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Ergonomics study on work related musculoskeletal disorders and discomfort feeling among bi-cycle garage workers

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Abstract
Keeping in view, the present scenario regarding Musculoskeletal Symptoms (MSSs) and Musculoskeletal Disorders (MSDs) in many organized and unorganized sectors, the present study has been undertaken on bi-cycle garage workers. Through Standardized Nordic Questionnaire, the discomfort feeling in different body parts, pain sensation in different systems and pain feeling at different time of the day have been taken. Besides these parameters, physical and physiological parameters have also been taken of experimental as well as control subjects were also taken. Body postures during work were taken by three separate methods such as Ovako Working Posture Assessment System (OWAS), Rapid upper limb assessment (RULA) and Rapid Entire body assessment (REBA). Body weight as well as BMI and BSA in experimental group were significantly lower than control subjects. Headache, neck pain and lower back pain were significantly predominant among the experimental workers than control group. As per report of body posture analysis by OWAS, RULA and REBA; no major threat was found as per the development of MSDs are concerned. To reduce the impairment found in this study among experimental subjects; proper training, ergonomics awareness and implementation of work rest cycle may be recommended.

Keywords: Musculoskeletal disorder, musculoskeletal symptom, posture, discomfort feeling, OWAS, REBA, RULA

Introduction
Bi-cycle garage workers have been focused in this present study from the ergonomic view point. The main focus has been concised on the bi-cycle garage workers who generally involve themselves for repairing the bi-cycles. The main concerns of this study are the postures and posture related musculoskeletal disorders among the bi-cycle garage workers. Musculoskeletal disorders (MSDs) extend to almost all occupations and sectors, bearing critical physical and economic consequences for the sufferer. The continual exposure of workers to different labor risks lead to these disorders and despite their varied forms of appearance. The Finish Institute of Occupational Health (FIOH) identified musculoskeletal disorders as one of the most common work-related infirmity. The back accounts for most of the discomfort. Work related musculoskeletal disorders (WMSDs) are one of the most common occupational diseases which mainly affect the lower back, neck and upper and lower extremities. Work related MSDs have been emerged by ergonomic identification due to poor working environment after world war-II in the developed countries [1]. In the developing countries people approached towards industrialization but proper ergonomic knowledge was due. Due to this reason the WMSDs arose in various industrial sectors mostly in developing countries [2, 3, 4]. It has been found that among the motor cycle mechanics, there was prevalence in pain sensation due to manual materials handling and others awkward postural reason [5]. Low back and shoulder pain were observed due to the pulling and pushing type of work. A strong relationship was found between this type of work and shoulder complaints [6]. Different risk factors for MSDs and sickness related to MSDs absence related to this problem was identified. Work related physical and psychological factors were also identified for the occurrence of MSDs [7]. ILO's policies were also identified in regard of protection of labourers. The future policies were also reviewed previously as per occupational safety is concerned [8].

It has been found that, WMSDs was prevalent among the farmers in Gujrat. Low back pain was most dominant among those farmers as per study is concerned [9]. An ergonomic intervention was found to reduce the MSDs among the semiconductor assembly workers [10]. It was observed that intervention was found to reduce the probability of developing MSDs among computer workers. It was also supportive to reduce the physical and psychological problems [11]. It has been stated that, in dynamic type of work, risk of development of MSDs was higher. The interventional approach was also found to reduce these MSDs [12]. It has been identified that, Musculoskeletal Disorders were prevalent among handloom weavers in different body parts as well as in different systems of the body [13]. According to earlier report, MSDs were also frequent among rice farmers. They experience discomfort (pain) at lower back, knee and foot region. They also suffer from low capacity of lung due to inhalation of dust particles [14]. On the basis of brief review mentioned above, it can be said that, no such work has been undertaken on bi-cycle garage workers from ergonomic view point. So, this present study has been selected to observe the discomfort feeling of bi-cycle garage workers in their present working environment. This study will also focus on tendency of developing Musculoskeletal Symptoms leading to Musculoskeletal Disorders among bi-cycle garage workers in Murshidabad, West Bengal, India.

