Validation of test protocols for assessing motorcycle protective clothing using real world crash investigation

Meredith[a,b], L., de Rome[a], L., Fitzharris, M[c]., Baldock, M[d]., & Brown[a], J.

[a] Neuroscience Research Australia, [b] Medicine, UNSW, [c] Monash Injury Research Institute, [d] Centre for Automotive Safety Research

Abstract

This paper presents the methodology developed and preliminary data from a study designed to investigate the adequacy of testing protocols included in the European Standard for motorcycle protective clothing, EN13595. The study is being conducted as an adjunct to an ongoing Austroads funded in-depth study of motorcycle crashes. The Austroads study includes examination of the crashed motorcycle, crash scene and interview with the rider. In this study, the clothing worn by the rider during a crash is examined and the clothes collected for later testing of the protective capacity using standard laboratory tests. Kinematic analysis of each crash is used to determine the riders' motion and observe the location of impacts to the riders' body during a crash. Equipment that is capable of testing the abrasion resistance of motorcycle clothing is being constructed and validated. The clothing worn by motorcyclists involved in crashes collected during the Austroads funded study will be tested using this equipment and the clothing performance will be compared with injury outcomes. This paper presents preliminary results for the first 20 cases to demonstrate the methodology being employed to investigate the adequacy of the abrasion resistance requirements of EN13595. The results of this work will be of interest to those developing programs to enhance or monitor the quality of protective clothing available to motorcyclists.

Introduction

Motorcyclists only represent one per cent of vehicle kilometres driven, yet account for 22% of serious injury and 16% of fatal injury attributed to road crashes. With increases in motorcycle usage, the number of fatalities and serious injuries has also risen. Specifically, between 2000 and 2010 motorcycle deaths increased by 17% while motorcycle usage increased by 82% (ATC, 2011).

One of the most effective ways of reducing injury for motorcycle riders is by wearing appropriate personal protective equipment (PPE) such as motorcycle specific clothing, footwear and gloves. There is now considerable evidence that protective clothing can substantially reduce the risk of injury to motorcycle riders (ACEM, 2004; Aldman, Cacciola, Gustafsson, Nygren, & Wersall, 1981; Danner, Langwieder, Polauke, & Sporner, 1984; de Rome et al., 2011; Engström, 1980; Hell & Lob, 1993; Hurt, Ouellet, & Thom, 1981; Hurt, Ouellet, & Wagar, 1981; Kalbe, Suren, & Otte, 1981; McIntyre, Nieuwesteeg, & Cockfield, 2011; Otte & Middlehauve, 1987; Otte, Schroeder, & Richter, 2002; Schuller, Beier, & Spann, 1982, 1986), particularly to soft tissue (de Rome et al., 2011) and open wound injuries (McIntyre et al., 2011).

The ability of clothing to protect riders during a crash depends on the quality of the equipment. The Gear Study, which included an examination of motorcycle protective clothing worn by riders during a crash, reported that PPE worn by riders in the study experienced substantial damage. Almost 30% of cases had the protective layer of the clothing torn or holed, exposing the rider's skin to potential injury (de Rome et al., 2011).

The European standard for motorcycle protective clothing, EN13595 *Protective clothing for motorcycle riders- Jackets, trousers and one piece or divided suits*, specifies the general requirements for clothing intended to protect the rider against mechanical injury. In Europe, EN13595 is not a mandatory standard but manufacturers must have their clothing approved to the

Standard if they claim that the clothing provides protection from injury. Clothing that is approved to the Standard displays the CE mark. Currently, there is no Australian Standard or requirements for manufacturers when producing and selling motorcycle clothing; however, some clothing sold in Australia does display the CE mark.

The lack of any Australian requirements for motorcycle clothing means that the adequacy of protective clothing available to Australian motorcyclists is unknown. Furthermore, the European Standard focuses on the injury reduction benefits of motorcycle protective clothing and is based on the distribution of damage seen to motorcycle clothing in a study by Woods (1996). Woods (1996), examined the location of damage seen to 100 crash damaged motorcycle suits (99 leather, 1 fabric) and based on the frequency of damage in different locations, developed a motorcycle clothing template with four different zones. In the European Standard these zones are required to provide varying levels of protection based on the risk of impact, with level one required to provide the highest protection and level four the lowest. Based on the type of damage seen to motorcycle protective clothing in that same single study, Woods developed test machines to measure the clothing's ability to resist damage (Abrasion, burst strength of seams, cut resistance and tear resistance). These machines were incorporated into the Standard, and in order for clothing to pass the Standard, materials used in motorcycle clothing must meet acceptable levels in each mechanical test. There is a need to validate the observations on which the Standard requirements are based, particularly using a greater range of materials and more modern materials. Additionally, there has been no previous study examining whether or not the level of damage that the clothing is subjected to within the Standard tests is comparable to the damage experienced by the clothing in the real world.

