

## Motorcycle protective clothing

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### Abstract

This paper describes a comprehensive review of research into the safety value of motorcycle protective clothing. The project is funded by the MAA to provide guidance for motorcyclists on the benefits of different features when purchasing protective clothing.

Protective clothing is available with a variety of features, however apart from advertising material, there is little information about the relative benefits of such features to guide purchasers. While protective clothing is unlikely to prevent serious injury in high impact crashes, it can reduce gravel rash, friction and exhaust pipe burns, stripping of skin and muscles, torn or severed ligaments, some broken bones and the infection of wounds. Clothing designed specifically for motorcyclists can contribute to personal comfort and assist in reducing fatigue and dehydration.

Australian manufacturers and importers are not subject to any mandatory standards in relation to protective clothing apart from helmets. Local purchasers have no information and no guarantees as to whether such products in fact provide the claimed protection. In addition, Australian motorcyclists are also disadvantaged by the lack of information about the relative benefits of different features of clothing. Different fabrics and designs are widely promoted for their protective value, but information about the testing of such claims is difficult to obtain.

The methodology involved documenting the range of features available in protective clothing and establishing what was known about the safety benefits of those features. Sources included:

1. Research reports on motorcycle crashes, the types of injury sustained in relation to protective clothing worn;
2. Research reports on tests of materials used in motorcycle protective clothing;
3. The European Standards for motorcycle Personal Protective Equipment (PPE);
4. Patent applications for the design features and materials used in motorcycle protective clothing; and
5. Manufacturers, importers and retailers.

The final product will be a user-friendly guide on protective clothing for motorcyclists which will be published on the MCC motorcycle safety web site.

### **Introduction**

Any discussion of motorcyclist clothing should distinguish between the different purposes for which it may be worn. Motorcyclists clothing may:

1. Prevent or minimise injury in the case of a crash
2. Protect from ambient conditions – wind, rain and temperature
3. Draw the attention of other motorists
4. Make a desired fashion statement.

My focus here is on protection from injury, although comfort and conspicuity are also safety issues for motorcyclists. The issue of fashion is not entirely trivial, motorcycle clothing can be very expensive and one of our objectives with this project is to try to help riders distinguish between clothing features that really are just fashion and those that have some genuine protective merit.

My discussion does not include helmets because they are mandatory in Australia and usage is very widely accepted. Protective clothing generally includes gloves, boots, a long sleeved jacket and pants, or one piece suit, made of leather or other fabric with high abrasion and tear resistance. Most items, these days will also include some impact protectors which are padding and/or plates to absorb or distribute force at specific impact points. The challenge is to provide protection from injury as well as from the elements (wind, rain, cold and heat) without restricting ease of movement or creating stress fatigue.

### **Projection from injury**

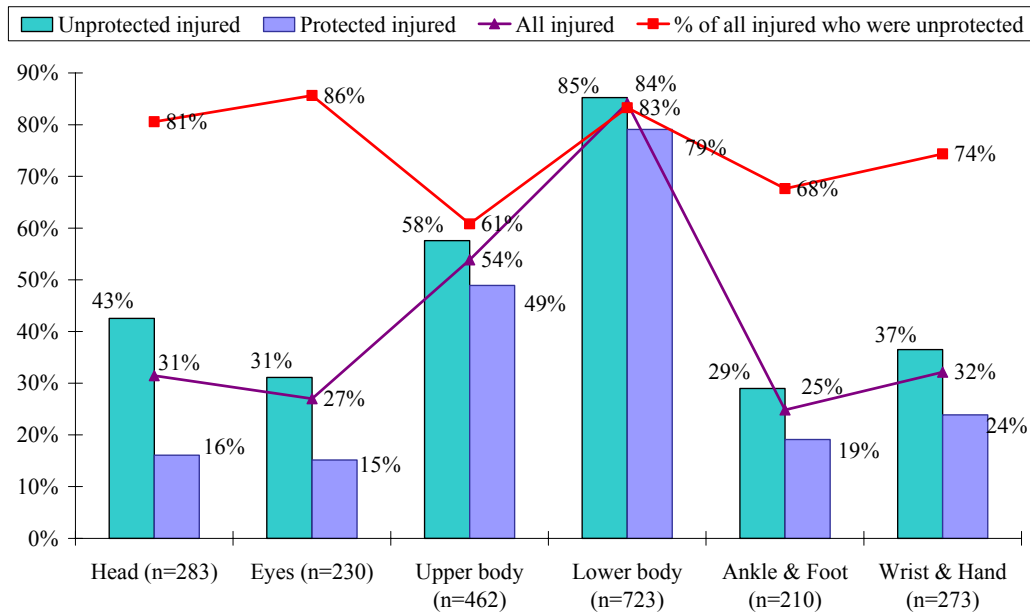
The use of protective clothing to reduce injury to motorcyclists has been the subject of scientific discussion at least since 1976, when Feldkamp reported on protective clothing being associated with a reduction of serious injuries in motorcycle crashes in Germany (Feldkamp, et al 1976). Since then a number of studies have confirmed the value of protective clothing in reducing the frequency and extent of abrasions and lacerations of the skin and soft tissue in motorcycle crashes (Hurt, Ouelett & Wagner, 1981; Schuller et al., 1982 & 1986; Otte & Middlehavre, 1987; Hell & Lob, 1993).