Materials and Methods

Selection of the subjects

Total number of 60 male bi-cycle garage workers were selected for this study randomly. These subjects were taken from 22 bi-cycle garages in Berhampore, Murshidabad, West Bengal. 60 male office workers were also selected as control subjects. It was strictly followed that no subject of control group was involved in any type of awkward posture.

Methods of the study

The bi-cycle garage workers were asked few questions on the basis of questionnaire regarding the age, experience in this work and occurrence of any type of discomfort in different parts of the body and systems in various working times of day. They also shared their past history regarding the pain sensation and relevance with the MSDs. Standardized Nordic Questionnaire (SNQ) [15] was used for this purpose in this study.

Measurement of Physical Parameters and their procedures

Physical characteristics such as body weight, height, BMI, BSA are calculated by following processes

A. Height: Heights of the subjects were measured in cm by using standard Martin anthropometric rod.
B. Weight (in Kg): Weights of the subjects were taken by properly calibrated weighing machine. The subjects were asked to stand on the weighing machine steadily without footwear and the reading was noted.
C. Body Mass Index (BMI): BMI was measured to know the height-weight relationship of the subjects. From the anthropometric data the BMI of the subjects were calculated [16, 17].
D. Body Surface Area (BSA): With the help of the anthropometric data, BSA of all control and experimental subjects was calculated [18].

Analysis of Working Posture

The working posture has key importance to measure the tendency of development of MSDs. For analysing the posture of all experimental subjects and the angles created by different body parts during working time, the methods such as OWAS (Ovako working Posture Analysis System) [19], RULA (Rapid upper limb assessment) [20] and REBA (Rapid Entire body assessment) [21] have been applied in this present study. The most frequent postures by the bi-cycle garage workers have been accepted in this study by these three methods mentioned above.

BPD scale rating or discomfort feeling

A tool used for analyzing workplace activities is the Body Part Discomfort Form. Such forms are based on the principle that the static loads (static work) involved in a given activity can be assessed by measuring the muscular pain experienced. The intensity of pain of feeling/discomfort was measured by utilizing the body part discomfort (BPD) [22]. The workers having no such discomfort feeling are not included in this rating.

Statistical analysis

Two tailed student's 't' test [23] was performed to generalize the results of various physical parameters of experimental bi-cycle garage workers in comparison to their respective control group. Statistical analysis was also performed applying two tailed chi square test [24] to generalize discomfort feeling (pain) of bi-cycle garage workers in comparison with control group. Considered significant level was $p<0.05$.

Results

The results of this study have been represented in tabular form below.

Table 1: Comparative demographics of control group and garage workers. Values are mean±SD, n=40. Asterisk (**) indicates significant values ($p<0.001$).

Parameters	Control group		Working group	
	Range of values	Mean values ± SD	Range of values	Mean values ± SD
Age (Yrs.)	20-60	24.06±3.54	20-60	29.20 ± 7.15
Height (Cm)	145-168	162.48±8.20	150-170	162.43 ± 7.90
Weight (Kg)	37-52	46.05±5.24"	40-75	54.0 ± 6.09"
BSA (m^2)	1.32-1.54	1.40±0.16"	1.55-1.73	1.63 ± 0.06"
BMI (Kg/m^2)	23.18-33.81	28.29±3.05"	17.2-30.3	23.10 ± 3.81**

Above table shows significant ($p<0.001$) relation of body weight, BMI and BSA between control and experimental group.

Table 2: Comparative health problems of control group and garage workers, n=40, no. Of affected subjects given with proper percentages (within brackets). Asterisk (*) used to identify significant values ($p<0.05$).

