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Analysis of upper body ergonomic parameters on commuter motorbike users

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ABSTRACT

Introduction: Motorcycle is one of the major modes of personnel transport in developing countries. The motorcycle are often used in commuting, dense traffic, poor conditioned roads and thus the repetitive loading on the musculoskeletal system of the rider leads to risk factors associated with musculoskeletal disorders.
Objective: The effective posture is an important factor to overcome the musculoskeletal disorders. This study was aimed to examine the influence of the posture on the human body and to overcome the discomfort, stiffness and pain while riding the motorcycle.
Methods: Frequently adopted three different postures (A, B and C) were identified from the subjects (motorcyclist). The muscle strain was evaluated using objective and subjective measurements. Rapid Upper Limb Assessment (RULA) analysis was conducted to identify the suitable posture to overcome the muscle strain. The Root Mean Square (RMS) of muscle activity was recorded at the biceps, deltoids, trapezius, and erector spinae of the twelve subjects. Subjective measurements were performed to identify the perception of posture comfort and muscle strain using the Borg's scale.
Results: The objective and subjective measurement results suggest that posture A of, angle between vertical and the lumbar bone, cervical region and the biceps, arms and forearms are of 16°, 119° and 153° respectively has less muscle strain than posture B and C. The erector spinae muscle has more muscle strain compared to the biceps, deltoid and trapezius muscle in all postures.
Conclusion: Subjects were aware about the level of muscle strain for different postures. The results recommended by the study will create awareness among the motorcyclist to maintain the posture while riding.

1. Introduction

Motorbikes have high relevance in the daily activities like transport commuting, mobility, economic activities, and sports (Balasubramanian and Jagannath, 2014). In spite of the benefits included driving a motorbike is riskier due to the level of noise, vibrations, and the surroundings (Walker et al., 2006). The continuous use of motorbikes leads the drivers prone to musculoskeletal disorders such as spine injury, lower back pain and disc dislocation (Alperovitch-Najenson et al., 2010). Stress and fatigue has a major contribution to

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the cause of motorbike accidents in developing countries due to several reasons including work related and socioeconomic conditions (Kar et al., 2010). Driving related Musculoskeletal Disorders (DMSD) occurs due to improper posture, stress and repeated body movements during driving. Lower back is also another common driving related musculoskeletal disorder among motorbike riders (Tushar el al., 2015). The vehicle body vibration, spinal injury and lower back pain are highly associated with DMSD (Thamsuwan et al., 2013; Okunribido et al., 2007).

Motorbike riders are relatively more exposed to sitting posture hazard compared to car drivers. Shoulder and neck are the well known problems for the motorbike riders (Roseiro et al., 2016). The sitting posture is also normally associated with shoulder and neck problems for motorbike riders. Sitting without lower back support and sitting without back support creates pain in lower back and in central back respectively (Karmegam et al., 2008). Back pain occurring in adults with high recurrence rates is most common in musculoskeletal disorders (MSDs). High frequency of bike drivers exposed to discomfort during their driving leads to the musculoskeletal symptoms on their body parts. The comfort of the motor bikers' is associated with less stress, a relaxed situation whereas the discomfort is associated with biomechanical factors such as postures, joint angles, pressure distribution during seating, and the muscular contractions (Zhang et al., 1996). Muscles, ligaments and joints are affected over a period of time due to abnormal driving body postures (Bulduk et al., 2014; Kee and Karwowski, 2007).

The perception of comfort and discomfort are unique estimates in the field of ergonomics of the work and machine (Alias et al., 2016). Discomfort of the motor bikers' could be related to the body parts due to the sitting posture (Kolich, 2008). Normally, discomfort is the first symptom, which leads to several types of musculoskeletal disorders. Ergonomic design procedures are involved in providing the most comfortable posture for riding a vehicle (Jirapure et al., 2012). The ergonomic principles are considered the most effective in providing the basic scientific information regarding the seating posture among the motorbike riders. Objective and subjective measurements are used to identify the comfort and discomfort of the motor bikers (Bridger, 2008).

One of the most efficient methodologies to quantify the muscle activity is Electromyography (EMG). The European standards for (SENIAM) must be followed for the muscle activity measurement (Hermens et al., 1999, 2000). The upper limb movement for human essentially involve motion and muscle action. The muscle actions can be accessed through EMG signals. Doheny et al. (2008), investigated biceps and triceps force relationship using EMG, during elbow flexion and extension. EMG torque relationship for four muscles in the biceps and triceps was investigated without mentioning the elbow angle. Ahamed et al. (2015), examined the EMG – time relationship of the biceps brachii muscles during isotonic and isometric contractions. The signal during the wide range of motion was investigated for different knee angles to quantify the EMG signal activity (Earp et al., 2013). The previous studies included mostly the investigations of the biceps and triceps muscles (Gopura et al., 2010; Manal et al., 2006; Wu et al., 2010).

