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Original Article

Risk Factors of Muscular Discomfort among Motorcyclist- Review Article

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Abstract

Background: Motorcycle has been one of the vital modes of transportation worldwide. It is quite difficult to identify the risk factors that affect muscular discomfort among motorcyclist due to not much research having been carried out on the motorcyclist. The purpose of this study was to have a better understanding of the risk factors of muscular discomfort among motorcyclist due to motorcycle riding.

Method: Five databases were searched based on keywords that related to the risk factors might cause discomfort among motorcyclist. The research screened covered years between 1973 until 2013. In order to identify and classify research studies, specific keywords were identified and used in order to guide the discovery of relevant studies.

Result: As overall, five risk factors were identified that might affect the muscle activity and cause discomfort on various parts of body among motorcyclist. Risk factors such as biological, environmental, vehicle, physiological and life activities factors were related to each other and might contribute to the discomfort among motorcyclists during riding process.

Conclusion: This review was done to relate risk factors of muscular discomfort among motorcyclist, as there is currently not much information available on the riding and muscular discomfort of motorcyclists in Malaysia.

Keywords: Risk factors, Muscle, Discomfort, Motorcyclist, Motorcycle

Introduction

Motorcycles are the main mode of transport for the majority of people in many low and middle-income countries and the fastest growing sector of motor vehicles sales globally. Their presence on the roads is mirrored in the increasing number of motorcycle crash casualties in both high and low-income countries (1). The reason behind the increase in number of commercial motorcycles is the fact that motorcycles are sold at cheaper prices than most other vehicles (2). Concerning the types of road transportation, statistics from the Road Transport Department of Malaysia, show that about half of the registered vehicles using roads are motorcycles (3, 4). Motorcycles are considered an essential part of Malaysian people's daily lives, as they contribute a very cost-effective (5) mode of transport.

Despite the fact that motorcycles are the most common mode of transport in Malaysia, only a few studies have been carried out on the context of motorcycle ergonomics, especially concerning the comfortability of motorcyclists during their riding process. The lack of research in this area is because motorcycles are a constrained workstation in which have limited available adjustment to improve the comfortability of the various sizes of motorcyclists (6).

Motorcycles are characteristically unstable and have to be controlled by the rider to travel immovably. This point when contrasted with automotive drivers, the direct exposure to the environment, noise and vibration dangerously affects the person who rides the motorcycle (7). A number of researchers have analyzed rider behavior and have attributed some elements, for example, rider age, gender, circadian rhythms, experience, type of road and characteristics of motorcycle to the increase of the risk of accidents among motorcycle riders (8).

The word ergonomics cover a broad discipline in a mixture of fields, including industrial and nonindustrial applications. The International Ergonomics Association (IEA) had defined ergonomics as a scientific discipline concerned with the understanding of the interactions between humans and other elements of a system, and the profession that applies theory, principles, data, and methods to design to optimize human well-being and overall system performance (9). Largely, the aims of ergonomics are to ensure that the human necessities for safe and efficient working are met in the design of work frameworks (10, 11). As for the setting of motorcycles, ergonomics provisions should upgrade (performance, safety and satisfaction) the interaction between the motorcyclists and the motorcycle in a typical riding environment. The comfortability or satisfaction of the human body is in fact an imperative factor in the current research and flow of innovative work of the automotive industry (12, 13). The terms comfort and discomfort are a unique estimation in the ergonomics field as they include the human perception (feedback) of the machine and work system environment. They are additionally troublesome to characterize because they involve both objective and subjective measurement (10). However, some researchers define "comfort" as a lack of discomfort (14). As for the motorcyclists, the comfort and discomfort might be identified as discomfort symptoms on their body parts due to the sitting posture (14, 15) during the riding process. Overall, many musculoskeletal disorders start with humans experiencing discomfort in their body parts. The comfort and discomfort on the motorcyclist throughout the riding process might be related with an assortment of factors, such as the machine (motorcycle), the riding environment, or the motorcyclist themselves. Nevertheless, there is very little (or no) information about the motorcyclists' riding discomfort in Malaysia (16).

Based on diagram (Fig. 1) below, the purpose of this study was to have a better understanding the risk factors of muscular discomfort among motorcyclist due to motorcycle riding. This paper will relate the factors in terms of biological, environmental, vehicle, physiological, life activities, and motorcyclist's discomfort that has important implications on musculoskeletal disorders especially people that use motorcycle as their daily mode of transportation.