A recent study by Meredith et al. (2013) examined the validity of the zoning principle of the European Standard by observing the impact distribution to clothing worn by riders during a crash. The results indicated that the impact distribution was largely consistent with the European Standards; however, minor changes were suggested. A large number of impacts were seen to the forearms, lower legs and thigh areas designated as zone 3 regions and the findings suggest these areas might be better designated as zone 2 regions. Additionally, the chest and abdomen, which is a zone 4 region, had a larger number of impacts than the back which is a zone 3 region, indicating a potential benefit of extending the zone 3 region to the chest and abdomen. This study also examined the types of damage to motorcycle clothing and found that the vast majority of damage was abrasion and tear damage, indicating the higher priority of these assessments over burst and cut tests.

Currently, there have been no studies that: (i) characterise the level of abrasion resistance and impact protection required to prevent injury; (ii) examine these characteristics in modern materials, or (iii) study the adequacy of current test protocols. This lack of evidence may inhibit moves towards mandatory standards, and development of consumer-based programs (e.g. star rating systems) to inform riders about the relative performance of protective clothing (Haworth, de Rome, Varnsverry, & Rowden, 2007).

This paper presents the method developed and preliminary data from a study designed to investigate the adequacy of testing protocols included in the European Standard for motorcycle protective clothing, EN13595. As abrasion is the most common form of clothing damage (Meredith et al., 2013), research will initially focus on the Standards for abrasion resistance, extending this to other forms of damage at a later stage.

Methods

This study has been designed as an adjunct to an Austroads funded case control study of motorcycle crashes in NSW. The Austroads study involves a 3 year in-depth motorcycle crash investigation of motorcycle crashes occurring on public roads within a 3 hour drive of Sydney and has been running since August 2012. This study analyses the causes and consequences of motorcycle crashes on public roads in order to inform countermeasures aimed at reducing the risk of crash and risk of sustaining an injury during a crash to motorcycle riders within Australia. This study will examine at least 100 cases of crashed motorcyclists.

Eligible participants are motorcyclists aged 14 years and older who had been admitted to hospital. Motorcyclists are currently being recruited by research nurses from two Sydney hospitals with the aim to expand this to five hospitals in Sydney.

Following recruitment, motorcyclists complete a face-to-face interview which collects self-reported data on the details of the crash, including the overall scope of the crash, the individual impacts which occurred during the crash, injury details and clothing details. Medical records are also examined to observe the injury outcome of the crash.

Following the initial interview, the motorcycle ridden during the crash is inspected to help determine whether the motorcycle played a factor in the crash and to corroborate the kinematics of the crash to the interview report. The crash scene is then examined for evidence of the crash to give an idea of the crash kinematics and any factors of the scene which may have influenced the crash risk and injury outcomes. The crash scene is inspected as soon as possible after participant recruitment. In reality this generally occurs 1 – 2 weeks post-crash. From the scene inspection, information is collected on the type of road and the type of road surface where the crash occurred as well as the speed limit, median, shoulder and road-side details. Information about what clothing was worn is collected and classified into whether it was designed for motorcycle use or not as well as the fabric type. The clothing worn by the motorcyclist during the crash is also inspected and where possible, the clothing is kept for mechanical testing to the European Standard.

Based on the details of the crash, a kinematic analysis is carried out to determine the riders body movements during the crash. This helps to determine the specific cause of injuries and the severity of forces acting on the body during a crash and whether protective clothing may have been of use in reducing the risk of injury to the rider. From this, the source of each injury is recorded.

Clothing inspections are undertaken to observe the impact locations and the type of damage that occurred during a crash. Clothing damage is classified using a purpose designed classification system similar system to the National Accident Sampling System (NASS), Occupant Injury Classification (OIC) scheme (U.S. Department of Transportation National Highway Safety Administration, 1981). This purpose designed system classifies the damage to clothing in terms of where the clothing would lie on both the OIC and ISS body regions, indicates the aspect of damage (both left/right and front/back), type of damage (abrasion, burst, cut, tear), depth of the damage (surface, partial or full), the clothing system damaged (waterproof layer, abrasion resistant layer, thermal layer etc.), the source of the damage and the source of the data (e.g. clothing inspections or participant interview). Photographs are also taken of the clothing. For participants who were unwilling to give up their clothing, sufficient information is being collected in order to allow for purchase of the same or similar clothing items so that the clothing can be tested according to EN13595.