Rapid Upper Limb Assessment (RULA) is another method used in ergonomics to investigate the workplace related upper limb disorders (McAtamney and Corlett, 1993). RULA technique is used to assess the postural stress by using photography and videography methods (Dutta et al., 2014, 2017). A new autonomous digital human model was represented using computer-aided human factor analysis (De Magistris et al., 2013). In RULA analysis mankin models were developed with particular height, weight, forward kinematics, posture and was used to measure the strain in the various body parts as a form of score (Patil et al., 2014). The risk factors can be identified by performing RULA analysis for frequently adopted postures (Hoy et al., 2005).

Surveys, questionnaires and self-reports were most commonly used technique to identify the level of fatigue, pain and discomfort of the motorcyclist. Rehabilitation Bioengineering Group (RBG) pain scale and Borg CR-10 scale subjective rating scale was combined to evaluate the comfort of motor bike riders (Velagapudi and Ray, 2017). The postural comfort was gathered by Standard Nordic Questionnaires (Dutta et al., 2017) and posture analysis tool (Dutta et al., 2014). Direct assessment results such as electromyography, vibration assessments and anthropometry were combined with the questionnaires methods.

The study was aimed to identify the driving posture; so that it can help to reduce the Driving related Musculoskeletal Disorders (DMSD) and discomfort among the motorcyclist. In order to identify the exact posture the objective (RULA analysis and EMG) and subjective (Borg's scale) measurements were carried out. The objectives of the present study are, to identify the ergonomic posture using computer-aided human factor analysis (RULA), and to quantify the muscle strain using EMG and subjects perception.

2. Materials and methods

2.1. Subjects

Twelve male subjects (motorcyclist) between the ages 0f 18–28 volunteered to participate in experiment. The subjects had no

Table 1
Description of participants' anthropometric measurements.

Characteristics	Mean	S. D	Range
Age (years)	24	5.48	18–28
Height (cm)	164	3.92	152–170
Weight (kg)	62	8.89	58–74
BMI	24.33	2.11	22–28
Knee height (cm)	52	5.43	48–58
Forearm length (cm)	45.8	1.78	43–48
Foot length (cm)	24.75	2.03	43–47
Years of riding	5	1.54	2.5–7.5

history of musculoskeletal disorders and were not allowed to do any difficult physical activity on the day of measurement. The detail description of the experimental procedure was explained for all the subjects before the experiment started. Measuring tape, gonimeter, meter scale, and weight machine were used to collect the statistical data of the subjects. The anthropometric descriptions of the participants are shown in the Table 1.

2.2. Data collection

2.2.1. Subjective assessment technique

Questionnaire method is the one of the important technique employed to explore the motorcyclist posture preference and discomfort (Marhavilas et al., 2011). All subjects were interviewed separately with the body part discomfort questionnaire (weighing) to identify the strained parts during riding. The subjects were asked to rate their opinion on a three point scale (High strain, Medium strain and No strain). The subjective assessment technique results are shown in Fig. 1. The results indicate that subjects felt discomfort in the biceps, deltoids, trapezius, and erector spinae as the highly strained muscles.

2.2.2. Posture identification

Rapid Upper Limb Assessment (RULA) was generally performed to discover the risk among the motor bike riders by capturing the frequently adopted postures (Hoy et al., 2005). TVS star city bike (Type: 4-stroke, air-cooled OHC; Engine Displacement: 109.7cc; Max. Net Power: 6.1 kW @ 7500 rpm; Max. Net Torque: 8.1 Nm @ 5000 rpm; Transmission: 4 speed, constant mesh) was used by all the subjects to identify the posture and discomfort. Different riding postures were captured from the motorcyclist and three different frequently adopted postures were identified as Posture A, Posture B and Posture C. The frequently adopted postures (A, B, and C) photographs were imported to the AUTOCAD® software and the posture angle was identified as mentioned in the Table 2.

2.3. Computer-aided human factor analysis

The computer-aided human factor analysis can be represented by the digital human models (De Magistris et al., 2013). The frequently adopted postures A, B and C of the motorcyclist were created as human models using CATIA V5® with the identified posture angle using AUTOCAD®. RULA analysis was performed in CATIA V5® software to understand the response of the human strain during different postures A, B and C and to identify the effective posture. RULA scoring is an effective tool for evaluating the work related disorders in the entire body and in the upper body (McAtamney and Corlett, 1993). The advantage of RULA scoring is to provide immediate results for any number of samples (Hoy et al., 2005). Fig. 2 shows the digital human models for frequently adopted postures from the subjects.

2.4. Electromyography (EMG)

Electromyography (EMG) experimental analysis was performed to identify the important information about the physiological status of skeletal muscle and the nerve supply to the subjects during posture A, B and C. Voltage difference for each muscle was considered while sitting in a particular posture for the twelve subjects. While conducting the experiment the subject is required to sit in that particular posture for a brief amount of time to feel the strain. EMG readings for each posture were recorded for ten minutes of time. Surface EMG (BIOPAC SYSTEMS MP150) was used to measure the upper limb muscles with silver-silver chloride electrode and then connected to the computer using acknowledgement software. Fig. 3 shows the surface EMG used to measure the muscle activity (Biopac system 150).