Method

Five databases such as ELCOSH, PubMed, Science Direct, Google Scholar and OSH-ROM were searched based on keywords that related to the risk factors might cause discomfort among motorcyclist. The research screened covered years between 1973 until 2013. Larger span of years would maximize the research and articles related to this review and ensured to cover all possible risk factors that might relate to the discomfort of motorcyclists during riding process. In order to identify and classify research studies, specific keywords (risk factors, muscle activity, muscle discomfort, discomfort, motorcycle, and motorcyclist) were identified and used in order to guide the discovery of relevant studies.

Results and Discussion

As overall, five risk factors such as biological, environmental, vehicle, physiological and life activities factors were identified and related to each other that might contribute to the muscle discomfort among motorcyclists during riding process.

Overview: 5 risk factors of muscular discomfort among motorcyclists

Biological factors

All commercial motorcyclists were males with the greater part at the age aggregation of 18-24 years (17-19). Age was categorized into identified typical motorcycle crash risk age groups (20). A study completed by Rome et al., (21) turned out with the association that were adjusted for potential confounders of injury identified from literature including the age and gender of the motorcyclist, type of impact for example road surface, other vehicle or fixed object, and the estimated speed of impact.

Majority of these motorcyclists endure discomfort in their body parts throughout the riding process. It has to be noted that the majority of female motorcyclists begin with higher discomfort symptoms concerning the relating factors such as BMI, riding hours and riding experience compared with male motorcyclists. Most male discomfort symptoms were concentrated on the buttock and upper body parts, whereas the female motorcyclists experienced discomfort in all their body parts (lower buttock and upper body parts). Moreover, the outcomes likewise highlight that the motorcyclists' discomfort was correlated with riding postures (16).

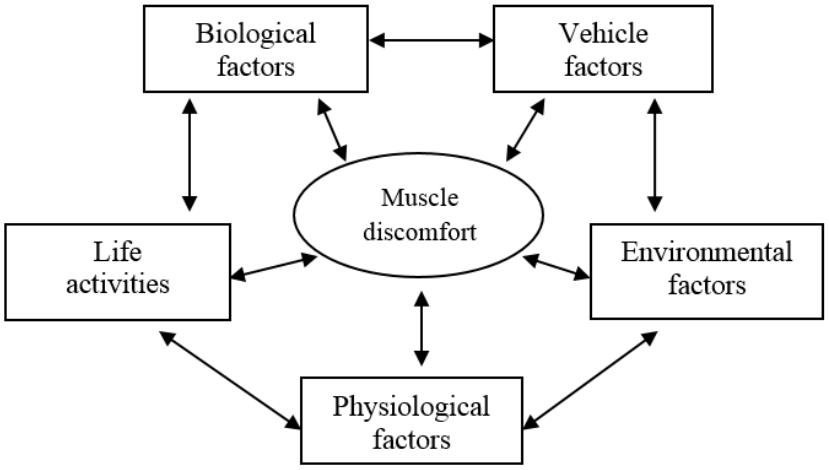

Fig. 1: A diagram to show five risk factors of muscle discomfort among motorcyclists

More than 50% of male and female motorcyclists suffer from discomfort symptoms during the riding process (3). The Motorcycling Fatigue Model (8) has brought up that biological factors such as age, weight, and height potentially contribute to fatigue in motorcycling. The motorcycle riding process involves a range of physical demands that may potentially influence the motorcyclist's physical fatigue (8, 22). The level of the motorcyclist's nutritional status such as body mass index, or BMI is viewed as a vital component. BMI can be used to represent the overall quality of human life, such as health status and productivity of workers, which indirectly, improve the development of the country's economic development (23).

The male and female motorcyclists have statistically significant differences between the discomfort symptoms and riding posture (3). However, for both sexes, the motorcyclists with the non-ideal posture have a higher rate of discomfort on a particular symptom. Females additionally have a higher number (total) of significance (on discomfort symptoms) compared with males motorcyclists. These discoveries raise the question of the compatibility of the motorcyclist with his/her motorcycle. The vehicle controls skills involved in riding a motorcycle are more complex and unpredictable compared to driving a car (24) and factors such as age, experience (25) and the user's physical body play a vital role throughout the riding pro-

cess, such as controlling the motorcycle and perceiving and responding to hazards.