The cases are then reviewed at interdisciplinary crash review meetings. These meetings are used to re-examine the cases from different perspectives and give insight into the most likely causes and consequences of the crash. Possible countermeasures are also formulated.

Equipment that will allow testing to the requirements of EN13595 is under construction. Once operational, clothing will be assessed against the requirements of EN13595 and the performance in the Standards testing will be compared to the performance of the clothing in the real world crashes.

Test samples will be taken from a non-damaged equivalent area of the damaged clothing. If the clothing is too severely damaged and there is no such material left on the clothing, new clothing will be purchased in order to source test samples. A validation study will be completed to compare the performance of pre-crash and post-crash clothing.

Testing will initially involve the abrasion resistance test of EN13595. We will test the clothing and see if it passes the Standard requirements. The clothing has a known injury outcome, so we can see if clothing that passed the Standard prevented injury, or if injury is still occurring.

Two sets of analyses will be performed. In the first, each item of clothing will be coded as having met the abrasion resistance requirements of the Standard or not, and whether injury occurred or not. The Chi square test will be used to assess for significant differences in injury outcome by standards test performance. We will then code the abrasion results in terms of the 'time to hole' of the items tested and test the association between the abrasion resistance and the presence and severity of injury to the body region protected by the clothing while controlling for crash characteristics using logistic regression.

Figure 1 illustrates the data collection process used in this study and outlines the purpose of the data being collected.

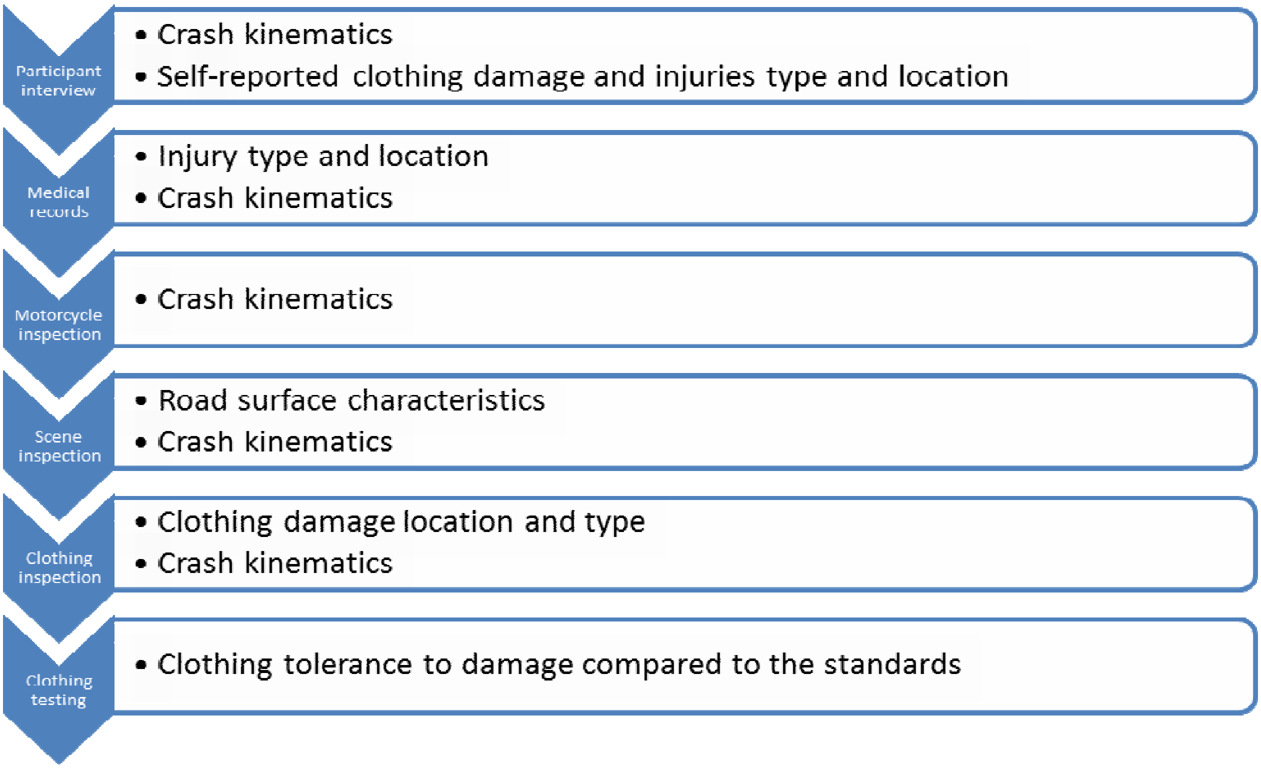

Figure 1. Process chart

Preliminary results for the first 20 cases are presented. Two cases are presented in further detail, showing the variability of the response of clothing in crashes. No test data is available at this stage.