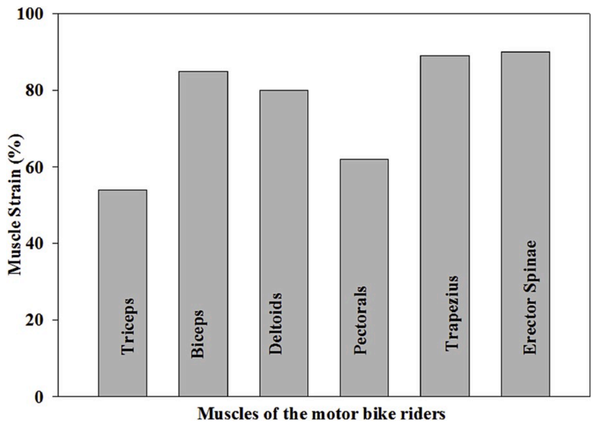

Fig. 1. Subjective assessment results about muscle strain.

Table 2
Frequently adopted posture angles by the subjects.

Description	Posture A	Posture B	Posture C
Angle between vertical and the lumbar bone	16°	26°	33°
Angle between cervical region and the biceps	119°	119°	119°
Angle between arms and forearms	153°	136°	127°

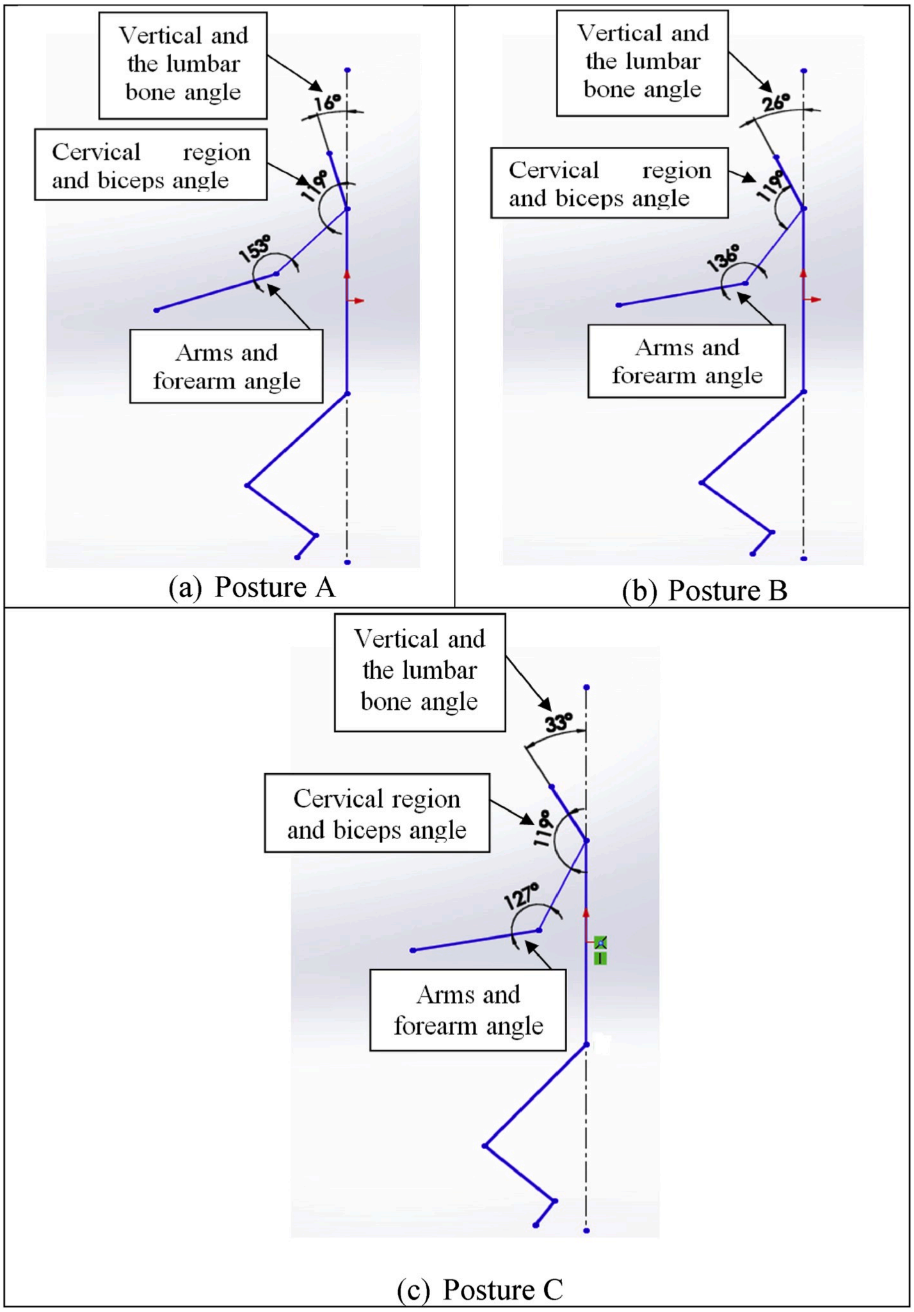

Fig. 2. Average measures of joint angular deviation (a) Posture A, (b) Posture B, (c) Posture C.

(a) Posture A (b) Posture B (c) Posture C

Fig. 3. Digital Human Models for frequently adopted postures from the subjects.

