2002), neck extension is defined in a clinical setting as a motion that brings the long axis of the distal portion of a joint parallel with the long axis of the proximal portion while from engineering perspective, it is referred to as bending (Melvin & Lighthall, 2002). With the additional protection to the neck, it can minimize and decelerate the head in a controlled manner, while at the same time reducing dangerous ranges of head movement in order to reduce the bending forces (torque) on the cervical spine. In addition, from our survey, the neck protection is not commonly available in Malaysia and it is seldom found as an accessory to protective clothing and usually neck protection can only be found at airbag jacket type as a standard fit. However, the market price is still high.

Besides the neck impact, this study has also measured the impact at the chest with solid round impactor. The result shows that all test protective clothing with chest protection (MJT 02, MJT 04, MJT 05 and MJT 06) register a reduction in chest deflection by not more that 4mm as compared to wearing no protective clothing. Even though this test did not represent or

replicate the real impact during accident, it may at least indicate the effectiveness of having some protection to the chest area. However, a study conducted by European Experimental Vehicles Committee (1993) suggests that the protective clothing cannot mitigate:

- Severe bending, crushing and torsional forces to the lower limbs;
- Massive penetrating injuries to any part of the body;
- High energy impacts on the chest or abdomen causing injuries through shock waves, and severe bending forces such as when the torso strikes an upright post.

Other parts of body that can potentially increase the risk of serious injury or death is the spine area. A study has revealed that the rate of spinal cord injuries among motorcyclist is higher as compared to car occupants (Lieutaud et al., 2012). The use of back protectors may be an effective preventive measure for back injuries including spinal cord injuries among motorcyclists. Back protectors have been designed for racing sports to reduce abrasion injuries caused by sliding on the road. However, the back protector can be used in daily ride (Otte, 1998). In addition, Hinds et al. (2007) revealed that by using the amour, it can protect the back of the rider from the upper thoracic to the lower lumbar spine. Result from the market survey showed that almost all protective clothing comes with a back protector. However, the effectiveness of the product is still unknown.

Moreover, to be conspicuous while riding, protective clothing can be good reflective element to other road users. Conspicuity can however be improved by using colourful protective clothing with reflective strips. Road accidents usually occur when other road users especially vehicle driver are unable to see clearly especially during night-time and rainy days (Plainis & Murray, 2002.; Reimer et al., 2007; Baldock et al., 2006). The situation can be improved significantly if motorcyclist enhance their conspicuity (Solah et al., 2013). The risk of a motorcyclist getting into a traffic collision is 37% lower if the rider wore reflective or fluorescent clothing (Wells et al., 2004). However, based on our survey, there was a limited colour choice for protective clothing available to consumers. Most of the online stores offer dark colour and this might be due to the demand from consumers.

Due to the lack of data in Malaysia regarding the effectiveness of protective clothing among motorcyclists to mitigate injury, this study serves as a baseline data focusing on the current products in the market. It should be noted that wearing motorcycle protection attire is not mandatory in Malaysia. Therefore, there is a number of protective clothing or impact protectors which are not certified, but are offered to consumers although their effectiveness is uncertain. The findings can also help in providing insights and recommendations to related stakeholders for road safety advocacy especially regarding the standard as well as compliance of personal protective equipment for motorcyclists.

5.0 CONCLUSION

In summary, results of this study show that the use of motorcycle protective clothing can effectively increase protection to the chest and neck of motorcyclists at certain force of impact. Even though the test conducted does not fully represent the motorcycle accident situation or configuration, the result still indicated that impact to the human body can be reduced due to additional protection such as the armour protective gear. By wearing motorcycle clothing while riding, the severity of motorcyclist injury involved in road accident can hopefully be reduced.

There are several recommendations that may possibly enhance motorcycle protective clothing acceptance in Malaysia, namely:

- Embark in future research to gauge PPE acceptance among motorcyclists in Malaysia;
- Future study to investigate association between motorcyclists' crash risk and usage of PPE in hot weather, particularly in Malaysia's situation; and
- Conduct large-scale study to examine the association between body armour for different parts of the body and injury, specifically on fractures.

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