Results

The average age of motorcycle riders for the first 20 cases was 33 with a range of 16-69 years. There were 18 male and only two female participants. Two-thirds (n=13) of motorcycle riders had a full/unrestricted motorcycle licence and 25% (n=5) were on their Learners licence. Only one rider was on the first level of provisional licence and one rider had their second provisional licence. The majority (75%) of cases occurred on roads where the speed limit was 60km/h or less, while the other 25% of cases occurred on roads with a speed limit between 70-100km/h. The majority of crashes were located on major arterial roads (n=9), followed by minor arterial roads (n=6), local roads (n=2), national park roadways (n=2) and freeways (n=1). Ten of the road surfaces were of medium coarseness, six were on fine road surfaces and four were on very coarse surfaces. Almost half (n=9) of riders reported that they slid along the road surface following the crash, while 25% (n=5) reported that they experienced some other form of movement over the road surface, i.e. rolling or tumbling. The remaining cases (30%, n=6) did not report that they slid over the road surface; however, this was often due to being unable to remember if they did in fact slide on the road for a brief period of time. Only one case recalled that he definitely did not slide, tumble or roll on the road surface.

Injuries

The average maximum AIS for the motorcycle riders was two, with values ranging between one (minor) and five (critical). The average ISS was 8.65, with values ranging from one to 38. Out of the 20 cases, 20% had an ISS between 9 and 15 (moderate injury) while 10% had an ISS greater than 15 (severe injury). The injuries sustained by the first 20 cases are summarised in Table 1.

Table 1. Injuries sustained in the first 20 cases

Case	Injuries	MAIS	ISS
1	Fractured left midshaft tibia (undisplaced), fractured pubic rami, scrotal haematoma, small laceration above testicle, fractured left distal radius, closed head injury	2	9
2	L3 left transverse process fracture, neuropraxia 6th nerve	2	8
3	Left wrist fracture, right C7 transverse process fracture	2	8
4	Abrasions to chin, abrasion left side of neck, abrasion base of neck, contusion anterior neck, abrasion left abdomen wall, fractured left 11th rib posteriorly, fractured right 9/10/11th ribs posteriorly, right apical nuemothorax, right basal pulmonary laceration, right haemothorax, bilateral pulmonary contusions, abrasion left knee, abrasion right knee	3	10
5	Left forearm contusion, left inner knee contusion, right knee degloving injury, right biomalleolar fracture, base of 5th metatarsal fractured on right foot, right posterior cruciate ligament tear	2	8
6	Abrasion at the back of the right thigh, abrasion left inner knee, right scaphoid wrist injury	1	1
7	Fractured clavicle, right finger avulsed, abrasion right knee, left knee degloving injury, left ankle abrasion, left toe abrasions (1st, 2nd and 3rd)	2	8
8	Contusion left upper back, soft tissue injury of the right wrist, left thigh haemotoma, abrasion right foot	1	1
9	Contusion left lower chest, abrasion left elbow, right carpal fracture, contusion left knee, closed head injury	2	5
10	Soft tissue injury right wrist, contusion left knee, right knee and right lower back, soft tissue injury right hand, soft tissue injury right middle and ring fingers, contusion on the right foot and right big toe.	1	1
11	Fractured right ribs 3-8, right pleural effusion, adrenal haematoma, left distal radius fracture, four abrasions on the left knee, abrasion on the left abdomen, right calf haematoma, right arm haematoma	3	14
12	Abrasions to both right and left elbows, right wrist, left and right hand, right knee, left thigh and left shin. Left knee ligamentous injury	1	1
13	Left rib fracture, left forearm abrasion, left elbow laceration, left knee abrasion	1	1