2.5. Experimental procedure

The subjects were asked to maintain the posture as mentioned in the Table 2. Once the subject was comfortable with the posture the experiment was initiated. The skin in the muscle area of each location was shaved and cleansed with alcohol while placing the electrodes. Electrodes are attached at biceps, deltoids, trapezius, and erector spinae muscles of each subject to evaluate the muscle strain with adhesive medical tape. Subjects were instructed to maintain every posture for 10 min in order to identify the muscle strain. For every subject left and right side of each muscle was measured.

EMG signal detects the electrical potential generated by the muscle when these cells are neurologically or electrically activated. The electrical source of the muscle membrane potential is about −90mv. Measured EMG signal potentials range between less than 50 μV and up to 20-30mv depending on the muscle under observation. Fig. 4 shows the attachment of electrodes position at the subjects for different postures.

2.6. Subjective analysis

Subjects were allowed to take rest for the period of 15 min between different posture analyses. During the rest period subjects were asked to rate each posture based on the comfort and muscle strain. Subjective scores were assessed using Borg's 10-point linear scale from 0 to 10 (CR-10) as shown in Table 3. The CR-10 scale perceived the perception from 0 (very comfortable posture/no muscle strain) to 10 (very uncomfortable posture/maximum muscle strain). After the subjective analysis, the data was analyzed for each posture.

Fig. 4. sEMG (Biopac System 150).

Table 3
Subjective assessment questionnaire.

Scale	Description on posture	Description on muscle strain
0	Extremely comfortable	No muscle strain
0.5	Very very light discomfort	Just noticeable muscle strain
1	Very light discomfort	Very weak muscle strain
2	Fairly light discomfort	Weak muscle strain
3	Moderate discomfort	Comfortable muscle strain
4	Somewhat discomfort	A little uncomfortable muscle strain
5	Hard discomfort	Strong muscle strain
6		
7	Very hard discomfort	Uncomfortable muscle strain
8		
9		
10	Very very hard discomfort	Maximum muscle strain

2.7. Data analysis

Data from EMG and subjective analysis were uploaded to a spreadsheet. MATLAB® programming code was generated for obtained EMG signals and frequency graph was generated with the amount of muscle fatigue in each subject during different postures. The RMS value for each subject for four different muscles in left and right side was evaluated. For each subject average of two trails was performed to maintain the accuracy in the experiment. The mean RMS for each muscle in left and right side and then the subjective rating for each posture were evaluated.

3. Results

3.1. RULA scoring index

Three different postures (A, B, and C) normally adopted by the motorcyclist were considered for RULA analysis. CATIA V5® software was used to develop human models by considering the angle between vertical and lumbar bone, the angle between cervical region and the biceps and angle between arms and forearms for posture A (S: 16°, Arm: 119°, Forearm: 153°), Posture B (S: 26°, Arm: 119°, Forearm: 136°) and Posture C (S: 33°, Arm: 119°, Forearm: 127°) respectively and RULA analysis was conducted. Fig. 5 shows the individual RULA scoring for postures A, B and C of the motorcyclist riders to identify the highly strained body parts.

In posture A, the RULA scoring was found to be 3 for upper arm, 2 for forearm, wrist, neck, and trunk and rated with the overall scoring index of 4. The posture B has RULA scoring of 4 for upper arm and wrist, 3 for forearm, 2 for trunk and wrist and rated with overall scoring index of 6. In posture C, upper arm and neck was scored as 5, forearm and wrist has 3 and trunk 4, with overall scoring of 7. In all the postures the leg has the least scoring index of 1.

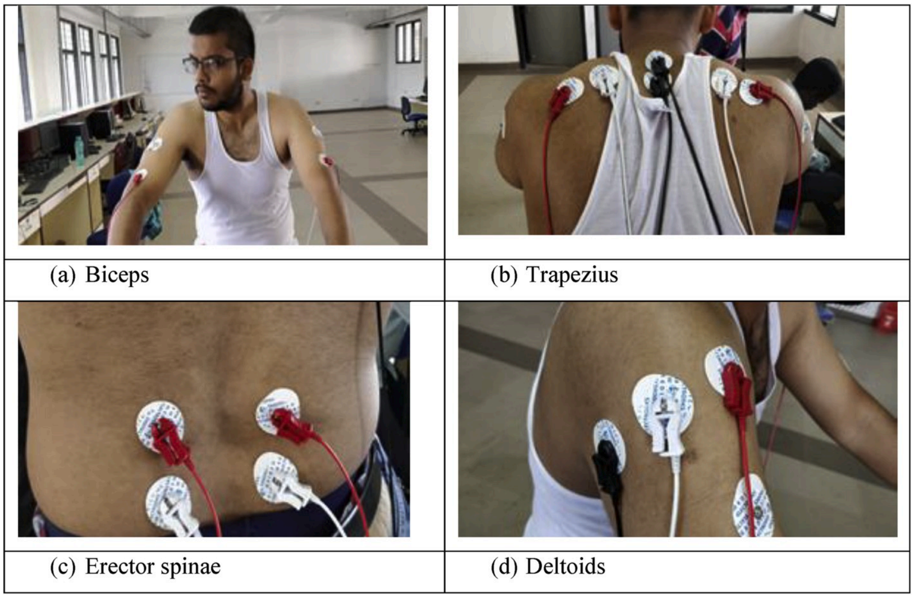

Fig. 5. Electrodes position at the muscles of the subjects.