Different body systems	Health related problems		X^2	P value
	Control	Garage workers		
Respiratory	10 (16)	18 (30)	0.48	$p>0.05$
Cardiovascular	12 (20)	20 (32)	0.82	$p>0.05$
Digestive	13 (21)	18 (30)	1.14	$p>0.05$
ENT	05 (08)	10 (16)	1.40	$p>0.05$
Eye	11 (18)	19(31)	1.02	$p>0.05$
Skin	07 (11)	12 (20)	1.13	$p>0.05$
Headache	15 (25)	40 (66)	10.32	$p<0.05$*

This table represents the comparative analysis of health problems between control and experimental group. Among various parameters, only 'headache' is significantly ($p<0.05$) different between these two groups.

Table 3: Discomfort feeling (pain) at several body parts between garage workers and control group. n=40, no. of affected subjects given with proper percentages (within brackets). Asterisk (*) used to identify significant values ($p<0.05$).

Pain at different body parts	Discomfort feeling		X^2	P value
	Control	Garage workers		
Neck	18 (30)	40 (67)	7.24	$p<0.05$*
Shoulder	10 (16)	16 (26)	0.48	$p>0.05$
Upper back	12 (20)	18 (30)	1.52	$p>0.05$
Lower back	14 (23)	49 (81)	8.22	$p<0.05$*
Hand	08 (13)	14(23)	1.42	$p>0.05$
Chest	05 (08)	08 (13)	1.14	$p>0.05$
Elbow	10 (16)	19(31)	0.82	$p>0.05$
Knees	09 (15)	12 (20)	0.78	$p>0.05$
Feet	08 (13)	09 (15)	0.40	$p>0.05$

Above table depicts the results of comparative analysis of discomfort feeling (pain sensation) at different body parts of control and experimental bi-cycle garage workers. Neck pain and lower back pain were significantly ($p<0.05$) predominant among experimental subjects in present study.

Table: 4: Comparative pain feeling at different time of control group and garage workers, n=40, no. Of affected subjects given with proper percentages (within brackets). Asterisk (*) used to identify significant values ($p<0.05$).

Pain feeling body parts at different time	Pain feeling at different time		X^2	P value
	Control	Garage workers		
Pain felt during work	01 (02)	30 (50)	8.94	$p<0.05$*
Pain felt after work	08(13)	18 (30)	0.98	$p>0.05$
Pain felt before or after Sleep at night	10 (16)	19 (31)	0.82	$p>0.05$

Analysis of pain feeling at different times of the day of both control and experimental individuals has been reflected in above table. Pain feeling during work among the bi-cycle garage workers significantly ($p<0.05$) differs from their control counterpart.

Table 5: Posture analysis of garage workers by OWAS method, n=40, no. Of affected workers given with proper percentages (within brackets).

OWAS codes	OWAS remarks	No. of affected subjects
1	No necessary action	14 (23.33)
2	Corrective measures required in near future	43 (71.66)
3	Necessary action required very soon	03 (5.00)
4	Necessary action required immediately	00 (00)

Work posture analysis of all experimental subjects by OWAS method has been of tabulated above.

Table 6: Posture analysis of garage workers by RULA method, n=40, no. Of affected workers given with proper percentages (within brackets).

RULA codes	RULA action category	No of sampled postures
1-2	Acceptable posture	11(18.33)
3-4	Investigation required, change may be applied	39 (65)
5-6	Further investigation change soon,	10 (16.66)
7	Further investigation and change very soon	00 (00)

Work posture analysis of experimental group by RULA method has been represented above showing different action categories.

Table 7: Posture analysis of garage workers by REBA method, n=40, no. Of affected workers given with proper percentages (within brackets).

Reba codes	Reba action category	No of sampled postures
1	Negligible risk, no action required	16(26.66)
2-3	Low risks, change may be done	23(38.33
4-7	Medium risks, investigation needed	21 (35)
8-10	High risks, further investigation and change soon	00 (00)
11+	Very high risks, immediate change	00 (00)

Work posture analysis of experimental group by REBA method has been represented above showing different codes of action categories.

