SUSTAINABLE DESIGN FOR MOTORCYCLIST ERGONOMICS: EVALUATING A NOVEL ARMREST TO REDUCE MUSCLE STRAIN

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ABSTRACT

Motorcycles are a primary mode of transportation in Malaysia, widely used for daily activities and work. The well-being of motorcyclists is crucial, especially regarding comfort during prolonged rides. This study evaluates the effectiveness of an armrest prototype in reducing muscle activity, measured by surface electromyography (sEMG), thereby alleviating discomfort. In two sessions (with and without the armrest), 102 participants rode a motorcycle for two hours using a laboratory riding simulator. The simulator projected a road scenery video, simulating daytime riding conditions. EMG signals were recorded to assess muscle activity in the right and left arms, with electrodes attached to the skin. The findings revealed a reduction in sEMG levels for both arms when using the armrest prototype for the flexor carpi radialis and flexor carpi ulnaris muscles. Furthermore, there was a significant difference in exertion muscles levels (X^2 (63) = 757.76, $p<0.001$) between the experimental group and the control group during the two-hour riding process. This study demonstrates that the armrest prototype can effectively reduce muscle activity and improve comfort for motorcyclists. By promoting better posture, this innovation could enhance rider safety and health, potentially reducing the risk of accidents.

Keywords: *Armrest, muscle activity, motorcyclist, electromyography, experimental*

1.0 INTRODUCTION

Motorcycles are popular in Malaysia due to their simplicity and cost-effectiveness as a form of transportation. According to the Ministry of Transport Malaysia, motorcyclists and cars are the two most popular modes of transportation among Malaysians, with 718,416 motorcycles and 736,783 cars newly registered in 2022 [1]. Motorcycles are among the most popular two-wheeled vehicles in Southeast Asia. However, the riding posture has frequently been described as ergonomically inappropriate for humans. This is mainly because riders are usually sat in a static position with little support and no backrest [2]. Sitting discomfort on a motorcycle has become a key issue that must be addressed owing to limited space, constrained postures, extended riding hours, and the requirement to execute multiple tasks at once. These variables can contribute to muscular pain and musculoskeletal disorders (MSDs) [3].

The International Ergonomics Association [4] describes ergonomics as a scientific field concerned with developing and maximizing human well-being during interactions with product usage [5]. Ergonomics' fundamental purpose is to eliminate discomfort which can result in low work satisfaction, activity limits, and long-term disability [6]. In fact, ergonomics refers to the

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design or arrangement of workplaces, products, and systems to fulfill the demands of those who use them. It covers all components of the profession, including physical demands on joints, muscles, nerves, tendons, and bones, as well as environmental conditions that impact hearing, vision, and general comfort and health [7-8]. The primary goal of ergonomics experimental research is to establish a good fit between people and the equipment or settings with which they interact, therefore improving comfort, efficiency, and safety [9].

Ergonomics in motorcycle design frequently favor rider comfort and safety. Motorcycles, on the other hand, have a natural difficulty providing the same degree of comfort and safety throughout the journey as cars [10]. With that, the major goal in this study for developing an armrest prototype for motorcyclists is to improve comfort and minimize muscular fatigue while riding. These armrests assist relieve tension on the hand and arm, which can become more noticeable during lengthy rides or in heavy traffic. This increased support not only enhances overall comfort but also helps to reduce muscular pain and fatigue, resulting in a more pleasurable and long-lasting riding experience. Such ergonomic improvements are especially advantageous to riders' long-term health and well-being, making motorcycle travels safer and more pleasant.

According to the Motorcycle Council of New South Wales [11], riding motorcycles requires a substantial amount of movement, which can lead to rider weariness. According to the Motorcycle Council of New South Wales [12], riding in the same position with restricted movement for long periods of time can produce muscular stiffness and reduced blood circulation, resulting in pain and discomfort. As Elliott *et al.* [13] have noted, there is an urgent need for extensive study into rider discomfort in order to develop approaches that reduce road accidents. Therefore, the purpose of this study is to show that implementing an armrest prototype may successfully reduce electromyography levels, so immediately reduce body and muscle discomfort caused by lengthy rides.

2.0 METHODOLOGY

2.1 Selection of Respondents

This study used a pre-post test experimental design to evaluate the effect of an armrest prototype on muscular stimulation in motorcyclists during riding process. The study was conducted in a controlled laboratory environment and recruited among male motorcyclists who met certain inclusion and exclusion criteria. Participants were recruited using purposive sampling with established criteria. The research included 102 motorcycle riders, split equally into two groups of 51 each. All subjects were in good health and had no history of musculoskeletal issues or arm discomfort at the time of the investigation. The eligibility requirements included being male, between the ages of 20 and 35, and regularly riding motorbikes with engine capacity of 150cc or less. Exclusion criteria were a lack of sleep before to the trial and simulator adaptation syndrome symptoms such as nausea, headache, and dizziness.