The overall RULA scoring of the subjects was given in the Table 4. Posture A, B and C was rated with overall RULA score of 4, 6, 7 respectively and the subjects preferred the posture was at 24.56%, 33.23% and 42.21% respectively. The risk level was found low for posture A, medium for posture B and high for posture C. A similar response was identified in excavator driver with high level of risk at upper arm, wrist and trunk through human factor analysis (Koushik Balaji and Alphin, 2016).

In posture A, the body parts like forearm, trunk and the back region experience comparatively lesser strain than the other postures B and C. So this posture tends to be far more comfortable than the other two postures. The posture of riding the motorbike the trunk wrist and the forearm regions experience more pronounced strain which tends to affect the person over a long period of time. The RULA analysis results suggest that posture A (S: 16°, Arm: 119°, Forearm: 153°), has least muscle strain compared to the remaining two postures B and C.

3.2. EMG analysis

The voltage differences for the three different postures were recorded at the biceps, deltoids, trapezius and erector spinae to identify the muscle strain. The readings are taken at intervals of time intervals and the responses are plotted in the time domain. The Root Mean Square (RMS) of the each muscle, posture and sample are taken for analysis and discussions. RMS value of the muscles and postures for each subjects were calculated using MATLAB® coding. The sample graph for electromyography reading for different postures in different muscles is shown in Fig. 6.

The equivalent RMS value for left and right muscles of the biceps, deltoids, trapezius and erector spinae for posture A, B and C are shown in Fig. 7. The results inferred that for posture A, the RMS value is between 0.114 mV in left biceps muscle and 0.044 mV in the right biceps muscle. In posture B, the RMS value is between 0.6035 mV in left biceps and 0.2315 mV in the right biceps. The results show that in posture C the left and right RMS values in biceps are of 0.854 mV and 0.339 mV respectively. It is observed from the Fig. 7 (a), the left bicep muscle has more strain than the right bicep muscle for all the postures. Rashid el al. (2015) investigated erector spinae, latissimus dorsi, trapezius, triceps, and the carpi radialis extensor muscles. The results were found that muscle activity was strong in the extensor carpi radialis.

Fig. 7(b) shows that deltoids muscle has maximum muscle strain in posture C with 0.368 mV in right and 0.184 mV in the left muscle, whereas deltoids muscle has the least muscle strain in posture A with 0.086 mV in right and 0.043 mV in the left. It is inferred from the Fig. 7(b) that the deltoids right muscle has more strain than the left deltoid muscle for all the postures. Ma'arof et al. (2017) identified measurements of bilateral muscle activity in the latissimus dorsi (middle back), erector spinae (lower back), trapezius (shoulder) and extensor carpi radialis (forearm and wrist) muscles using the RMS. The results showed good agreement with the present study for all the selected muscles and meanwhile higher value of the muscle activity was identified during upright motorcycling posture.

As like other muscles, posture C has the maximum muscle strain in trapezius muscle as shown in Fig. 7(c). The RMS value of 0.095 mV is observed in left trapezius muscle and 0.084 mV for the right trapezius muscle. Posture A has minimum muscle strain of 0.095 mV in left trapezius and 0.084 mV in the right trapezius muscle. The left trapezius muscle has more strain compared to the trapezius muscle in the right. Torrado et al. (2015) investigated the mechanism of fatigue and designed fatigue protocol for motorbike riders by considering contralateral extensor digitorum communis.

Fig. 7(d) shows the erector spinae muscles strain during posture A, B and C. From the figure, the peak RMS value occurring in trapezius muscle for posture C of 2.09 mV in left and 2.46 mV in the right. The least muscle strain is found in posture A of 0.084 mV in left and 0.10 mV in the right. The right muscle of erector spinae has more strain than the left erector spinae muscle in posture B and C except posture A. The study results were in good agreement with force muscle relationship measurement performed to identify the effect at elbow flexor and extensor muscles (Doheny et al., 2008; Ahamed et al., 2015; Rashid el al., 2015).

3.3. Mean muscle strain

In order to identify the influence of posture on motorbike riding the mean muscle strain was calculated for each posture. The mean of left and right muscles of biceps, deltoids, trapezius, and erector spinae is shown in Fig. 8. From the figure, it is evident that in posture A, erector spinae has the maximum RMS muscle strain of 0.185 mV and minimum muscle strain of 0.130 mV in deltoids. Posture B has the maximum muscle strain of 1.94 mV in erector spinae and minimum muscle strain of 0.43 mV in deltoids. Erector spinae has the highest muscle strain during posture C of 4.57 mV and minimum muscle strain of 0.552 mV in deltoids. From the results it was inferred that in all the four muscle posture C has the maximum RMS muscle strain and posture A has the minimum RMS muscle strain (Fig. 9).