Case	Injuries	MAIS	ISS
14	Liver laceration on the right, haematoma pericolic gutter and pelvis on the right, splenic laceration, absent flow of the right kidney, right scapula fracture, right upper lobe lung contusion, right rib fractures 3-5 and 8, right adrenal rupture, right shoulder contusion, right shoulder abrasion, 1st metacarpal fracture of the right hand	5	38
15	Right 2nd rib fracture, contusion right shoulder, fracture right distal radius, left undisplaced radial styloid fracture, contusion left palm, abrasion fingers 4 and 5 on the right hand, testicular contusions, right femoral fracture, right proximal fibular avulsion fracture, pelvic open book fracture	3	11
16	Splenic laceration, vertical sheer injury right hemipelvis, contusion right abdomen, contusion right pelvis, contusion right upper arm, abrasion right elbow, contusion left forearm, abrasion left forearm	4	33
17	Laceration left forehead, laceration left neck, fractured left clavicle, fractured right clavicle, full thickness laceration right kidney, right lobe liver laceration, left scalp haematoma, closed head injury, abrasion left 2nd finger, abrasion above left knee	2	9
18	Left ankle sprain, right top of foot contusion, right elbow contusion, left elbow contusion, right 4th fingernail laceration, right 5th finger contusion	1	1
19	Right and left thigh/groin contusions, right & left thigh/groin abrasions, soft tissue injury of the pelvis, haematoma at the base of the bladder, soft tissue injury of the left hand	2	5
20	Abrasion right shoulder, abrasion right abdomen wall, abrasion right elbow/forearm, abrasion left elbow, abrasion right hand, contusion right hip, abrasion right knee	1	1

As detailed in Table 1, internal injuries occurred in six cases and included six lung injuries (pulmonary contusion 2, apical neumothorax 1, pulmonary laceration 1, haemothorax 1, pleural effusion 1), two adrenal injuries (adrenal rupture 1, adrenal haematoma 1), two kidney injuries (absent flow 1, full thickness laceration 1), two liver lacerations, two splenic lacerations, and haematomas on the pericolic gutter, pelvis and bladder. Internal injuries occurred in impacts with the road surface, impacts with the motorcycle handlebars, or impacts with another vehicle involved in the crash.

Fractures were incurred by 12 participants, for a total of 37 fractures. Fractures occurred to the ribs (n=16), forearm/wrist (n=5, radius 3, radial styloid 1, wrist 1), shoulder (n=4, clavicle 3, scapular 1), pelvis (n=3, pelvic open book fracture 1, pubic rami 1, vertical sheer 1), spine (n=2, transverse process 2), fingers (n=2), lower leg (n=2, tibia 1, fibular 1), femur (n=1), ankle (n=1) and toes (n=1). Fractures generally occurred due to impact with the roadway, with the exception of pelvic fractures which occurred from impact with the motorcycle fuel tank. In addition to pelvic fractures, pelvic soft tissue injuries and testicular injuries were also observed in four cases as a result of impacting the fuel tank of the motorcycle ridden during the crash. The pelvic soft tissue and testicular injuries include scrotal haematomas, testicular contusions, groin abrasions and testicular lacerations.

Closed head injuries (mild concussion) occurred in three cases and occurred from impact with the ground or impact with kerb-side infrastructure (pedestrian safety fence). These injuries occurred despite all participants wearing helmets.

Eleven participants experienced skin abrasion due to contact with the roadway, with one of these abrasions being a serious degloving injury. One participant received abrasion injuries due to contact with a clay embankment on the roadside and another participant incurred a degloving injury on the inner knee due to contact with motorbike parts. In total, there were 45 abrasions and two degloving instances for these 13 participants.

Clothing damage

Jackets were worn by 17 participants, with the remaining three participants wearing t-shirts. Out of the 17 jackets worn, 12 jackets (70%) were specifically designed for motorcycle use. Eleven (65%) of the jackets (10 designed for motorcycle use) were inspected and one t-shirt was also inspected.

Pants which were designed for motorcycle use were worn by seven participants (35%), with 13 not being designed for motorcycle use (65%). Five of the pants were inspected for damage (two designed for motorcycle use).

Gloves were worn by 10 participants with an additional five cases unknown whether they were wearing gloves or not. Five participants were not wearing any gloves. All 10 pairs of gloves worn were designed for motorcycle use. Seven gloves were inspected.

Seven of the participants wore footwear during the crash that was specifically designed for motorcycle use with the remaining 13 not designed for motorcycle use. Six of the participant's footwear was inspected (five designed for motorcycle use).

Only three participants reported that they were wearing clothing approved to the European Standard. This included three jackets, one pair of gloves, two pants and two pairs of shoes. This was confirmed via the clothing inspection for two of these cases.