Discussions

The bi-cycle garage workers generally perform various types of tasks throughout their daily working schedule. Their work pattern or the work schedule of these workers is not uniform or predictable. These work schedules includes lots of bending twisting and other precarious positions. Besides, it also includes repetitive motion and movements, few of which are potentially harmful to their health. The main stressful condition of the garage workers occurs due to the awkward posture and repetitive tasks. So, it is obvious that working environment is not worker friendly which may lead to work related Musculoskeletal Symptoms [25].

This present study on bi-cycle garage workers reveals that the physical indices like weight, BSA and BMI have significant difference between control and experimental worker group (Table-1 & Fig-1). Both the BSA and BMI have their relationship with body weight. As per outcome of this study the mean body weight of experimental group found reduced in this experiment, it might affect the BSA and BMI of garage worker.

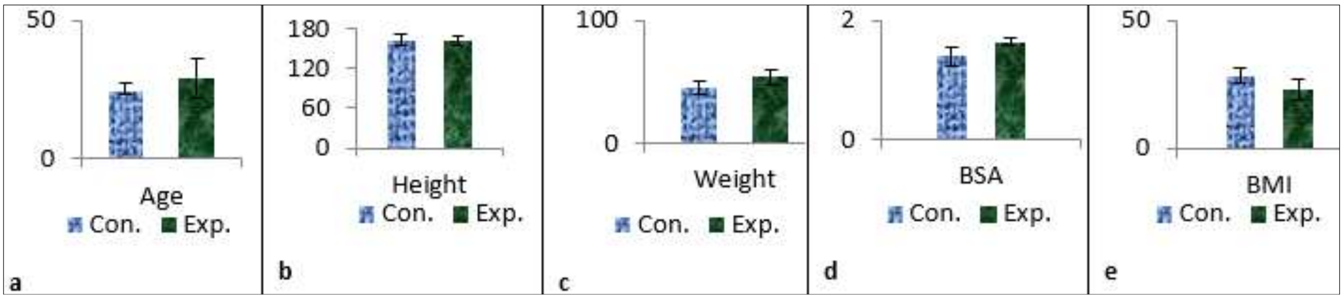

Fig 1: Graphical comparison of physical parameters between experimental and control subjects (a-e).

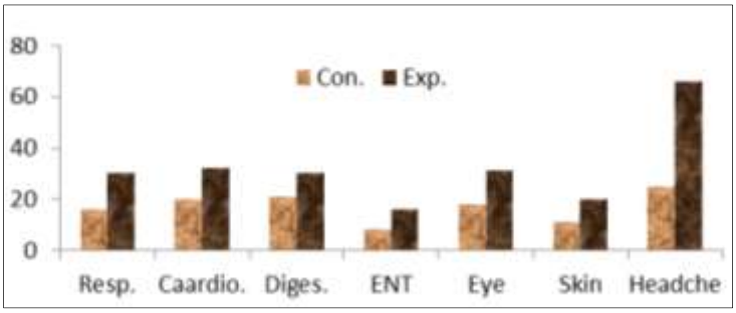

Fig 2: Health problems regarding various systems of workers in comparison with control group. Values are in %.

Outcomes of this study is quite clear that the system related problems like respiratory, cardiovascular, digestive, ENT, eye and skin related problems or disorder among bi-cycle garage worker are not significant in comparison with control group subjects. In case of headache, the result is not same but just opposite. It means that the headache is dominant among the experimental workers and it also differs significantly from the control group of the study (Table- 2 and fig-2). This difference may be due to strenuous nature of this job and also may be due to its long duration.

Reflection is transparent from the experimental outcomes that, the discomfort feeling at majority of different body parts studied in this experiment; do not vary between control and experimental groups. Discomfort feeling at shoulder, upper back, wrist, elbow, hand, feet, chest and knees do not differ significantly between control and experimental group. But anomalies have been observed in case of discomfort feeling at neck and lower back. These two parameters have significant difference between experimental and control subjects (Table-3 and fig- 3). It has been reported earlier that neck pain was very common and associated with shoulder pain [26].