Hurt, Ouellet & Thom (1981) in California, under took the first, large scale comprehensive study of motorcycle crashes in 1979. They collected detailed injury data for 900 motorcycle crashes using on-scene, in-depth investigations by specialist teams. They documented the type of clothing worn and classified it as either protective or non-protective.

Figure 1 illustrates their findings and compares the proportion of protected and unprotected riders who sustained injuries compared to the total injured. For example, 31% of all motorcyclists suffered head injuries, but these included 43% of those who were not wearing helmets compared to only 16% of those who were. In all, 81% of all those who sustained head injuries, were unprotected. A similar picture unfolds for hands and feet where 74% and 68% of all injuries occurred for riders who were not wearing gloves or boots respectively. There was less difference in the proportions injured between those who were and those not wearing motorcycle clothing on the upper and lower body. It is important to remember that this study was at a time when motorcycle clothing was less specialised, and the researchers' definitions of protective clothing included items

such as heavy denim jeans because they were sturdy and might be expected to provide some level of protection.

Figure 1. Proportion of injured protected and unprotected motorcyclists by area of injury (derived from Hurt et al, 1981).



In a similar study in Munich, Schuller et al. (1986) interviewed 264 injured motorcyclists immediately after their crash and then some two years later. He subsequently found a reduction in hospitalisation by an average of 7 days for those who had worn leather protective clothing compared to those who had not. The protected motorcyclists were also able to return to work or school on average 20 days sooner and were 40% less likely to suffer a permanent physical defect than their unprotected counterparts. He concluded that motorcycle clothing is significantly effective in preventing or reducing at least 43% of injuries to the skin and soft tissue with a 63% reduction in deep and extensive injuries.

More recently Otte et al (2002), has found that riders wearing protective clothing had significantly fewer leg injuries in crashes at the same relative speed (eg 40% vs 29% injury free at speeds between 31-50 km/ph). He also identified a significant benefit in reduction of foot injuries for riders wearing high boots. Overall he also reported that riders without protective clothing sustained injuries in collisions at lower speeds (80% at < 50 km/h compared to 80% <60 km/h for riders with protective clothing).

There are a number of other studies which confirm the benefits of motorcycle protective clothing, particularly in relation to soft tissue injuries (Zettas et al, 1979; Schuller et al, 1986, Otte & Middlehavre, 1987; Otte et al 2002; Hell & Lob, 1993). In addition to cuts and abrasions, protective clothing can prevent or reduce many serious injuries including exhaust pipe burns, friction burns and the stripping away of skin and muscle. A major benefit of protective clothing appears to be in reducing the risk of infection from wound contamination and consequent complications in the healing of severe injuries. Otte et al (2002) also found that

impact protectors reduced the incidence of complex fractures in favour of simple closed fractures which are easier to treat.

These are important and worthwhile benefits but there is a limit to the extent that protective clothing can prevent fractures or other serious injuries in high impact crashes or even some low speed crashes. Otte et al (2002) reported almost no difference in the distribution of MAIS (Maximum Injury Severity) grades between injured motorcyclists with and without protective clothing.