The overall muscle strain is calculated as a total of 4 muscles in each posture. Table 5, shows the overall mean RMS muscle strain for posture A, B and C. From the table it was found that the RMS muscle strain was 0.65 mV, 3.75 mV and 7.02 mV for postures A, B and C

Table 4
Overall RULA scoring results (N = 12).

RULA score	Risk level	Action	% of subjects
1–2	Negligible	Acceptable	Nil
3–4	Low	Investigate further	24.56%
5–6	Medium	Investigate further and change soon	33.23%
7	High	Investigate and change immediately	42.21%

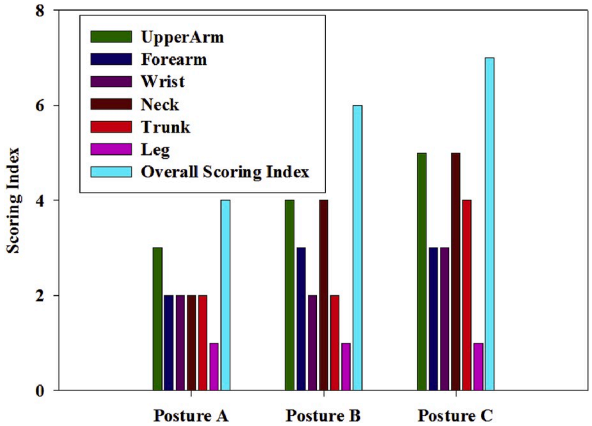

Fig. 6. RULA scoring index for posture A, B and C.

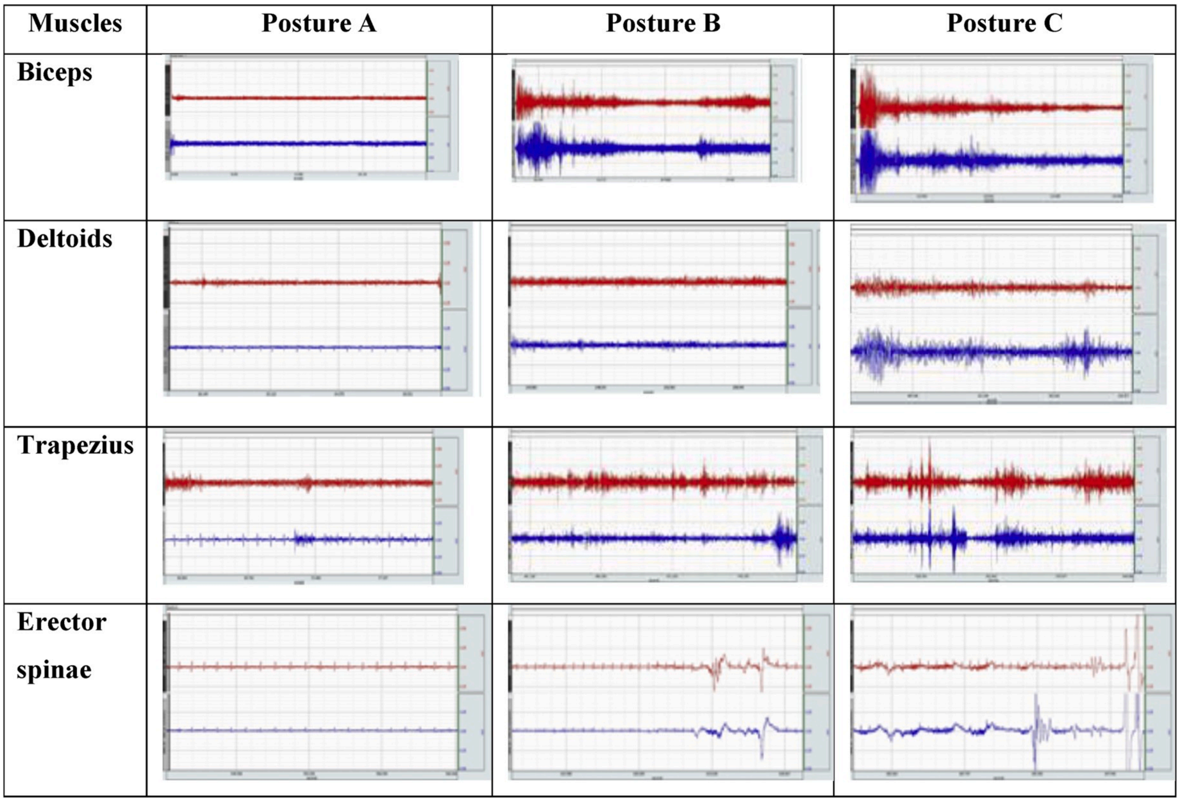

Fig. 7. EMG signals for different posture.

respectively. Obviously posture C has the higher muscle strain compared to the other two postures.

From the study results, it was evident that the posture of the each subject was maintained by the lower back muscle and absorbs the vibrations transmitted from the roads. Due to the seating position erector muscle (lower back muscle) got affected more than the other muscles. The results are in line with previous study reported that relevance of muscles strain was based on the interaction between the motor bike (Rashid et al., 2015; Velagapudi and Ray, 2017).