Clothing damage was seen in all of the first 20 cases. Of the 17 jackets worn, nine were damaged, including seven designed for motorcycle use, and five were not (including four designed for motorcycle use). The inspected t-shirt was not damaged. It was unknown whether the remaining three jackets and two t-shirts were damaged. There were 41 points of damage seen to the jackets, with majority being abrasion damage. There were only four cases of tear damage, two cases of burst damage and no cut damage seen to the jackets.

Among the pants, there were 12 that were damaged (including five designed for motorcycle use) and three were undamaged during the crash (including two that were designed for motorcycle use). It was unknown whether the remaining five were damaged or not. There were 42 damage locations observed on the pants worn by the motorcyclists during the crash. Abrasions accounted for almost half (20) of the damage seen. Tear damage was also relatively frequent (19) and there was one cut and one burst of the seams. The type of damage of the last damage location was unknown as the information was from the participant interview and not specified.

Among the gloves worn by participants, seven were damaged, two not damaged, and one unknown. There was 30 points of damage seen to the seven damaged gloves. Twenty seven of these were abrasion damage, two burst damage and one cut damage.

Of the footwear, damage was seen to eight (including five designed for motorcycle use), five were not damaged (none were designed for motorcycle use) and the remaining seven were of an unknown damage state. There was 19 points of damage observed, with 17 being abrasion and two being tear damage.

Figure 2 provides a summary of the distribution of the clothing damage and injuries according to the location the damage/injury occurred on the clothing.

