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Detecting motorcycle rider local physical fatigue and discomfort using surface electromyography and seat interface pressure

V. Balasubramanian [a,*], M. Jagannath [a,b]

[a] Rehabilitation Bioengineering Group (RBG), Department of Engineering Design, IIT Madras, Chennai 600036, India
[b] Department of Biomedical Engineering, SMK Fomra Institute of Technology, Chennai, India

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ABSTRACT

Whilst motorcycling is an activity of pleasure in most parts of the world, in India it is a regular mode of commuting. Incidence of fatigue is substantially higher among motorcycle riders than drivers of other modes of transport. The objective of this study was to detect physical fatigue due to motorcycle riding for an hour using surface electromyography (sEMG) and seat interface pressure. Twenty healthy male participants performed 60 min of motorcycle riding in a low traffic density environment. Muscle activity was recorded bilaterally from extensor carpi radialis (ECR), biceps brachii (BB), trapezius medial (TM), sternocleldomastoid (S) latissimus dorsi (LD) and erector spinae (ES) muscle groups. Interface seat pressure distribution was monitored using a pressure mapping system. Results showed that participants have significant ($p < 0.05$) physical fatigue in TM, LD and ES muscle groups during 60 min of motorcycle riding. Seat pressure distribution was found to be non-uniform during the course of motorcycling. Results suggest that the impact on local physical fatigue and seat discomfort are probably due to static seating demand and prolonged sitting posture balance required to ride the motorcycle for an hour.

1. Introduction

The purpose of this study was to better understand the physical aspects of fatigue among riders due to motorcycle riding. This paper encompasses the potential use of surface electromyography (sEMG), seat interface pressure, heart rate and blood pressure to quantify rider fatigue. This paper will provide an objective assessment of rider fatigue that has important implications for preventing fatigue-related accidents.

There were two main motivations for the present study. First, while a number of studies have concerned fatigue of drivers and pilots, there is little that has focussed on fatigue associated with motorcycle riding. Secondly, there has been increasing attention towards examining seat interface pressure which is reported to cause significant neurovascular compression within the perineum (Bressel, Reeve, Parker, & Cronin, 2007).

Whilst motorcycling is an activity of pleasure in most parts of the world, in India it is a regular mode of commuting. Motorcycles are used at work environment for various activities such as fast food delivery, deliver posts and police patrols. However, motorcycle has also been shown as a statistically unsafe method of personal transport (Shahar, Poulter, Clarke, & Crundall, 2010). Motorcycles are characteristically unstable and need to be controlled by the rider to travel firmly. When compared to automotive drivers, the direct exposure to the environment, noise and vibration dangerously affect the person who rides the motorcycle (Walker, Stanton, & Young, 2006). Hence, motorcycle riding attracts higher risk of accidents than

* Corresponding author. Tel.: +91 (44) 2257 4117; fax: +91 (44) 2257 4732.
E-mail addresses: chanakya@iitm.ac.in, chanakya@live.com (V. Balasubramanian).

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car travel (Horswill & Helman, 2003). Number of researchers have examined rider behaviour and have attributed several factors such as rider age, gender, circadian rhythms, experience, type of road and characteristics of the motorcycle to increase the risk of accidents among motorcycle riders (Haworth & Rowden, 2006).

The world health organisation (WHO, 2007) estimated that increase in global deaths between 2002 and 2030 will be predominantly due to the road related accidents. In India, 35.5% of the total accidental deaths (natural or unnatural) in 2009 were caused by road accidents (GoI, 2010). The Planning Commission of India had estimated the societal cost at INR 550 billion (USD 12 billion) on account of road accidents in India. When passenger transport is considered, a huge number of researches have been conducted to analyse the road accidents. The Government of India had assessed that 20.7% of total accidental deaths were riding on motorcycle, 19.8% were occupants of truck/lorry, 10.1% were killed while travelling in buses and 9.2% were travelling in car. It was observed that motorcycle has the highest percentage share of road accident among all road users (Mondal, Dalela, Balasubramanian, Sharma, & Singh, 2008).

