



IDENTIFICATION AND QUANTIFICATION OF STRESSORS AFFECTING MOTORIZED TWO WHEELER RIDERS: AN ERGONOMIC ATTEMPT

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Abstract:

Motorised two-wheelers are cost effective fuel-efficient system to manage occupational compulsions and time bound responsibilities but on the other hand they account for maximum traffic accident deaths. Bike riders are exposed to prolonged static posture causing significant angular deviations at all most all joints of the body as well as lumbar angle (L1-L5). All these postural alterations are contributory factors to stress and musculo-skeletal symptoms. Although the vibration remains within the OSHA limit, the vibration map and pain map of a two-wheeler rider's were observed to have strong correlations. Varied emotional and psycho-social components contribute to cumulative stress among them. Bike riding also involves visual acuity, which alters critical flicker frequency of the riders indicating immense visual stress and subsequent adaptation. Proper stress management, ergonomic intervention in engineering revisions of the two wheeler design may contribute to reduce chances of accident and ensure safety, wellbeing and performance of the riders.

Keywords:

Motorised two-wheelers, stress, accident, vibration, pain

1. INTRODUCTION

Throughout the world the growth of transport system has been and continues to be a key element in economic development. An increase in gross national product results in greater movement of people and goods [1]. In developing countries like India, in rural or urban areas, to maintain standard of living a fast, time and fuel-efficient low cost personal mode of transport is more of a necessity than just a possession. Utility of motorcycle (bikes) over other two wheelers is primarily because of its ability to commute fast, majorly for the purpose of sustenance. While globally cities are promoting non-motorized forms of transport Kolkata Police banned cycle in 174 roads although 112 were revoked later, but cycles were not allowed in remaining 62 [2]. Hence motorized two wheelers were obvious choice for many people. An earlier study says motorized two wheelers are most prone to Road Traffic Accident. The rising sale of motorized two wheelers reported confirms to its increasing demand. Bikes are the most sold motorized two wheelers [3] and hence were most prone to accidents among the other motorized two wheelers. It was also known that the most accident



prone age group was 20-29years [1] and hence Bike riders of the mentioned age group were considered for the present study.

Bike advertisements generally focus on the showmanship [4]. It exhibits stunts along with looks and style of the models almost ignoring the aspect of safety and physiological comfort. Hence safety and physiological comfort must also be taken into consideration while choosing a bike in order to reduce discomfort, stress and chances of accident.

Stress is a major contributory factor to cause accident. For bike riders major stressors can be classified into environmental, occupational, socio-psychological, postural and physiological.

In tropical countries like India, extremely humid sultry summers cause extensive sweating and immense heat stress. Sweat accumulation, as droplets on helmet glass cause disruption of vision. Winter reports of fog and wind, along with significant drop of temperature in comparison with summers causing limb numbness. Rainy season results in slippery roads and visual distress. A recent study also says the poor visibility of amber light in the signals due to yellow halogens around is also causing accidents [5]. Increasing sound and air pollution are also causative factors for stress.

Many people use bike for occupational purposes. Factors of occupational stress like deadline pressure, target pressure and excessive desire for incentives, prolonged working hours cumulatively affect the performance and may lead to accident [6].

The psycho-social discourses reflecting on bike riders involve showmanship, failure to give way, passion and added consciousness about looks causing diverted attention from priority issues like safety. A reflection of outward expression of suppressed emotion and certain amount of aggression is a peculiarity of the age group taken into consideration.

Prolonged maintenance of awkward static posture causes postural stress, which is magnified with continuous exposure to vibration. Deviation in joint angles from normal positions and for a long duration is obvious to cause physiological stress leading to pain. Change in spinal curvature contour, and deviations of lumbar angle, lead to altered disc pressure, causing compression of nerve and hence pain.