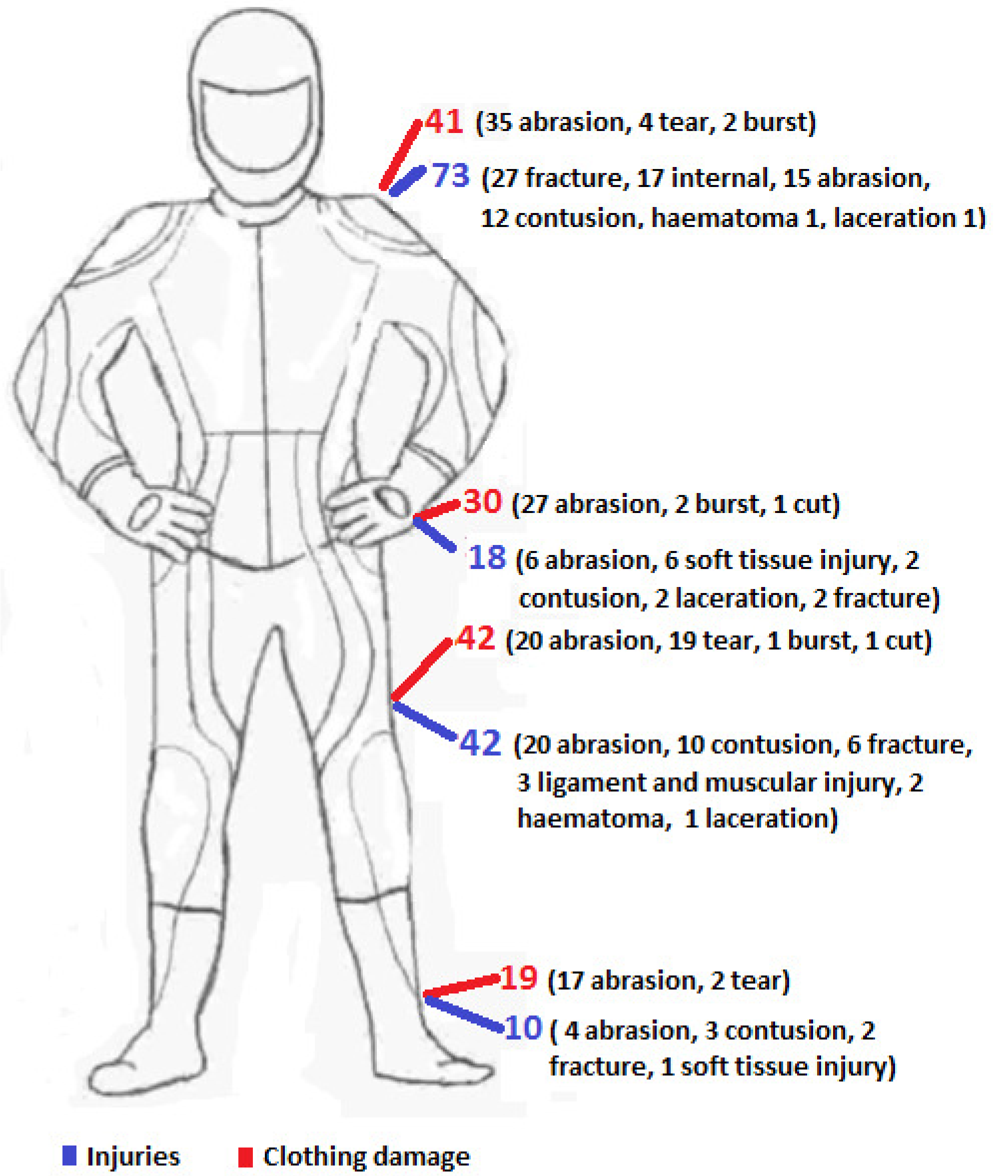

Figure 2. Injury and clothing damage distribution by clothing type

Protection provided by clothing

The ability of clothing to protect a rider during a crash was highly variable, with some clothing protecting riders and others not. Two cases are presented below as an illustration.

Case 7 involved a 28 year old male motorcyclist who had 6-7 years motorbike riding experience. He was wearing a jacket, pants and gloves designed for motorcycle use but normal runners. The crash occurred at approximately 8.45am in fine weather conditions. The rider was travelling on a two-laned road with a 60km/h speed zone, in the middle lane. A car (vehicle B) was travelling just behind him in the kerbside lane. They were approaching an intersection when a third vehicle (vehicle C) started to pull out of the side street. Vehicle B swerved to avoid vehicle C but clipped the motorcycle's rear tyre. The rider was immediately thrown off the right hand side of the motorcycle and slid along the road until he impacted a concrete barrier in the middle of the road which stopped his sliding motion. His left shoe came off leaving him with three toe abrasions on his left foot and abrasions on his left ankle. Despite wearing pants which were designed for motorcycle use, his pants ripped to the knee on impact and he obtained abrasions on his right knee and a degloving injury to his left knee which required a skin graft. The stitching on the glove of his right fourth finger burst, leaving his finger exposed to the ground and he had an avulsion of his fingernail on this finger. All of these injuries occurred from direct contact between the skin and the road surface as the riders body slid over the roadway. He was also wearing a jacket which was designed for motorcycle use and contained shoulder impact protectors yet suffered a clavicle fracture on the right from impacting the road surface. The ISS for injuries the rider sustained was eight.

Case 9 involved a 22 year old male who had six years riding experience. He was completely covered with protective clothing, all of which was designed for motorcycle use. The crash occurred in the afternoon, around 4pm, in daylight hours and under fine weather conditions. The rider was attempting a right turn onto a two-laned, minor arterial road with a speed limit of 60km/h and was reportedly travelling at 65-70km/h. He initially turned into the middle lane but noticed a truck travelling along this lane. The truck and motorcycle both attempted to move into the kerbside lane, and resultantly the motorcycle's rear tyre clipped the truck. The rider was high-sided and landed on the roadway, the first point of impact being his head and right hand. The rider's left hand and knee then impacted the roadway and he continued to roll and tumble over his left shoulder. The motorcycle fell onto its left side, slid along the road and impacted with the back of the rider's head. Damage to his clothing included an abrasion on the right palm, abrasion on the right toe and ankle of the footwear, abrasion on the left and right knees of the pants, abrasion on the left thigh, abrasions on the left and right shoulders of the jacket, abrasion on the left and right elbows and a burst seam on the back of his jacket. He also had a scratch on the left side of his helmet. Despite the large amount of damage seen, the clothing performed reasonably well with the rider having a contusion to the lower left chest, abrasion to the left elbow, right carpal fracture, a contusion to the left knee and concussion. The abrasion to the left elbow did not occur from direct contact of the skin with the road surface but from interaction with the jacket lining material.

Discussion

This paper presented the data collection protocols for a study that aims to validate the mechanical test requirements of the European Standard for motorcycle protective clothing using an in-depth crash investigation methodology and reported on preliminary data from the first 20 cases.

This method of data collection has been used previously in motorcycle crash investigation with studies such as the MAIDs study (ACEM, 2004) and a study by Hurt et al. (Hurt, Ouellet, & Thom, 1981; Hurt, Ouellet, & Wagar, 1981). These studies aimed to examine the causes and consequences of motorcycle crashes as well as determining the effectiveness of clothing in injury prevention. In contrast to the data reported here, the MAIDs study data was not used to validate the European Standard for motorcycle protective clothing while the studies by Hurt et al. (Hurt, Ouellet, & Thom, 1981; Hurt, Ouellet, & Wagar, 1981) pre-dated the Standard.