2.2 Armrest Prototype

The armrest, which were fabricated specifically for this study is intended to help arm mobility while riding, is movable and can be adjusted to be mounted to the left and right sides of the motorcycle's handle. It is securely connected to the handle with screws (see Figure 1).

Figure 1: Armrest prototype

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2.3 Electromyography (EMG)

Surface electromyography (sEMG) was the preferred method for measuring and evaluating muscle activity in the body. Electromyography (EMG) signals were collected from the flexor carpum radialis and ulnaris muscles in both the right and left arms. Surface electrodes were precisely placed on the arm areas to enable reliable data collection (Figure 2). To aid in signal capture, biopotential electrodes and lead wires were methodically connected to both arms for each muscle group. Before electrode implantation, the skin at the selected muscle areas was thoroughly cleansed with alcohol swabs to eliminate any oils or contaminants that could interfere with signal transmission. The skin was then allowed to thoroughly dry before the electrode pads were firmly fastened, guaranteeing excellent contact and signal integrity throughout the experiment.

Figure 2: Surface electrodes on both arms' muscles

2.4 Experimental Process of Armrest Prototype.

Each participant was told to complete two distinct sessions while sat on a motorcycle: one with an armrest and another without. These sessions took place in a controlled laboratory environment that was quiet and well-lit. To reduce any potential carryover effects, each participant attended the experimental sessions on two different days, with at least a three-day break between each. The experimental process was adapted from a study conducted by Karmegam *et al.* [10], which involved a lumbar support prototype for motorcyclists. Each lasted two hours, allowing plenty of time to analyse the results [10].

Participants in the experimental group were allowed to adjust the armrest to their chosen position for maximum comfort before beginning the experimental session. Throughout the two-hour session, participants interacted with a riding simulator that displayed a simulated road scenario and required them to move the motorcycle's handlebars as they would on a real road. Surface electrodes were mounted to the subjects' right and left arms simultaneously to acquire electromyography data, allowing for continuous monitoring of muscle activation. During the experimental sessions, electromyography signals were painstakingly captured to assess muscle activation in both the flexor carpum radialis and ulnaris muscles. This comprehensive technique enabled a full evaluation of the armrest's influence on muscle activation during simulated motorcycle riding scenarios (Figure 3).

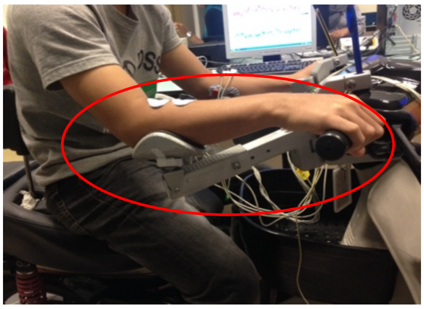

Figure 3: Armrest prototype attached to handlebar of motorcycle

3.0 RESULTS AND DISCUSSION

3.1 Muscle Activity Distribution among Motorcyclists

An armrest prototype for motorcyclists is primarily intended to improve rider comfort and safety, particularly on long rides. Here are some aims. 1) Improved Comfort: Armrests can lessen rider fatigue by supporting the arms and shoulders. This is especially effective for long-distance travels when prolonged posture can cause discomfort and strain; 2) Improved Control: By supporting the rider's arms, armrests can aid retain greater control over the motorcycle, especially at moderate speeds or while riding for lengthy periods of time. This may contribute to a calmer riding experience; 3) Increased Safety: With better comfort and control, the overall safety of the riding experience may be improved. Riders are less prone to make fatigue-related mistakes and can stay focused.

In this experimental study, by using sEMG data, it is possible to illustrate the amount of muscle activity and discomfort felt by motorcyclists throughout the riding process. While collecting sEMG data during actual rides is impossible owing to equipment size and logistics, participants were subjected to a realistic riding simulator system that as nearly resembled real motorcycle riding situations as feasible. This controlled setting reduced the effect of confounding variables and allowed for a detailed assessment of muscle activation with and without the use of an armrest. Furthermore, the laboratory setting reduced the effects of environmental variables like weather and road conditions on muscle activation [14]. Figure 4 and 5 showed that the experimental group had lower electromyography levels in both the right and left arm muscles than the control group.