2. MATERIALS AND METHODS

COLLECTION AND ANALYSIS OF HUMAN SAMPLES

2.1. JUSTIFICATION OF CHOICE OF BIKE

Three most popular bikes according to sales record were identified on Kolkata roads, which were Bajaj Pulsar, Bajaj Discover, Hero Honda Glamour (source: All India Bikers Association)



2.2. JUSTIFICATION OF CHOICE OF AGE GROUP

Data was collected from 10 male bike riders of each of these three types from the age group of 20-30 years. The age group was taken due to the highest accident proneness from earlier reported data.

2.3. CHOICE OF SUBJECTS

All the subjects were from similar socioeconomic background and nutritional status having no significant difference in height weight and BMI and age. All the bike riders regularly use bike as a mode of transport for at least two hours per day on Kolkata roads and are riding for over two years.

10 male controls subjects of comparable profile riding scooter were chosen of a particular scooter model (HONDA eterno). 10 male car drivers and 10 male sedentary people (students) of comparable profile were chosen as control subjects. This study was performed following the ethical guidelines for biomedical research on human participants as directed by ICMR, Govt. of India and due permission was taken from the Institutional Ethical Committee (IEC) for research on human participant of Presidency University. The entire study was performed with the permission of the individuals and all the subjects were explained about the objectives and probable impact of the work. They unanimously agreed to volunteer for the study.

Extensive interview and data personal collection with respect to their task time period and non-task apparent relief period have been taken in an isolated manner. Their specific physical, cognitive, physiological and psychological inabilities, inconveniences and pain profile have been recorded with extensive dialogues and standardized questionnaire method. The entire process results into emergence of several ergonomic hot spots which are to be immediately intervened.

Statistical analysis was performed using two tail t-tests by difference method among all the comparable groups. The statistical analysis was performed using the data generated in present study, have been processed by a modified statistical software minitab-17 for windows version 2009. Probability (p) values of less than 0.05 were considered statistically significant.

- 1) **Posture analysis by observation and photographic technique:** A video tape was used to create a permanent record of the jobs and personal computer to perform the clerical and time keeping task associated with posture analysis. Posture analysis tool software (RULA, REBA, Suzanne Rodgers, Moore and Garg) was used to evaluate the videotape and still photography. The result of which are highly reproducible in nature. Detailed present and past personal and occupational history was taken.
- 2) **Goniometry** using Laffayette Gollehon extendable Goniometer was done to measure joint angles at working and normal posture and the deviations were statistically analyzed



- 3) **Spinal curvature** contour was taken employing flexi-curve and it was used to record the spinal shape [7].The angle of deviation in the lumbar region was calculated and recorded, the recorded data was further statistically analyzed.
- 4) **Pain mapping** was done by questionnaire method using standardized pain map (10-point subjective scale)[8]
- 5) **Segmental exposure to vibration** was recorded using vibration-meter (handheld vibration meter, Omega HHVB82)
- 6) **Fusion threshold** was also recorded using ascending trials that is decreasing rate of flickering of red light inside and the point where flickering stimulus was perceived to be steady was noted down using standard electronic apparatus.
- 7) **Rate of perceived exertion** was measured using Borg scale by questionnaire method both in verbal and numerical scale, cardiovascular stress was estimated from this subjective method since heart rate of a bike rider was difficult to measure while in action. [9]
- 8) **Several other preferences** regarding bike various discomfort and causes of psychological stress affecting behavior of bike riders were recorded by an online survey among 100 random bike riders, who uses bike as a mode of transport on Kolkata roads and are riding for over 2 years.

Age, Height, Weight, BMI were assessed by standardized technique.

Statistical analysis was performed using a two tail t-test by difference method among all the comparable groups.