The limitations for injury prevention and reduction is summed up in the report on motorcycle safety by the European Experimental Vehicles Committee in 1993 (EEVC, 1993). They noted that protective clothing cannot, so far as is known, significantly mitigate:

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

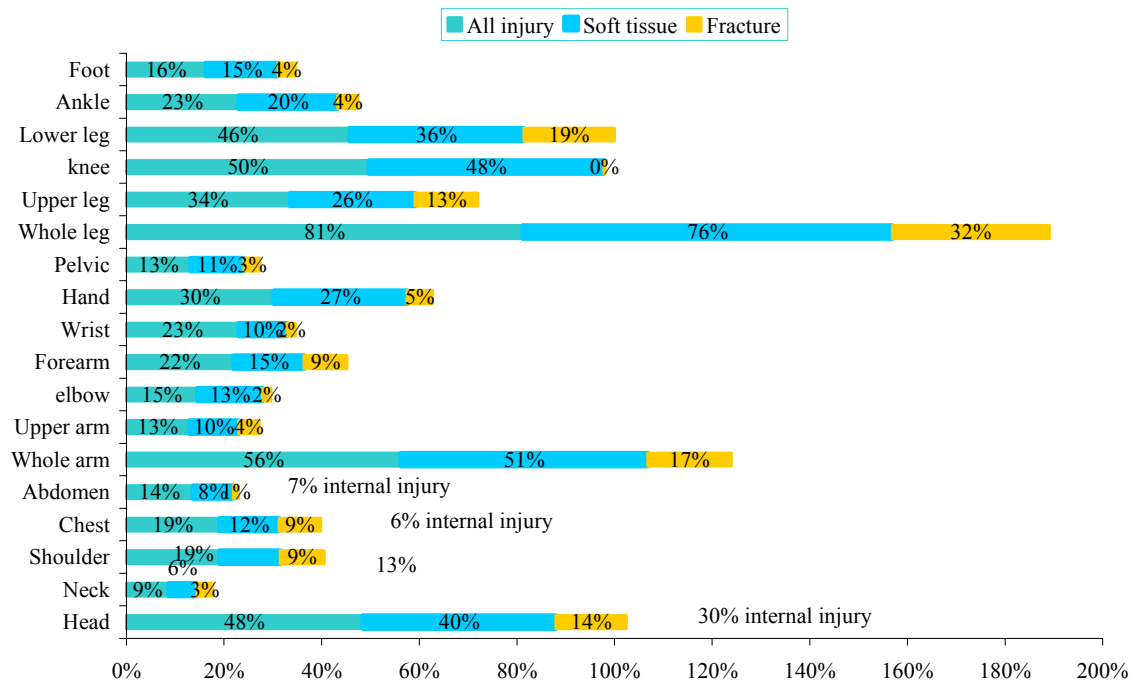
The question for Australian motorcyclists is:

1. Which parts of the body should be protected?
2. What sort of protective clothing will make a difference?

### **Which parts of the body should be protected?**

In their 1993 report, the European Experimental Vehicles Committee provided the following figures on the distribution of injuries by body part as reported by Otte & Middlehavre, (1987), which the Committee concluded were fairly characteristic of findings by other accident investigators (EEVC, 1993). The general pattern of injuries reported here is similar to other contemporary studies in USA, UK and Germany (eg Hurt et al, 1981; Craig et al, 1983; Schuller et al, 1986).

Figure 2. Motorcycle injury patterns (Otte & Middlehavre, 1987).



It is evident from this data that the legs are the area most commonly injured, (81% of casualties). Legs are also the site of most fractures (32%) and most soft tissue damage (76%). Note the percentages do not add up to 100% as many cases suffered injury to more than one part of the body.