Vehicle factors

Motorcyclists that are exposed to excessive physical demands during riding may have impact on their fatigue (rider fatigue) (26). The Motorcycle Council of New South Wales (27) states that sitting in the same position with limited movement for prolonged periods can lead to muscle stiffness and reduced blood flow, bringing about distress, resulting in discomfort and possibly fatigue. This accentuates a necessity for an effective rider fatigue research for the advancement of countermeasures to reduce road accidents (28). The existing methods of assessing rider fatigue are restricted to subjective experience or observations and objective measurements of vehicle parameters like steering torque, shock absorption level, and acceleration during riding. These parameters estimate same exhaustion for all riding postures. The subjective experiences of fatigue have not always been reliable in the literature (29).

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. 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. Other measures of physical exertion such as heart rate, systolic and diastolic blood pressure were monitored as potential indicators of fatigue (30, 31).

During typical on riding, a motorcyclist sits approximately in the same position throughout the journey for safe riding. The retention of posture and exposure to whole body vibration causes low-level muscle contraction that produces muscle aches and pain (32). Motorcyclists possibly encounter rider fatigue that may be potentially caused due to riding posture. Factors such as motorcycle's design parameters, for example height, angle and location of foot pegs, seat and handlebars and rider's physical dimensions such as anthropometry (overall rider height, torso, arm, thigh and leg length) determine the riding posture. Besides, these ergonomics constraints are factored in choosing motorcycles (33). Riders adopted a standard posture on the commuter motorcycle, which is the rider sits with a slight lean forward. Riders also reported physical discomfort at the end of 60 minute riding especially in bums, back and shoulders.

To maintain this constrained riding posture, muscles are in a continuous contractile state without intermittent relaxation, especially at the shoulder, neck, back and lower extremities (34, 35). Muscles with predominantly slow contracting motor fibers (Type 1) are more resistant to fatigue than those that are with fast contracting motor (type II) fibers (36). Muscles associated with the Type 1 fibers contribute in maintenance of posture and stability during activities, such as standing, walking, driving and riding. The percentage of type 1 fibers per chosen muscle groups are: *Biceps brachii* (46.5%), *Deltoid* (57.1%), *Trapezius* (53.7%), *Latissimus dorsi* (50.5%) and *Erector spinae* (56.4%) (37).

Motorcycles seats are designed to provide a balance between static and dynamic seating comfort (38). While riding, the static seated posture of the rider causes high intramuscular pressure that creates an obstruction of the blood supply. This results in a deficiency of oxygen to tissue cells that can lead to seat discomfort and possibly rider fatigue (39, 40). Differences in bums and thigh contours are influenced by personal attributes of the rider like seat contact area, posterior size and bone structure (41, 42). The present study shows sitting for an hour while riding the motorcycle yields dominant pressure distribution with peak pressure at the *ischium* region. These observed uneven pressure distribution over motorcycle seat have substantial contribution to cause rider discomfort.

The motorcyclist's riding posture is not static and changes during the riding process. An ideal riding posture will be similar to sitting in a chair or car with a static posture or some mechanical features in that particular system that can support the body concerning the posture adjustments or changes. However, current motorcycles do not have these features (43). Therefore, during the riding process, motorcyclists keep changing their posture to avoid the mechanical load and *ischemia* of tissue similar

to car drivers (14), which will contribute to the discomfort effects on the body parts.

For the neck and shoulder, there is strong evidence that non-neutral posture is associated with development of disorders in the region. For the arm, combinations of forceful actions awkward postures and movements are associated with the development of carpal tunnel syndrome and tendinitis (44). Motorcyclist's experience discomfort in their body parts during the riding process (3). The finding also highlighted that the current interaction of humans (motorcyclist) and machine (motorcycle) is not an ideal ergonomic philosophy. As stated by the previous study (43), motorcycles are considered a constrained and complex workstation. The limited space and the lack of mechanical features that can support the back posture will contribute to the mechanical load and ischemia of tissue (14) of the motorcyclists, which could then contribute to the discomfort effects on the body parts and could lead to major musculoskeletal disorders (MSD). Studies have stated that MSD are among the principal causes of activity limitation and long-term disability of human beings (45).

Environmental factors

The mechanisms for motorcyclist and discomfort are altogether different from those that apply to other road users. This distinction is no less obvious in the interaction of the motorcyclist and the road environment. Indeed a few issues of specific concern related to the road surface, road markings, traffic signals and crash barriers. Road surface conditions may show a risk and bring discomfort to motorcyclists such as slippery surfaces, repaired patches on the road, unevenness and road markings (14).