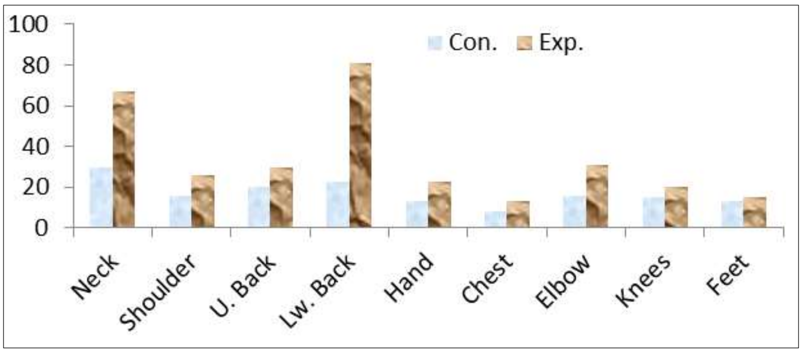

Fig 3: Discomfort feeling regarding various body parts of workers in comparison with control group. Values are in %.

The nature of this job incorporates lots of movements of neck and also includes awkward posture. Duration of this kind of awkward posture is very long which may be the probable reason behind this significant difference of these two parameters. Another contributing factor may be curved back posture which may initiate the tension in the related muscles [27].

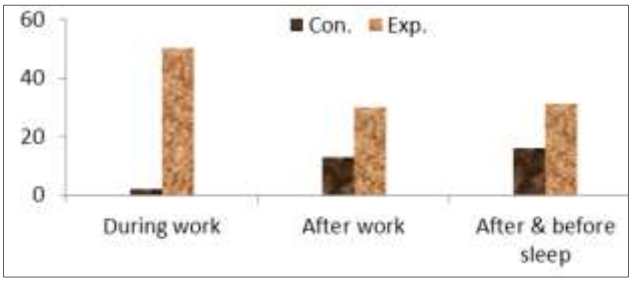

Fig 4: Pain feeling at different times of workers in comparison with control group. Values are in %.

The current observation also depicts that, the bi-cycle garage workers feel pain during their regular work time. This pain feeling during work is different from the control group in significant way (Table 4 and fig-4). It has also been observed that except work time, no such significant pain was felt by the bi-cycle garage workers in comparison to the control subjects. Severity of pain felt by the experimental workers during the work may be due to its long duration without any scheduled rest. Same type of result was observed earlier in the experiment on two wheeler garage workers [28].

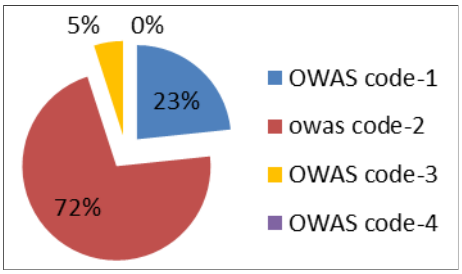

Fig 5: Graphical presentation of OWAS action category of sampled posture of experimental subjects.

One of the most preferred methods of assessing body posture is OWAS. For this reason, it has been successfully used in several work places [29, 30, 31]. In this present study, posture analysis of bi-cycle garage workers by OWAS method clearly reveals that majority (71.66%) of sampled workers are in OWAS action category-2. It indicates that corrective measure may be required in near future. 23.33% experimental workers are in action category-1 which indicates that corrective measure is not required for those workers. Only 5% sampled bi-cycle garage workers are under action category-3 which implies that corrective measure should be taken as soon as possible (Table-5 & Fig-5). So, from the OWAS analysis it may be recommended that the bi-cycle garage workers are not in great risk with their present work schedule because no worker was under OWAS action category-4 which suggests immediate change of work posture.

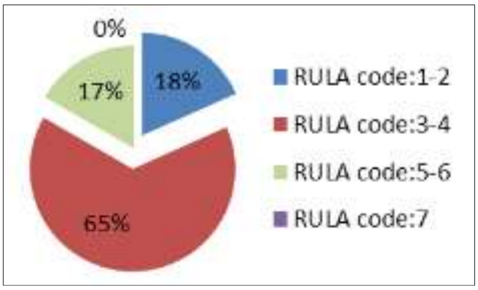

Fig 6: Graphical presentation of RULA action category of sampled posture of experimental subjects.