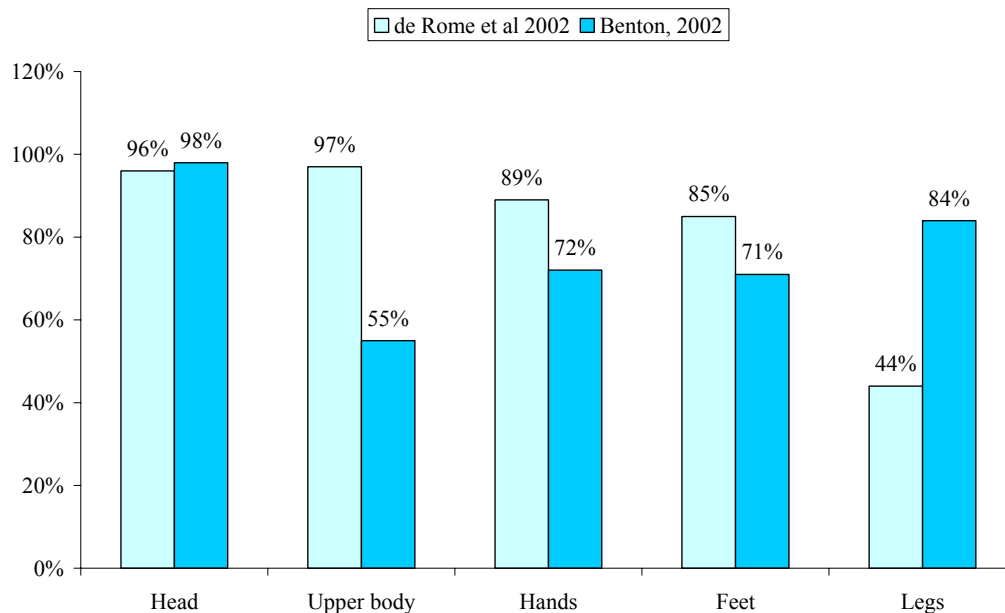
### What do Australian motorcyclists wear?

Injury patterns over the past 20 years consistently and conclusively demonstrate that the most common and serious injuries are to the legs, and yet it is apparent that this is the area least likely to be protected. Surveys of motorcyclists suggest that many do not appear to appreciate the relative risks to different parts of their bodies. While almost all now wear an approved helmet due to the mandatory helmet laws across Australia, legs, feet and hands are less likely to be adequately protected.

In a survey of 796 motorcyclists in NSW, de Rome et al (2002), found that one in ten riders did not wear gloves, 15% did not wear motorcycle designed boots and 57% did not wear motorcycle pants. Over half reported normally wearing jeans when they rode (54%). The situation was markedly worse for pillions – 40% did not wear motorcycle designed boots and 64% did not protect their legs. Almost two thirds (64%) of the de Rome et al sample were members of motorcycle clubs indicating a high level of involvement in the sport and possibly a higher level of awareness of the value of protective clothing. Motorcycle club members were more likely to wear motorcycle boots (89% vs 75%) and motorcycle pants (52% vs 36%) than were non-club members. However if one can assume that club members might be expected to be more aware of the value of protective clothing, it is disappointing that almost half still normally wear jeans.

A similar study of 505 motorcyclists, conducted for the NSW Roads and Traffic Authority, found lower levels of usage of protective clothing amongst a sample that were predominantly (78%) non-club members (Benton, 2002). Figure 3 illustrates the proportion of riders from the two studies who wore motorcycle protective clothing.

Figure 3. Motorcyclists use of protective clothing in New South Wales (de Rome et al, 2002, Benton, 2002).



Note: The apparently high incidence of motorcyclists protecting their legs reported by Benton, is misleading as it refers to all who wore long trousers, but does not distinguish between regular trousers and motorcycle protective trousers.

Short trips (30%) and hot weather (26%) were the situations where riders most commonly report not always wearing protective clothing (Benton, 2002). Heat discomfort as a disincentive is understandable, particularly in the Australian climate, and heat fatigue is in itself a safety issue for a motorcyclist.

Traditionally motorcycle protective clothing has been made of leather, which has disadvantages for every day use. Leather motorcycle suits are hot and the close fitting design makes them uncomfortable for wearing except while riding, so motorcyclists have the added inconvenience of having to change clothes once they arrive at their destination.

#### **What sort of protective clothing will make a difference?**

Research into protective clothing has followed two paths. One has been to identify suitable materials in terms of abrasion and tear resistance while retaining manoeuvrability, temperature control and comfort (eg Prime 1984; Woods, 1996).

Under the EU Standard for motorcycle clothing, abrasion resistance is required to be between 4 and 7 seconds over high impact areas of the body. Under the test procedures specified in the Standard, a single layer of 1.4 mm cow hide will last 5.8 seconds, whilst 200 gsm denim is abraded away in 0.6 of a second (SATRA, 2003). In high impact areas of the body, even leather must be in double or triple layers to comply with the EU standards.