Table 1: Assessment of physical parameters

Serial no	Parameter	Method employed
1	Age	Questionnaire method
2	Height	Anthropometrical Rod
3	Weight	Standardized weighing machine
4	BMI	Online BMI calculator
5	Joint angle	Goniometer
6	Spinal curvature	Flexi-curve
7	Vibration	Vibration meter
8	Critical Flicker Frequency	Standard electronic apparatus (Anand Agencies, Pune ,India)
9	Pain Mapping	10-point subjective scale
10	Rate of perceived exertion	Borg Scale



Table 2: Posture analysis and analytical method

Serial no	Parameter	Method employed
1	Rapid Upper Limb Assessment (RULA)	Videography and Ergofellow 2.0 (FBP SISTEMAS)
2	Rapid entire Body Assessment (REBA)	Videography and Ergofellow 2.0 (FBP SISTEMAS)
3	Suzanne Rodgers	Videography and Ergofellow 2.0 (FBP SISTEMAS)
4	Moore and Garg	Videography and Ergofellow 2.0 (FBP SISTEMAS)

3. RESULTS AND DISCUSSIONS

Male bike riders are generally subjected to postural, Biomechanical, physiological, environmental and psycho-social stress.

Goniometric recordings revealed significant deviations in joint angles at shoulder, wrist, hip, knee and ankle during working posture at those joints in comparison with the normal standing posture at those joints. The significant deviations (data were obtained on two tail t test and $p < 0.05$) within the range of motion of joints were obvious to cause pain [10] due to the awkward static posture maintenance. Results are presented in following tables

Mean, \pm SD and Deviation of lumber spinal angle (in degrees) of the bike riders in normal and working postures

Bike Name	Normal	Working	Deviation
Pulsar n=10	166.6 ± 1.83	174.8 ± 1.31	8.2 ± 2.25
Discover n=10	163 ± 2.58	175.3 ± 1.49	12.3 ± 1.94
Glamour n=10	165 ± 1.00	176 ± 1.00	11 ± 1.22



Mean and \pm SD of different joint angles (in degrees) of the bike riders (n=30) in normal and working postures.

Joint Angle	Normal	Working
Shoulder Angle	34.7 \pm 4.93	83.2 \pm 11.64
Elbow Angle	162.8 \pm 7.81	157.1 \pm 18.73
Wrist Angle	171.9 \pm 4.10	150.3 \pm 19.96
Hip Angle	168.6 \pm 4.69	108.6 \pm 7.99
Knee Angle	167.2 \pm 4.64	103.2 \pm 8.59
Ankle Angle	95.7 \pm 6.73	115.8 \pm 8.44

Mean and \pm SD of critical fusion frequency of bike riders and car drivers

Subjects	Critical fusion frequency
Bike Riders n=30	34.2 \pm 2.58
Car Drivers n=30	32.6 \pm 0.93

Angular deviations of lumbar region (L1-L5) in working posture was found to be significant in comparison with the normal standing posture (two tail t test $p < 0.05$). Contour alteration and angular deviation leads to high disc pressure leading to compression of nerves hence pain[11]. Whole Body vibration was noted but Low back and arm experienced maximum