3.4. Subjective rating

The mean and standard deviation for posture comfort perception and muscle strain perception were evaluated based on Borg's-10 point scale. From the Table 6, it is evident that, posture C has very less posture comfort perception of 6.9 and rated with maximum of

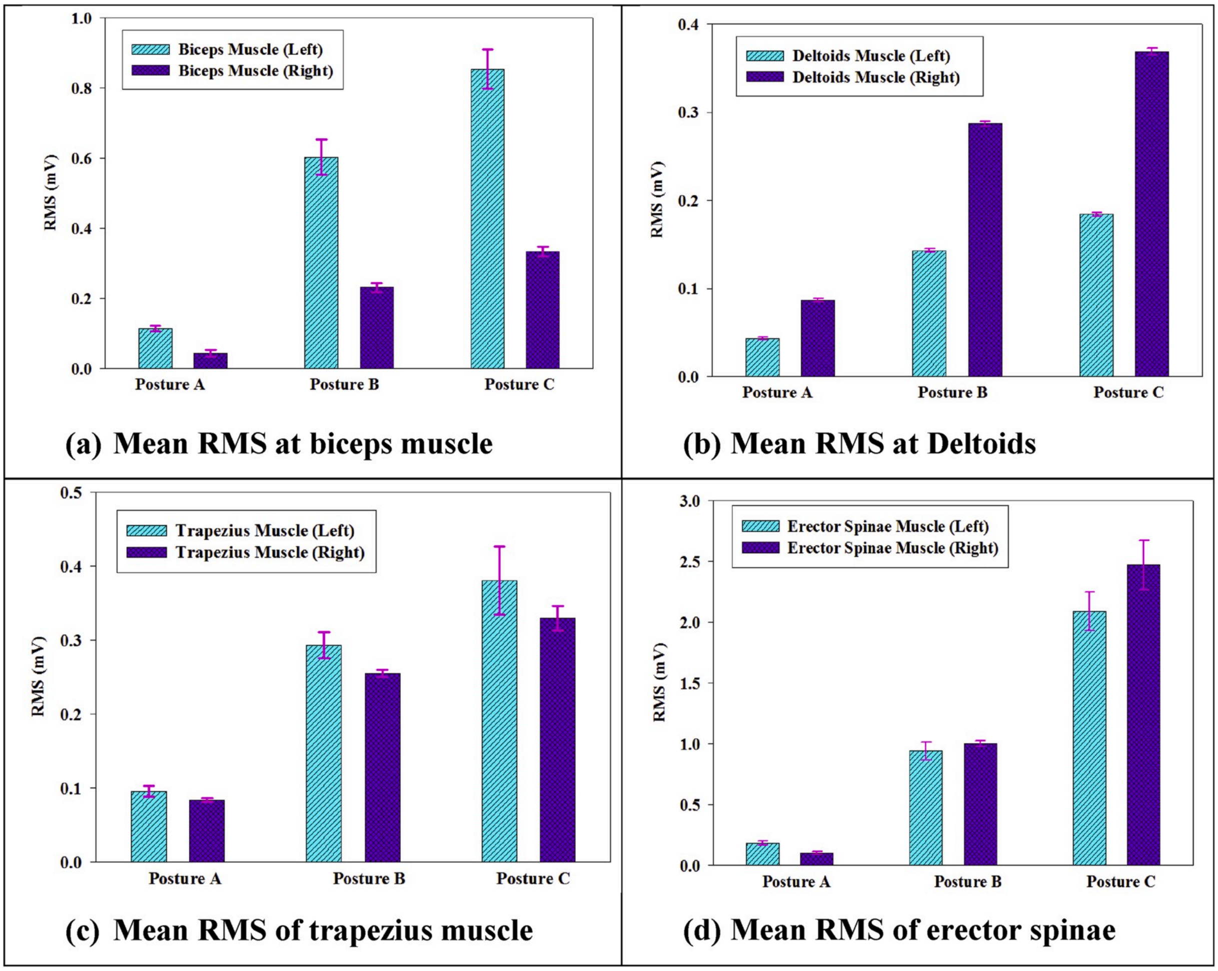

Fig. 8. Mean RMS (mV) of muscles for three different postures, (a) Mean RMS at biceps muscle, (b) Mean RMS at Deltoids, (c) Mean RMS of trapezius muscle, (d) Mean RMS of erector spinae.

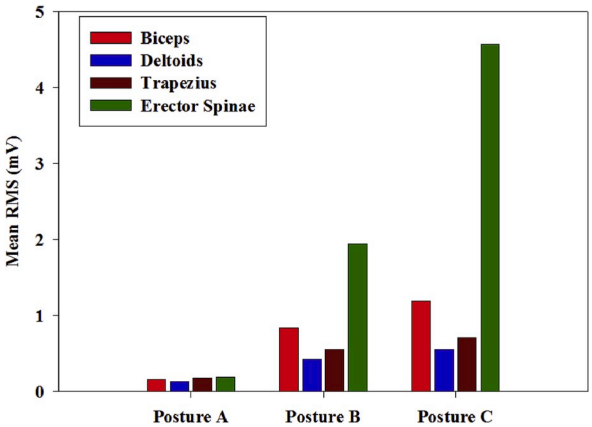

Fig. 9. Mean muscle activity for posture A, B and C.

muscle strain of 5.8. Posture A has been rated as more comfortable posture with 1.6 and has least muscle strain of 2.1 by the subjects. Posture B was rated with 4.2 for posture comfort perception and 3.6 for muscle strain perception. Subjective analysis results suggest that subjects are more comfortable with posture A than the other two postures B and C. In the present study experimental results and

Table 5
Overall mean RMS muscle strain for posture A, B and C.