In the first 20 cases of the Austroads study, the majority of the riders wore jackets which were designed for motorcycle use. However, they were less likely to wear pants, footwear and gloves designed for motorcycle use. This observation aligns with previous studies (ACEM, 2004; de Rome et al., 2011; Hurt, Ouellet, & Thom, 1981; Lateef, 2002; Meredith et al., 2013) and indicates a need to provide a more desirable form of protection to these body regions. Few riders were wearing clothing that was labelled as complying with the European Standard, so there is no assurance as to the likely performance in a crash.

The performance of clothing observed to date has been variable, with riders being injured despite being fully protected. The mechanisms of injury observed among protected riders have also been variable. As illustrated in the cases presented, abrasion injury has occurred both by failure of the clothing during the crash and via interaction between the rider and the clothing i.e. by friction that occurs between the lining-skin interfaces. Clothing has also been observed to not perform well in preventing impact injuries such as fractures and internal injuries. This indicates the scope for improvement in protective clothing and potentially the scope for improvements to clothing standards. The missing piece of information is whether or not the clothing that allowed the injuries to occur would pass the Standard requirements and/or whether the standard is testing the materials under the same conditions that this clothing is being subjected to in the real world. This will be investigated in stage 2 of this project.

In the absence of having yet conducted the mechanical testing it appears at the least there may be some benefit in controlling the friction between the clothing lining-skin interface and currently this is not covered in EN13595. There also appears to be a clear need for greater attention to the protection provided in the chest and abdomen areas. The large number of impact injuries to the chest seen to date mirrors the results of an earlier study by Meredith et al. (2013) indicating there is a need to rethink the zoning of these regions in the Standard. Re-design of impact protection, airbag jackets, or the inclusion of chest impact protectors would also potentially reduce the occurrence of these injuries.

There were also a large number of pelvic injuries seen to participants in this study due to impact with the motorcycle tank. It is possible these injuries could be ameliorated through regulation of motorcycle tank design and or attention to this area of clothing within the standard. Currently the groin area of clothing is zoned as zone 3 or 4 and is therefore required to offer only low levels of protection.

The kinematic analysis in this study was limited by the self-reported nature of information. This meant that the specific body movements during the crash, such as sliding distance, and the causes of injury were based on estimation. The scene inspection helped to decipher the events of the crash; however, it was not always possible to pinpoint the exact location of the crash. Additionally, there was often no evidence of the crash at the site, and in the early cases, the exact crash site was sometimes difficult to identify. Participants are now required to provide coordinates of the crash through the use of Google maps to help determine the exact crash location. The use of police records is being explored as another method of gaining information about the crash and would be helpful to provide another perspective on the crash.

Riders were included in the study if they were admitted to hospital. This creates a possible bias in the results toward clothing which has not performed adequately in the crash by excluding clothing that protected the rider from injury. However, the ultimate goal is to assess the quality of the Standards and associated test protocols, so it is most important to assess whether clothing which has failed provide adequate protection to the rider in the real world would have been deemed satisfactory according to the current Standard. While not possible to arrive at unbiased risk estimates, given the lack of an appropriate denominator, the findings are invaluable in informing the development future, safer choices for the rider and pillion.

Another limitation of this study was that the clothing was not able to be inspected for all cases as the clothing has often been thrown out or sent to insurance companies. Out of the 70 items of clothing worn, 30 were inspected. The information provided by the participant on their clothing from the interview is often limited as the participant does not remember the clothing damage details. To increase the number of clothing inspected, researchers will travel to any location possible to view the clothing including the participant's house. It is also being investigated whether it will be possible to obtain clothing from insurance companies after the insurance claiming process is complete. To improve the quality of the data obtained about the clothing damage from the participant interview, a diagram has been included in the participant interview for the rider to draw on where the damage was to their clothing. In the planned mechanical testing, clothing identical to that being worn by the participants who do not surrender their clothing will be purchased and tested so at the least information about the performance of this clothing in the Standards tests will be collected.

Conclusion

The preliminary results presented here demonstrate the feasibility of the planned study to validate the requirements for EN13595. The results presented confirm observations from previous studies that while Australian riders wear protective jackets, they are less likely to wear protective motorcycle footwear and pants. Few items being worn by Australian riders have been identified as complying with the European Standard. Early observations also suggest there is much room for improvement in the quality of protective clothing as well potential improvements in the requirements of the current European Standard.

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