# Motorcycle protective clothing: heat discomfort and physiological strain

## Grantees: L. de Rome, O. Troynikov, N. Taylor, J. Brown

## Introduction

Good quality motorcycle protective clothing can reduce the risk and severity of injury in crashes, but can be uncomfortable to wear in hot conditions and many motorcyclists ride unprotected in summer.[1-3](#_ENREF_1) Until recently the implications of heat discomfort for rider safety had not been investigated. In 2014 the NRMA ACT Road Safety Trust funded a series of Australian studies into the thermal management properties of motorcycle protective clothing and their physiological and cognitive impact in hot conditions.

**Laboratory tests of clothing properties.** The first study used laboratory tests to determine the thermal management properties of motorcycle clothing and whether effective injury protection necessarily required highly insulating materials.[4](#_ENREF_4),[5](#_ENREF_5)

A thermal, sweating manikin was used to test the thermal and water-vapour resistance of ten motorcycle protective jackets and pants representing a range of textile, leather and reinforced denim products. The garments were then tested for abrasion resistance to see how long they would last sliding on a road.Tests were conducted as specified by the European Standard for motorcycle protective clothing impact abrasion resistance.[6](#_ENREF_6)

Garments varied widely in thermal management but all were found to be thermally insulating with low water vapour permeability. Together these factors limit the body’s capacity to lose excess heat by restricting the transfer of dry heat and the evaporation of sweat. High vapour permeability of clothing enables the body to cope better with dry heat, because it allows the transfer of water vapour (sweat) away from the skin and reduces the risks of heat stress.[4](#_ENREF_4)

On the tests of abrasion resistance, eight of the ten jackets and seven of the pants failed to achieve the minimum (4 secs) impact abrasion resistance required by the European Standard.[6](#_ENREF_6) The very low correlation (r=0.18) between abrasion resistance and vapour permeability suggests that injury protection need not necessarily be achieved at the expense of thermal comfort.[4](#_ENREF_4),[5](#_ENREF_5)

The failure of the majority of garments to pass the minimum abrasion resistance requirements of the European Standard for motorcycle protective clothing is a critical finding which needs to be addressed urgently. The wide variation in thermal management between garments also suggests that thermal comfort can be improved.

**Climate chamber trials** The second study compared the physiological and cognitive impact of wearing motorcycle clothing compared to street clothes under controlled climate conditions.[7](#_ENREF_7),[8](#_ENREF_8) Volunteers completed a series of trials under conditions controlled to simulate motorcycle riding in an Australian summer. Sun and wind were simulated by using overhead infra-red lamps and a high velocity fan. Relative humidity was 40% for all trials. Participants (n=12) completed 90-min trials under three ambient temperature conditions (25°C, 30°C and 35°C).

Volunteers were screened to ensure their fitness for the trial (see footnote).[[1]](#footnote-1) Participants wore the least breathable motorcycle suit from the laboratory tests in the experimental trials (25°C, 30°C and 35°C) and street clothes (jeans, long-sleeved t-shirt) for the control trial (25°C). Helmet, gloves and boots were worn in all trials. Heart rate, deep-body temperature (auditory canal) and skin temperature were continuously monitored. Self-reports of thermal comfort were collected at regular intervals. The final trial conducted at 35°C included computer-based cognitive tests consisting of reaction time[9](#_ENREF_9), mood[10](#_ENREF_10) and perceived workload.[11](#_ENREF_11)

The results demonstrated significant thermal strain associated with motorcycle protective clothing under hot conditions. Under temperate conditions (25oC), there was no difference in body core temperature between wearing street or motorcycle clothing, but sweat production doubled and heart rate and skin temperature increased significantly with motorcycle clothing. Under hotter conditions (30oC and 35oC) there were significant increases in heart rate, body core and skin temperatures. In the hottest condition participants’ reaction and movement times slowed and the number of premature responses increased. As the physiological indicators increased, riders perceived the work-load of the trial to increase and their mood changed, feeling less alertness, contented and calm.

This study was conducted in the climate chamber laboratory to enable the impact of the selected motorcycle garment to be tested while controlling for both the environment and riders’ physiological condition. The results strongly suggest there is potential for riders’ ability to ride safety to be compromised when wearing highly insulating protective clothing in average Australian summer conditions.

**On-road riding trial.** Finally the impact of different riding environments on riders physiological, cognitive and psycho-physical responses were compared when wearing motorcycle protective clothing under real-world riding conditions.[12](#_ENREF_12)

Volunteer riders wearing their own motorcycle protective clothing, were randomly assigned to 90-min. rider on either an urban commuter route or rural recreational route in the Australian Capital Territory and NSW region. Skin temperatures and humidity inside their clothing were monitored continuously by wireless sensors attached to the skin. Self-reports of comfort were recorded at departure, two pre-determined 5-min rest stops and on return.[13](#_ENREF_13) Computer-based tests of reaction time[9](#_ENREF_9) were conducted before and after the ride, and tests of mood[10](#_ENREF_10) and perceived workload[11](#_ENREF_11) at the end of the ride.[12](#_ENREF_12)

Unexpectedly cool weather on the day of the ride (21oC with 37% relative humidity) meant that riders were not exposed to high ambient temperatures. Riders’ mean skin temperatures decreased but the relative humidity inside their clothing increased, confirming the importance of vapour permeability. Riders’ subjective reports of temperature and wetness sensation were consistent with the objective measures, but there was little discomfort reported and this did not vary over the duration of the ride. Comparison between groups found that those riding the urban route were objectively warmer and wetter, and subjectively less comfortable than those on the rural route. Comparing before and after the ride, urban riders’ reaction and movement times had slowed and errors increased compared to rural riders. On completion of the ride urban riders also reported greater perceived workload and mood disturbance, feeling less alert and contented than did rural riders.