Body posture of sampled bi-cycle garage workers during work schedule was also analyzed by the method of RULA. Outcomes of this analysis states that, majority of the sampled postures (65%) of experimental subjects are under the RULA codes 3-4 which suggests further investigation in near future. Only 16.66% of garage workers are under RULA codes 5-6 suggesting necessary change in working posture after further investigation. 18.33% bi-cycle garage workers are under the RULA codes 1-2 indicating the safe posture, which is acceptable and no corrective measure is necessary (Table-6). It is also obvious from present observation that no worker is under severe threat (RULA code-7) that needs immediate corrective measure.

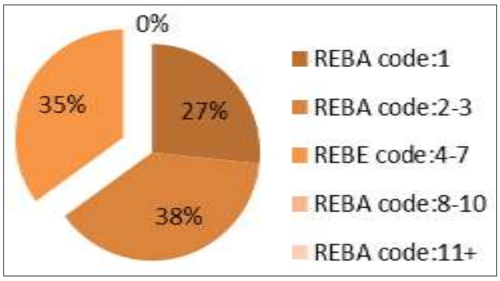

Fig 7: Graphical presentation of REBA action category of sampled posture of experimental subjects.

It has been reported earlier by many of the authors that development of MSDs are largely dependent on unsafe working posture [32, 33, 34, 35, 36]. Keeping this on focus, posture of experimental group of bi-cycle garage workers were also analyzed by the REBA method. Analysis of body posture of working experimental group by this method indicates that no worker is under high risk and very high risk group. 35% sampled posture in this method are in medium risk group which has no necessity of corrective measure after investigation in near future. 38.33% of sampled working postures are under low risk group indicating that corrective measure may be needed after investigation in future. 26.66% of sampled working postures of experimental subjects in this method are under negligible risk which needs no corrective measure (Table-7).

Essence of this present experiment clearly focuses on few physical and physiological parameters which have been hampered due to the nature of this work. First of all, it may be mentioned that, the BMI of experimental group is significantly less than the control group but its range in present study is well accepted. If the work rest cycle would be implied in future, the strenuous nature of this job may be decreased and consequently the headache, pain in neck and lower back may also be reduced. It has been reported that, unsafe working posture is one of the main reasons for the development of MSDs [37]. It has been studied earlier that posture, weight of a load and location are the factors of exerted force on lumber region and internal vertebral disc [38, 39] which may lead to musculoskeletal disorders (MSDs). This study on bi-cycle garage workers reveals that there is awkward postures (Fig-8) exerting force on lower back but not in combination with huge load. So risk of developing MSDs is minimized. Pain felt by experimental workers during work may also be reduced if rest period is provided to the garage workers. As per the results of posture analysis of bi-cycle garage workers by three separate well accepted methods, no immediate action or corrective measure is necessary. This also indicates that there is no threat of severe and immediate MSDs among the experimental group of workers.

Fig 8: Different postures of bi-cycle garage workers

Conclusion and future scope

Extracts of impairments focused in this present study is mainly due to lack of ergonomics awareness and guidance. Proper implementation of ergonomics views such as applying proper work rest cycle, the strenuous nature of this job may be reduced which may consequently reduce the headache, neck pain and lower back pain felt by the experimental worker in this study. Using proper tool and equipments as well as proper technique may increase the status of working postures of working subjects. This kind of improvements may help in minimizing the development of MSDs among working experimental group.

In future this present study on bi-cycle garage workers may be extended dividing the total working individuals in different groups on the basis of their work experiences. Introducing the recommendation of present study mainly giving emphasis on proper use of tools, equipments and techniques, in future this experiment should be done with individuals of nearly same age group to discard the aging effect. This might be an updated approach to differentiate and generalize the outcomes of the study.

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Conflicts of interest

Authors declared no conflict of interests.

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