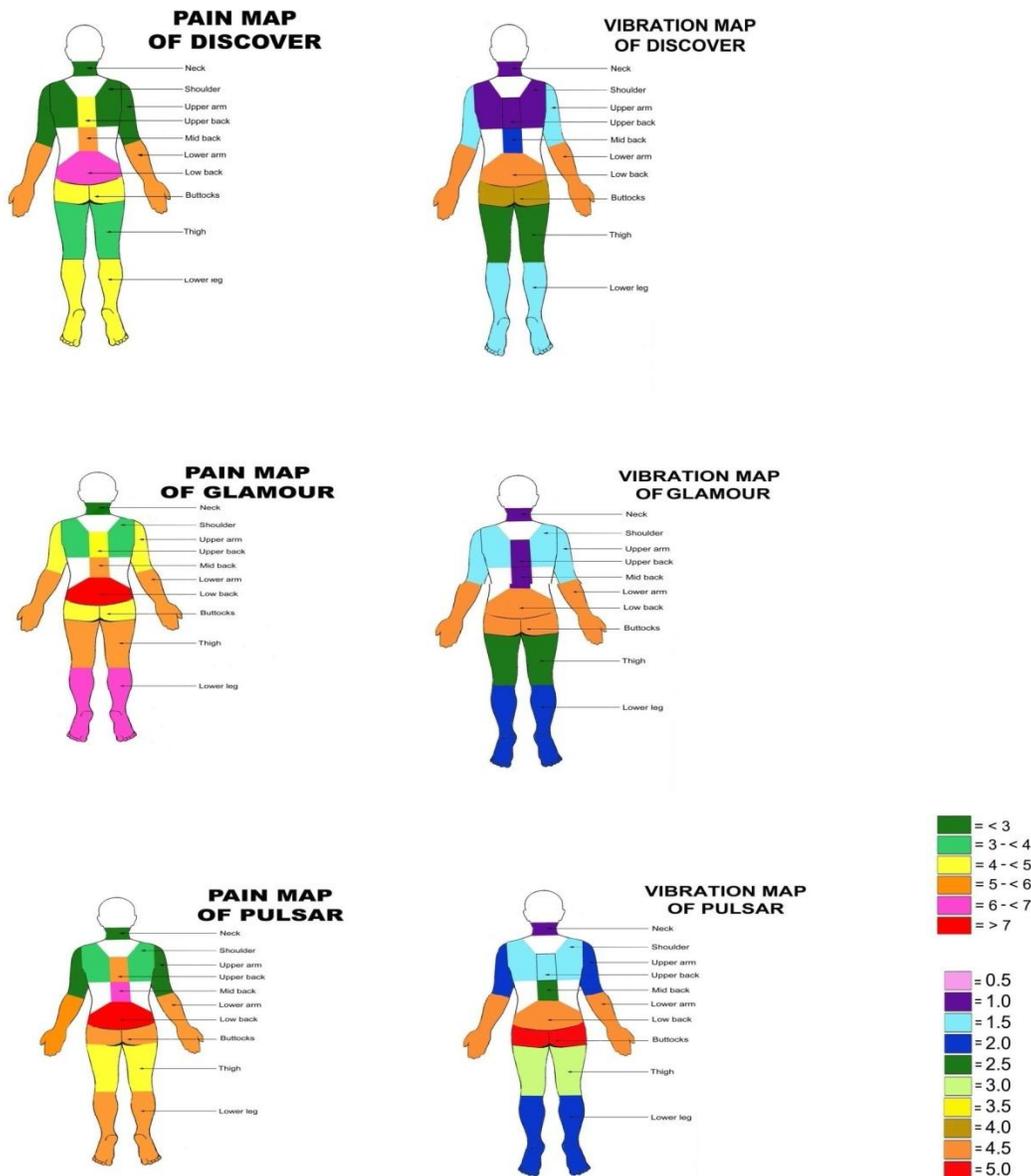


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vibration about an average of 4.3m/s^2 and 4 m/s^2 . The maximum bikers were reported to ride bike 1-2 hours per day according to the data obtained by survey response. According to OSHA limits [12] although Personal Exposure Limits (PEL) is denoted to be hazardous but a strong correlation between high pain zones and zones exposed to high vibration in the pain map and vibration map respectively was observed. It may be because Vibration may lead to altered disc pressure release of neuro-peptides and histological changes leading to pain [13].





Limitation of statistical analysis: in case of evaluating goniometric recordings, lies in the fact range of motion of all joints are different and degree of deviation of joint angle and discomfort arising from it are not always equal. For a joint small degree of deviation may cause immense pain but in another large degree of deviation may not give rise to pain at all. For this reason the survey conducted was used to find out people percentage reporting of areas were pain is experienced.

Area of pain	Percentage of people
Low back	43
Wrist	21
Shoulder	9
Neck	9
Arm	3
Leg	4
No pain	11

Low back pain had several contributory factors for a bike rider like deviated lumbar angle, deviated hip angle in working posture along with continuous exposure to vibration [14]. While wrist pain had few contributory factors apart from deviated working wrist angle, like wrist twist, wrist acting away from midline and repetitive work of wrist which amplifies wrist pain [15].

The comparison of working posture angles at each joint and the lumbar region were done with a type of bike with the other two types but no significant differences were observed hence each of the bikes may be inferred to be equally stressful and required equal attention followed by ergonomic intervention.