Posture	Overall muscle strain (mV)
Posture A	0.65
Posture B	3.75
Posture C	7.02

Table 6
Perception of comfort and muscle strain.

Posture	Borg's Scale	
	Posture comfort perception	Muscle strain perception
A	1.6 (0.876)	2.1 (0.761)
B	4.2 (0.567)	3.6 (0.432)
C	6.9 (1.321)	5.8 (0.651)

subjective ratings results are in good agreement and which shows that subjects were aware about the muscle strain during each posture. It is also advised to combine the direct assessment measurements with subjective assessment methods for better identification (Velagapudi and Ray, 2017).

4. Discussion

This study demonstrates that human posture can affect the muscles while riding the motor bikes. The muscle activity during the postures are assessed in biceps, deltoids, trapezious, erector spinae and evaluated as RMS muscle strain. Three different frequently adopted postures (A, B and C) were identified from motor bike riders with respect to the angle between bone and muscles. Identified postures were assessed using the computer-aided human factors analysis (RULA) (Koushik Balaji and Alphin, 2016), Objective measurement (EMG) ((Marina et al., 2015; Rashid et al., 2017) and Subjective measurement (Borg's scale) (Wos et al., 1988).

Computer-aided human factor analysis was performed by developing the human mankin models from the identified posture. The results generated from the RULA procedure is that posture C was found with high risk and to be investigated immediately. Posture B was found with medium risk level and should be soon examined. Low level of risk was identified in posture A and the action related to it should be investigated further. Various stressors associated with the motorbike riders which are of joint angles of wrist, knee, hip, and ankle and shoulder were evaluated using RULA analysis (Dutta et al., 2014).

Muscle activity was analyzed in the objective measurements for posture A, B and C from the subjects. The results imply that posture C has the highest muscle strain mean RMS than the posture B and posture A. Erector spinae muscle has the highest muscle strain and are followed by biceps, trapezious and deltoids in the postures. However different postures were capable of reducing the level of muscle strain for all the subjects. The findings of this study provided an insight into the posture importance and validated the potential effectiveness of muscle strain. Marina et al. (2013) assessed the RMS (amplitude) of muscles to identify difference in strain and confirmed the importance to the requirement of precision and fine adjustment. Rashid et al. (2017) reported that erector spinae and trapezius muscles were the most fatigued region during the prolonged activity of motorcyclist.

Excessive physical demands while driving a motorbike has an impact on physiological and physical fatigue (Dutta et al., 2014). The subjective measurements are based on the perception of the posture comfort and muscle strain by the subjects. Subjects also rated posture A as the most comfortable position than the other two postures B and C. The subjective measurement findings conclude that, subjects are very aware about the level of level of muscle strain during different postures. Koyano et al. (2003) studied the static seating comfort using the feeling evaluation. Borg's CR-10 scale applied to identify the body discomfort was evaluated for a 15-min time period (Shafiei et al. (2015). Individual exposure to MSD risks were evaluated using observational tool, also known as Quick Exposure Ckeck (QEC) (Ramasamy et al. (2017). A motorcyclist performs several tasks in static posture causes decreased blood flow in muscles parameters (Chou and Hsiao, 2005).

The motorcyclist's postural conditions and importance were identified by Shafiei et al. (2015) for different designs of motorcycle. Intradiscal pressure causing problems in the lumbar region during seated posture is always greater than standing posture (Garcia et al., 2016). The present study reported the significant differences in muscle strain and subjective rating due to different postures. In order to overcome the discomfort in the motorbike riders, posture is also an important parameter to be considered along the seating design. Both the objective and subjective measurement results suggest that posture C has more muscle strain than the other two postures. Future work could be done in anthropometric studies and can be focused on motorcycle design by considering the physical and comfort.

5. Conclusion

The influence of motorcyclist postures has been assessed in this research. The study demonstrates the ergonomic posture to enhance the comfort of motorcyclist. Computer-aided human factor analysis (RULA) results suggest that biceps, deltoids, trapezius, and erector spinae as the highly strained muscles and posture A (S: 16°, Arm: 119°, Forearm: 153°) has low risk level compared to the other postures. Posture A has been rated as the most comfortable by the subjects with least muscle strain. Objective (EMG and RULA) and subjective measurement results suggest that, subjects were aware about the level of muscle strain. The results suggested by the study will create awareness among the motorcyclist to maintain the posture while riding.

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CRediT authorship contribution statement

B.Jain.A.R. Tony: Conceptualization, Methodology, Investigation, Writing - original draft, Writing - review & editing. **M.S. Alphin:** Validation, Resources, Supervision. **G. Sri Krishnan:** Data curation, Formal analysis.

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