The other path has been the search for a way to shield the rider from the impact of a collision. Essentially the objective is to devise a means of absorbing and distributing the energy in an impact to divert pressure and bending stress on the skeleton, to provide crush resistance particularly for the feet and ankles and to prevent penetration by sharp objects. Helmets have demonstrated the feasibility of achieving impact protection for the head, but it has proved a far more difficult task to develop effective

armour for the rest of the body. The limiting factor has been the need to ensure it does not detract from the wearer's fitness to ride either in terms of comfort or manoeuvrability (Koch, 1996).

A result of much work in the area has been the development of standards for the production of motorcycle protective clothing.

### **European Standards for motorcyclists protective clothing**

There are now European Standards which apply to motorcycle jackets, trousers, one or two piece suits, impact protectors, boots and gloves. These Standards set minimum levels in Europe for the construction and test performance of all motorcyclists' clothing, which claims to provide protection from injury. They identify the following body regions as impact areas: shoulder, elbow and forearm, hip, knee and upper tibia, knee, upper and middle tibia, and the front of the lower leg.

By law, in Europe, motorcycle clothing can only be designated "protective" if it is capable of providing protection from injury. The Personal Protective Equipment Directive (PPE, 89/686/EEC) requires that any clothing or equipment sold or provided as a source of protection from injury must be categorised as protective (PPE) and comply with the relevant European Standard. Motorcycle clothing that is only intended to provide protection from weather conditions is not included as PPE.

However, it would appear that the manufacturers are not rushing to have their products tested and approved. The actual Standards were issued only late in 2002, so it may be only a matter of time before manufacturers succumb to market pressure and engage in the compliance process. In the absence of any objective basis for comparison, consumers are forced to rely on manufacturers' claims and advertising or product reviews in motorcycle magazines.

A recent study subjected leather suits from 18 of the main European manufacturers to tests based on the EU standard (MCN, 21 May 2003). Only 4 passed with full marks, and while some of the most expensive made to measure suits failed to meet the EU standard, other cheaper suits, a quarter of the price did measure up. Two thirds failed the burst test due to either thread failure and/ or leather failure and impact protectors failed in 8 cases. A textile suit tested at the same time also failed on all tests. Only 3 of these manufacturers of leather suits (Carrera, BKS and Hideout) were at that stage submitting their products for CE certification (MCN 21 May, 2003). Earlier tests of motorcycle boots found that none passed the impact resistance test and only half passed the crush resistance test (MCN, 1997). Despite these results, the tests do suggest that most manufacturers have little to fear from putting their products through the CE certification process and could achieve compliance with relatively few modifications to their products.

A briefing paper issued by the British Motorcyclists Federation (BMF) lists only 17 companies who have obtained certification. They include manufacturers of motorcycle boots, impact protectors and gloves as well as leather and textile clothing (BMF, 29 May 2003).

### **Where to from here**

According to the Motor Accidents Authority of NSW, the average injury cost for a motorcycle casualty in NSW is almost double that of the average road casualty (\$99,381: \$52,817 in 2000, personal communication MAA, 2002). We know that many riders do not wear adequate protective clothing. One of the objectives of this

project is to provide motorcyclists with guidance as to how they should best spend their protection dollars, but the information is not readily available.

There are a number of textile products and designs that are promoted as being suitable for our climate, but consumers have no means of assessing their protective value. We need to establish standards for protective clothing that are appropriate to Australian conditions and to consider the most effective means of monitoring and enforcement. The EU Standards are the product of some ten years of consultation and debate. They place the onus for compliance on manufacturers and not riders and provide a useful model which we may adopt or adapt.

Standards Australia have issued guidelines for manufacturers on the production of motorcycle protective clothing (Standards Australia, 2002). However, the guidelines are not standards. They are not mandatory nor is there any requirement for manufacturers to provide information to the consumer about their application of the guidelines.

Much of the motorcycle clothing sold in Australia comes from Europe, however local importers and distributors are not required to comply with CE labelling requirements. We need to work with industry to ensure that the benefits of the EU standards can flow through to Australian motorcyclists.

International motorcycle crash research has demonstrated a benefit in the use of motorcycle protective clothing, however focus has been on leather products, which are largely unsuited to Australian conditions. The comparative benefits of textile alternatives do not appear to have been investigated in crash injury outcomes anywhere in the world. We need to undertake detailed crash and injury studies in order to map the pattern of injuries associated with different types of impacts and use of protective gear.

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