Posture analysis reveals **RULA** average grand score as 7 which indicates investigation and immediate requirement of changes. **REBA** average grand score was also obtained as 8 indicating high risk and need for further investigation and implementation of change. **Suzanne Rodgers** test results demands for high priority changes at neck; shoulder; back; elbow and arms; wrist, finger, hand; legs, knees, ankle alignments. Strain Index obtained on **Moore and Garg** investigation is which is much higher than tolerable, nonhazardous limit of score 7. The Strain Index demands immediate ergonomic interventions.

Fusion threshold measured is significantly higher in bike riders when compared with car drivers (data were obtained on two tail t test followed by one tail test). Fusion threshold of bike riders were also significantly high when compared with sedentary people (students) (data were obtained on two tail t test followed by one tail test). The high value of fusion



threshold indicated higher perceptual accuracy and delayed fatigue onset of pupillary muscles and acclimatization in bike riders. The difference with the car drivers were due to the reason bike commutes in small spaces which demand of higher visual acuity [16]

Rate of perceived exertion helped in assessment of cardiovascular stress of the bike riders. But the observer's evaluation of perceived exertion (very hard, 17) was higher in comparison with the riders perceived exertion in case of each bike. This may be due to dominant sense of psychological comfort over physiological comfort in the riders caused lesser realization of the feeling of stress. Among the bikes, Pulsar riders had highest perceived exertion (hard, 15), but Discover (somewhat hard, 13) and Glamour (somewhat hard, 13) riders had little lesser perceived exertion, indicating maximum cardiovascular stress of the Pulsar riders.

With the help of the online survey among the bike riders in Kolkata:

- The age group (21-23 years) was identified to have highest percentage of bike riders.
- The most preferred speed limit was identified to be 40-80 Kmph.
- Bike was chosen over scooter mainly due the style factor followed by advanced technique, since scootys were designed including certain style component scooter sales improved
- Most of the bike riders use bike for necessity followed by passion.
- Bike models were mainly chosen on the basis of looks and style followed by mileage and next comfort. Safety factor was negligible to consider.

Comparison test among bikes revealed:

- Glamour as most cost effective bike followed by Pulsar
- Glamour to be the safest bike followed by Pulsar and then discover.
- Pulsar as the most stylish bike
- Pulsar as the most comfortable bike
- Discover as the bike providing best mileage almost equally followed by Glamour

According to the reports the most sold in Kolkata bike is Pulsar corresponding to the facts that it is stylish and comfortable.



Evaluation of the survey conducted:

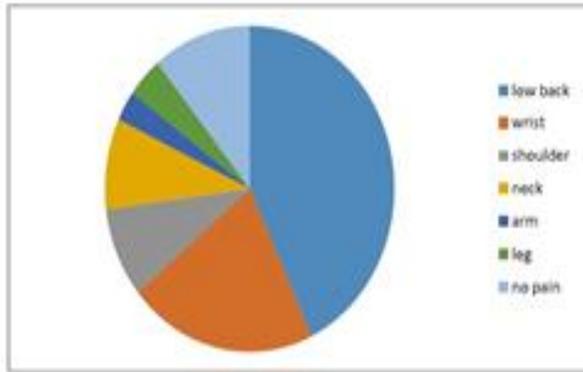


Figure 1: Areas experiencing pain

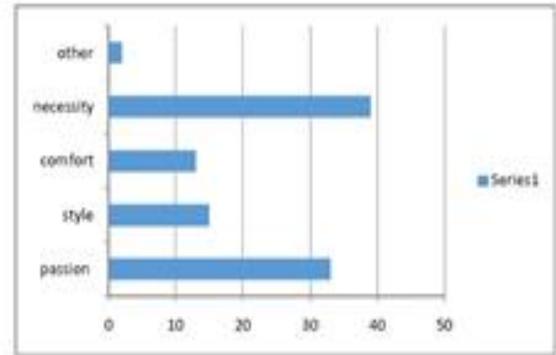


Figure 3: Reason for riding bikes

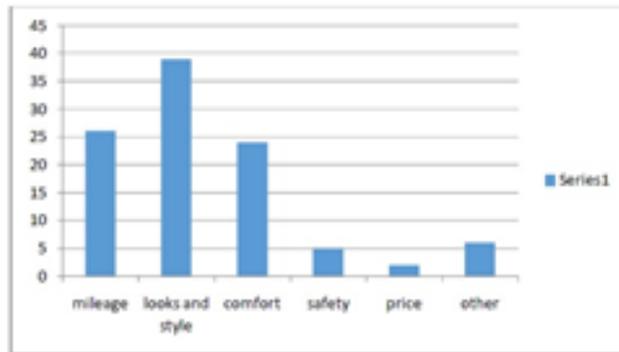


Figure 2: Factors effecting choice of bikes

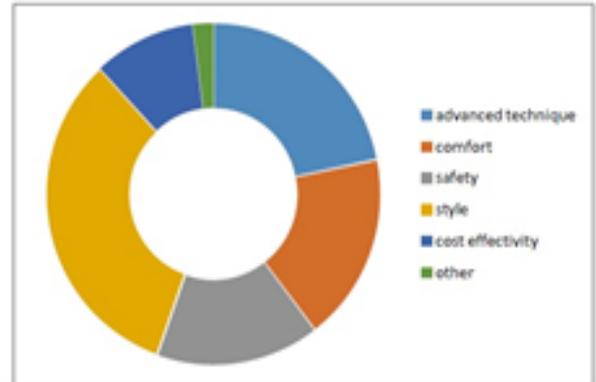


Figure 4: Reasons for choosing bike over scooter



Comparison test for 3 most popular bike Kolkata roads:

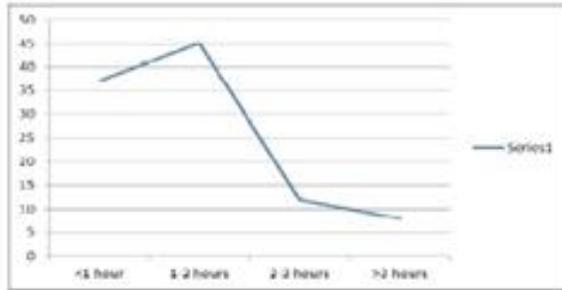


Figure 5: Duration of riding bike per day

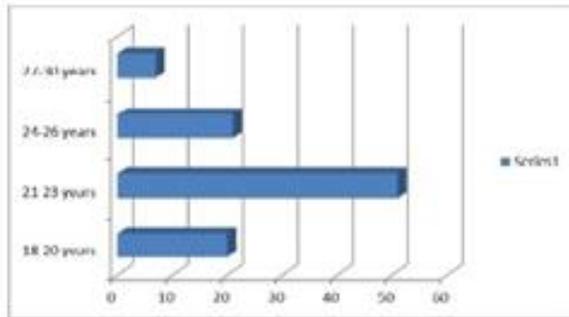


Figure 6: Percentage of people in a particular age group using bike

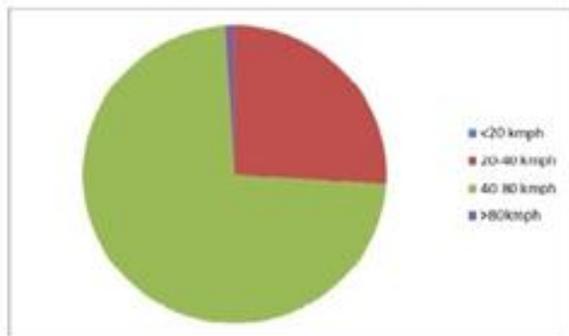


Figure 7: Most preferred speed limit

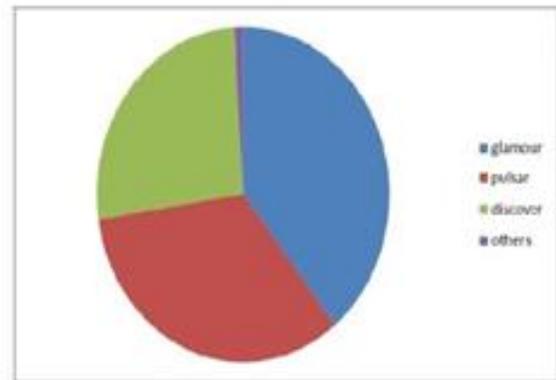


Figure 1: Cost Effectivity

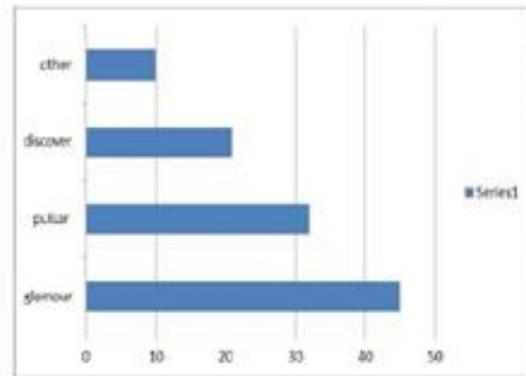


Figure 2: Safety

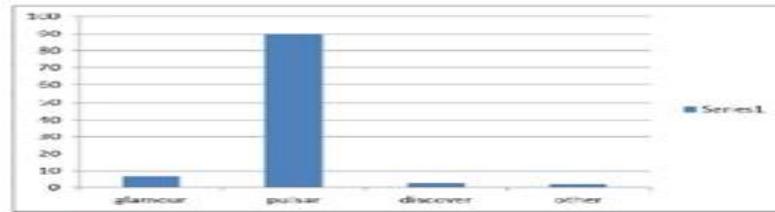


Figure 3: Style

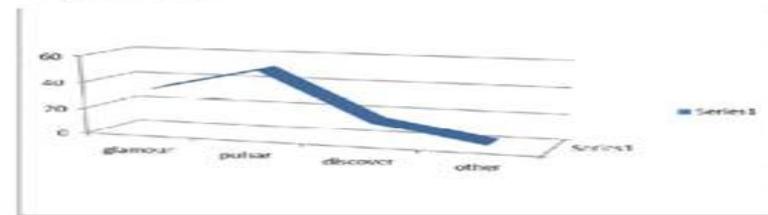


Figure 4: Comfort

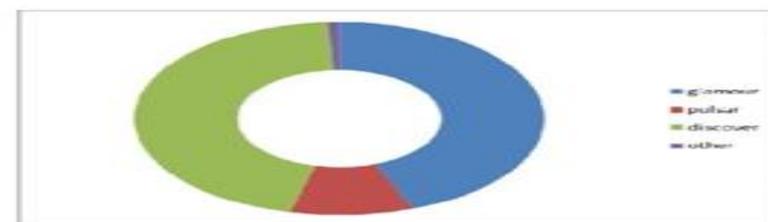


Figure 5: Mileage

4. CONCLUSION

A detailed evaluation and analysis of postural, physiological, biomechanical, Psychological and environmental stressors affecting bike riders were done. Assumptions of awkward postures with angular deviations at joint and spinal curvature contour were identified and quantified. Postures were analyzed to identify hazards and areas seeking intervention. A strong correlation of vibration and pain was identified. Relationship of different driving skills with visual acuity was also evaluated. Psychological evaluations of bike riders were also done along with estimation of perceived exertions of bike riders and predicted heart rate. An online survey was conducted to identify several preferences reflecting effects of psychological and social factors influencing intensions and behavior motorcycle riders.

The study conducted reveals the most popular bikes on Kolkata road were equally stressful and required attention and engineering revision by ergonomic intervention to reduce stress and accident proneness.

5. ACKNOWLEDGEMENTS

We would like to acknowledge the assistance and guidance of Dr. Debduot Ghosh Thakur. We would also like to thank Sarat Sindhu Mukhopadhyay, for helping with statistical evaluations, Pranjali Rawat for providing technical assistance to conduct the online survey.



We would like thank Sushanto Roy for helping me with graphics and illustrations. We are thankful to my friends Rubia Mondol, Amardip Kumar Singh, Avinandan Mondal and my other batchmates for being consistently helpful.

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