Motorcyclists are exposed to excessive physical demands during riding that may have impact on rider fatigue (Motorcycle Council of North South Wales, 2006). The Motorcycle Council of New South Wales (2005) states that sitting in the same position with restricted movement for prolonged periods can lead to muscle stiffness and reduced blood flow, resulting in discomfort and possibly fatigue. This emphasises a need for an effective rider fatigue research for the development of countermeasures to reduce road accidents (Elliott et al., 2003). The existing methods of estimating rider fatigue are limited to subjective experience/observations and objective measurements of vehicle parameters like steering torque, shock absorption level, acceleration, etc. during riding. These parameters estimate same fatigue for all riding postures. The subjective experiences of fatigue have not always been reliable in the literature (Williamson, Feyer, Friswell, & Finlay-Brown, 2000).

The objective measurement of physical fatigue can occur in two basic mechanisms, central and local. In central physical fatigue, proximal motor neurons of the brain and spinal cord are involved. However in local physical fatigue, motor units of peripheral nerves, motor endplates, and muscle fibres are affected (Asmussen, 1979). Increase in power of sEMG signal in the frequency band of 15–30 Hz is a more reliable index of fatigue than the median frequency, total power or peak amplitude (Balasubramanian & Adalarasu, 2007; Sparto, Parnianpour, Barria, & Jagadeesh, 2000). Hence, the present study was conducted as a remedial measure to detect local physical fatigue as measured by sEMG, due to motorcycle riding in a monotonous condition such as low traffic density.

The term "seat discomfort" is typically used to define the long-term effect of a seat on a human body; that is, the sensation that commonly occurs from sitting on a seat for a long period of time. A great deal of research has been performed in recent years to find objective measures of pressure change rate and pressure distribution for predicting seat discomfort perception. Our study also sought to gather information about the motorcycle rider's experiences of seat discomfort. Other measures of physical exertion such as heart rate, systolic and diastolic blood pressures were monitored as potential indicators of fatigue (Egelund, 1982; Hartley & Arnold, 1994).

Hence, in view of the limited resources available about the rider fatigue, in this study, we considered the fatigue outcome measures such as examination of muscle activity, seat interface pressure, heart rate and blood pressure. Our interest was to develop a methodology on comprehensive measurement of rider fatigue in order that future design directions may improve rider performance and safe riding.

2. Materials and methods

2.1. Participants

Twenty male participants volunteered in this study. Participants' mean age, weight, height were 22.5 ± 3.5 yr, 68.3 ± 10.1 kg and 1.75 ± 0.06 m respectively. The participants chosen for this study were required to be free from low back pain for a period of at least 6 months prior to taking part in the study. Furthermore, participants were habituated to frequent riding of at least 60 min daily or more prolonged weekly exposures. All participants held light motor vehicle (LMV) license with minimum of two years experience. All participants signed written informed consent prior to entering the study. Then the on-road riding session was performed for 60 min. All participants rode the same commuter type motorcycle (i.e., one has an erect posture) in a motor-way environment with low traffic density. All experimental procedures for this human volunteer research were performed in a controlled environment. The experimental set up is shown in Fig. 1.

2.2. Fatigue outcome measures

The physical aspects of fatigue were determined in order to accurately validate the motorcycle rider's local muscle fatigue and seat discomfort. Hence, simultaneous recording of the following signals were obtained during on-road riding.

2.3. sEMG analysis

The muscle groups were chosen based on preliminary studies for implication in riding, intensity of the signal and the accessibility of the muscle for electrode application. The following muscle groups were evaluated bilaterally for this study: extensor carpi radialis (ECR), biceps brachii (BB), trapezius medial (TM), sternocleldomastoid (S), latissimus dorsi medial