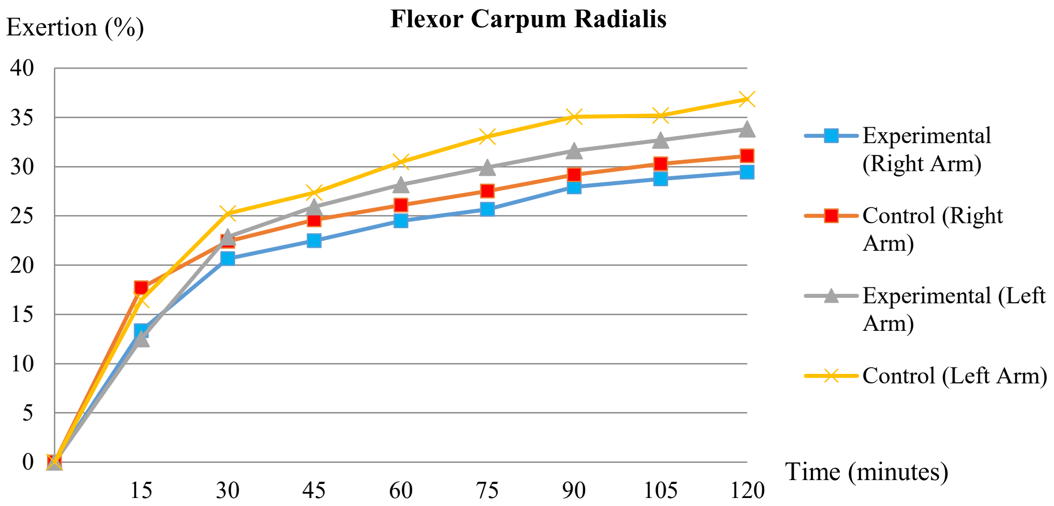

Figure 4: Muscle activity for flexor carpum radialis

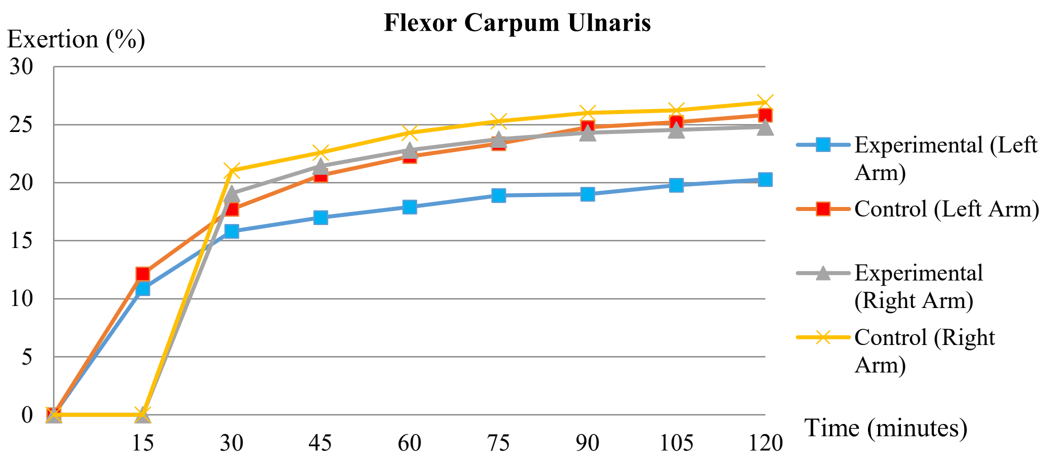

Figure 5: Muscle activity for flexor carpum ulnaris

Studies have shown that enhanced comfort might reduce muscular activation. For example, studies on ergonomic interventions in the workplace, such as the use of adjustable seats, have shown that they significantly reduce musculoskeletal pain and muscle activation. These treatments often include chairs with adjustable height and backrests, which aid with body alignment and reduce pressure on muscles such as the neck, shoulders, and back. Electromyographic (EMG) studies suggest that such ergonomic changes can dramatically lower muscle activity and intervertebral disc pressure, improving overall comfort and lowering tiredness [15]. Furthermore, research into the use of exoskeletons intervention, both active and passive, has demonstrated that these devices can minimize muscular activity and fatigue by providing external support. For example, passive upper-body exoskeletons used for lifting and carrying have been shown to minimize muscular activity in the lower back and upper limbs. This is accomplished by spreading the load and supporting the user's movements, which reduces muscular stress, discomfort and perceived pain [16].

According to recent research, motorcyclists frequently feel severe arm and hand tiredness as a result of lengthy riding, which can impair control and safety. This research also found that motorcyclists report higher levels of pain and weariness than other road users. This discomfort is mostly caused by the continual gripping and handling of the handlebars, which results in muscle tension in the arms and hands [17]. Overall, these data highlight the relevance of ergonomic adjustment (armrest prototype) and good riding position in reducing tiredness and improving motorcycle safety as Table 1 revealed that there were significant exertion within two hours riding process, X^2 (63) = 757.76, $p<0.001$ among motorcyclists when tested with armrest prototype. Therefore, these findings underscore the link between better ergonomics intervention in this study and lower muscular activity. By improving support and comfort, armrest prototype can reduce muscular effort, resulting in reduced tiredness and a lower risk of musculoskeletal problems among motorcyclists.