Sudden changes in road surface friction, which may cause instability in one-track vehicles, can be brought on by patches of diesel and oil on the road and in a few ranges by spillage of grease from standing buses. Instability can also occur when the road has been repaired by the use of bitumen, tar or other smooth sealants. Bitumen is a material utilized frequently in modern road repair and it is utilized mainly to fill and patch fissures by a process known as over-banding, to repair minor damage or to seal the edges of a patch repair. Bitumen is typically used in strips parallel and diagonal to the direction of the road and in some cases for more extensive road repairs to which the motorcyclist is particularly vulnerable (14).

Road markings can influence the riding dynamics of motorcycles considerably, contingent upon the quality of the markings and the weather conditions (14). Surface water brings about a loss of road grip (46). It is especially thin loss of grip and adhesion between the tyres and the road that causes problems for motorcycle riders.

In addition, negative attitudes towards helmet use (47) among other factors, explains the reason behind the reported low rate of use (48, 49). A few reasons for non-adherence and non-use of helmet include feelings of discomfort because of heat during the hot weather and lateral vision and hearing ability impairment (50). In spite of the advantages that motorcycles have, motorcyclists form a large proportion of those injured or killed on the roads. This is because they often share the traffic space with faster moving, heavier and bigger cars, buses and trucks and because they are less noticeable. In addition, their lack of physical protection makes their passengers helpless against being injured if they are involved in a collision (1).

Physiological factors

The discomfort brought on by physiological stress or anxiety is important because it can increase the likelihood that a motorcyclist might have an accident. It can cause (14):

a. Impaired sensation and accordingly recognition and a decrease in the accuracy of the control of movements.

b. Dulled reactions and expanded response times.

c. Impaired motor responses.

d. Increased fatigue

Physiological stress happens when physiological work has to be done to counter the discomfort, when there is a homeostatic physiological reaction to the changes the physical factors have caused in the body, or when a task is continued to the point when exhaustion happens. Robertson and Porter (33), showed that riders suffered the following stresses quantified in a survey:

a. 60% reported muscular stress
b. 33% reported thermal stress
c. 27% reported noise stress
d. 22% reported vibration stress

The preferred riding posture is categorized into two categories, which are ideal and non-ideal riding posture. The ideal posture was acknowledged as the best riding posture in the context of ergonomic sitting position. The pertinent position is considered ideal in this study is the flat position. Meanwhile, the other riding positions, which are long lordships, short lordships and slump, are considered as non-ideal position. The result indicate that most (>70%) of the respondents preferred the non-ideal riding position (14).

Previous findings has indicated that seating posture is regarded as potentially unhealthy and is considered as one of the major contributing factors for several musculoskeletal disorders (MSD) (51, 52). The sitting posture in a car (in this case, sitting posture on a motorcycle) involves more limited posture in a more restricted space, several controlling tasks and road vibration, which could lead to higher risk of MSD (52,53).

Life activities

An individual's motivation to undertake a healthier behavior can be divided into three fundamental categories: individual perceptions, modifying behaviors, and likelihood of action. Individual perceptions are factors that influence the perception of illness or disease: they deal with the importance of health to the individual, perceived susceptibility, and perceived severity. Modifying factors include demographic variables, for example age, gender, level of education, location, ethnicity, personality, socioeconomics and marital status as to perceive threat and cues to action. The probability of action discusses factors in probability of appropriate health behavior; it is probability of taking the recommended preventive health action. The combination of these elements causes a response that regularly manifests into action, gave it is joined by a rational alternative course of action (54).

Meanwhile, from a socioeconomic aspect, motorization rate rises with income. In wealthier countries, there has been dramatic growth for cars, but in many poorer countries, the increments have been principally in motorcycle and minibuses. Past studies have established that other factors, such as cost, productivity, reliability and ergonomics, play a prominent role in characterizing dimensions and layouts of workplaces and products (55-57). The product design (motorcycle) regarding the ergonomic context should involve the definition of physical references and layouts of components, taking into accounts the adequacy of posture and positioning of controls according to function, ability to reach and see all the necessary elements, and anthropometric peculiarities of potential users (motorcyclists) (55). This is critical for providing the comfortability between the human (motorcyclists) and the machine (motorcycle).

Conclusion

This review was done to relate risk factors of muscular discomfort among motorcyclist due to motorcycle riding, as there are very little information about the riding discomfort of motorcyclists in Malaysia. Further detailed studies are it in the laboratory or field study need to be carried out to uncover and fully understand fully the parameters or factors that constrain the ergonomic comfortability in the motorcycle riding process.

Ethical considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

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