**Discussion**

The laboratory studies provide the first objective measures of the thermoregulatory performance of the protective clothing commonly worn by Australian riders. The cognitive and psychophysical tests found significantly slowed reactions, increased perceptions of work load demand and mood disturbance associated with increasing thermal burden. Together these findings provide evidence that some types of motorcycle protective clothing may significantly compromise rider safety when worn in average Australian summer conditions.

The on-road trial demonstrated the importance of vapour permeability even in cool weather. In addition to the differences between urban and rural riders in thermal comfort, those observed in workload and mood is also of interest. Those routes were selected in order to contrast low speed, high complexity urban riding with higher speed, but low complexity rural riding. These results suggest that the complexity of urban riding may place higher physiological demands on riders than less complex but higher speed rural roads. Further work is required to investigate the features of urban versus rural riding environments and their impact on rider fatigue and mood as a potential factor in crashes.

Further work is required to establish the effectiveness of clothing features such as ventilation ports on thermal discomfort. The results will determine thresholds for the thermal qualities of motorcycle clothing required for an acceptable compromise between user comfort and injury protection. The outcome will inform industry and consumer information programs about the performance required of motorcycle protective clothing suitable for use in hot conditions.

## Acknowledgement:

## This series of studies was funded by the NRMA ACT Road Safety Trust. The abrasion resistance tests were conducted by Dr Chris Hurren at Deakin University. Dr Liz de Rome’s salary and the climate chamber trials were also supported by Australian Research Council Discovery Project DP140102866.

## References

**1.** de Rome L, Ivers R, Haworth N, Heritier S, Du W, Fitzharris M. Novice riders and the predictors of riding without motorcycle protective clothing. *Accid. Anal. Prev.* 2011;43(3):1095-1103.

**2.** Koch H, Brendicke R, eds. *Protective clothing: wearing patterns, knowledge and attitudes of motorcyclists.* Assen, Netherlands: Van Gorcum & Company; 1998. Rothengatter T, de Bruin R, eds. Road user behaviour: Theory and research.

**3.** de Rome L, Ivers R, Fitzharris M, et al. Motorcycle protective clothing: Protection from injury or just the weather? *Accid. Anal. Prev.* 2011;43(6):1893-1900.

**4.** Troynikov O, de Rome L. Thermal comfort features of ten commonly worn motorcycle suits. *(in preparation).* 2016

**5.** de Rome L, Brown J, Troynikov O, Hurren C. Abrasion resistance and thermal properties of materials use in motorcycle protective clothing. *(Paper in preparation).* 2016.

**6.** CEN. Protective clothing for professional motorcycle riders: Jackets, trousers and one piece or divided suits - Test method for determination of impact abrasion resistance. *EN 13595-2:2002*: European Committee for Standardisation, Brussels; 2002.

**7.** de Rome L, Taylor EA, Croft RJ, Brown J, Fitzharris M, Taylor NAS. Thermal and Cardiovascular Strain Imposed by Motorcycle Protective Clothing Under Australian Summer Conditions. *Ergonomics.* 2015:1-29.

**8.** de Rome L, Brown J. Motorcycle protective clothing: the cognitive and psychophysical concomitants of thermal strain. *(in preparation).* 2016.

**9.** Sahakian B, Owen A. Computerized assessment in neuropsychiatry using CANTAB: discussion paper. *J. R. Soc. Med.* 1992;85:399-402.

**10.** Bond A, Lader M. The use of analogue scales in rating subjective feelings. *Br. J. Med. Psychol.* 1974;47(3):211-218.

**11.** Byers JC, Bittner AC, Hill SG. Traditional and raw task load index (TLX) correlations: are paired comparisons necessary? In: Mital A, ed. *Advances in industrial ergonomics and safety.* Vol 1. London: Taylor & Francis; 1989:481-485.

**12.** de Rome L, Brown J, Troynikov O. Factors associated with the thermal comfort of motorcyclists wearing protective clothing under real world riding conditions. *(in preparation).* 2016

**13.** Gagge AP, Stolwijk JA, Hardy JD. Comfort and thermal sensations and associated physiological responses at various ambient temperatures. *Environ. Res.* June, 1967 1967;1(1):1-20.

1. Participants were asked to drink 15mL.kg-1 water before bed the night before the trial, eat a high-carbohydrate, low-fat evening meal and breakfast, and to abstain from heavy alcohol consumption, tobacco or strenuous exercise for 12 hours and caffeine two hours prior to testing. [↑](#footnote-ref-1)