According to research findings, arm support is advantageous for occupations or tasks that require prolonged arm holding, with a considerable effect on shoulder muscle activation. The weight of the arm generates a moment around the shoulder, which is counteracted by contractions of the anterior deltoid and other muscles, while the upper trapezius and rotator cuff muscles support the shoulder girdle. Applying a supporting force to the elbow or arm diminishes the moment around the shoulder and lowers anterior deltoid muscle activity. This support distributes part of the arm's weight, allowing the upper trapezius to exert less force while maintaining a static shoulder posture [18].

Table 1: Muscles activity among motorcylists

Time (min)	Median(IQR) Experimental Group (n=51)				Median(IQR) Control Group (n=51)				X^2-value (df)	p-value[a]
	Right (Radialis)	**Right (Ulnaris)**	**Left (Radialis)**	**Left (Ulnaris)**	**Right (Radialis)**	**Right (Ulnaris)**	**Left (Radialis)**	**Left (Ulnaris)**		
15	6.17 (4.12,11.20)	9.58 (5.26,11.09)	5.30 (3.77,10.95)	7.01 (4.09,11.26)	14.72 (7.56,43.86)	19.64 (7.04,39.96)	16.15 (7.34,41.47)	8.04 (6.26,20.88)	757.76 (63)	**<0.001***
30	8.62 (5.82,12.93)	9.95 (5.87,15.21)	6.14 (5.49,12.96)	9.40 (5.67,12.27)	22.33 (8.55,53.60)	23.11 (9.13,49.56)	31.87 (12.97,54.88)	14.33 (8.64,24.58)		
45	9.49 (6.93,14.28)	9.85 (5.73,17.27)	7.63 (5.58,15.82)	9.54 (5.80,13.51)	23.06 (9.27,62.70)	24.51 (9.86,52.99)	43.94 (14.89,62.13)	16.88 (9.03,28.61)		
60	12.48 (7.10,15.54)	10.28 (7.40,17.27)	8.55 (5.54,17.40)	9.34 (7.27,13.51)	24.23 (9.48,64.72)	28.02 (9.89,55.95)	48.47 (15.39,68.23)	20.18 (9.66,30.31)		
75	12.32 (7.28,16.65)	10.65 (8.34,17.95)	9.20 (5.53,18.26)	9.05 (7.61,12.90)	25.62 (13.77,66.86)	31.80 (9.90,57.55)	51.13 (16.02,74.14)	21.14 (9.62,33.64)		
90	11.75 (7.34,18.27)	10.09 (8.24,18.52)	9.81 (6.20,18.87)	9.32 (7.56,14.73)	28.27 (15.79,71.67)	34.48 (10.16,61.52)	53.26 (15.95,75.98)	19.23 (9.85,36.66)		
105	11.84 (7.66,18.98)	10.46 (8.23,19.65)	10.32 (6.74,20.02)	9.28 (7.73,14.12)	30.82 (17.09,76.30)	39.22 (11.16,57.33)	55.74 (15.87,73.77)	19.54 (9.85,35.81)		
120	11.61 (8.04,19.23)	10.89 (8.36,20.08)	10.57 (7.07,20.59)	9.36 (7.43,14.74)	31.79 (17.04,81.18)	37.13 (11.92,61.55)	56.16 (16.15,85.22)	19.22 (10.34,37.99)		

*p is significant at <0.001

3.0 CONCLUSION

The research conducted on the fitting of a motorcycle armrest prototype demonstrates significant benefits in terms of lowering muscle activity and improving rider comfort. By providing strategic support to the arms, the prototype efficiently reduces the strain on hand and arm muscles, notably flexor carpum radialis and ulnaris muscles, which are essential for maintaining arm posture when riding. This reduction in muscular strain provides dramatically better comfort and endurance for motorcyclists, potentially lowering the risk of musculoskeletal disorders over time. The findings emphasize the importance of ergonomic solutions in motorcycling, pointing out that the armrest prototype not only improves immediate riding comfort but also adds to long-term physical health by minimizing overuse injuries.

This discovery brings up new possibilities for future research into muscular relaxation for motorcyclists. Key research area includes investigating the biomechanics of armrest design and its impact on muscular strain, as well as analysing user satisfaction and comfort levels. Comparative evaluations with existing products will give useful information about efficacy. Furthermore, the importance of configurable features, the impact of environmental and sustainable elements, and the psychological benefits of comfort on rider confidence are worth considering. Collaborations with health professionals, as well as the research of new materials and technology, can help to develop rider ergonomics.

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