International Journal of Occupational Safety and Ergonomics (*JOSE*) 2012, Vol. 18, No. 4, 521–530

An Ergonomics Study on the Prevalence of Musculoskeletal Disorders Among Indian Bus Conductors

Somnath Gangopadhyay
Samrat Dev
Tamal Das
Goutam Ghoshal
Tarannum Ara

University College of Science & Technology, University of Calcutta, Kolkata, India

This study was undertaken among 100 randomly selected bus conductors from 2 routes. A questionnaire study based on the modified Nordic musculoskeletal questionnaire, assessment of physical and physiological parameters, analysis of working postures and a detailed work study were performed. The analysis revealed that conductors had a work schedule of 16–18 h each day; the duration of work could vary from 15 to 20 days at a stretch. Discomfort leading to musculoskeletal disorders mainly affecting the leg (93.3%), knee (83.3%), shoulder (80%) and back areas (56.7%) had the highest 12-month prevalence rates and increased day by day. The conductors also suffered from extreme physiological stress due to prolonged working hours in hazardous standing posture conditions, excessive work pressure and minimum rest between trips. Consequently, all those factors affected their health and work performance.

bus conductor musculoskeletal disorders work study India

1. INTRODUCTION

Transport or transportation is the movement of people and goods from one place to another. The term is derived from the Latin words *trans* (across) and *portare* (to carry). In India, many forms of public transportation are available for passengers. Among them, buses play a significant role. The safety of the general public both within the bus and on the road is given little priority [1].

Work-related musculoskeletal disorders (WMSDs) affect workers in many occupations including those related to operating large vehicles. Urban bus transportation workers have been found to have high prevalence rates of musculoskeletal problems. Kolkata, India, is a densely populated city with numerous public buses that constitute a major means of public transportation. Both physical and psychosocial risk factors affect WMSDs. There are many physical factors that may contribute to increased physical loading in the bus conductors' musculoskeletal system, resulting in discomfort and pain. The most commonly identified physical factors are prolonged standing, whole-body vibration, strenuous workload and prolonged working time. In terms of individual factors, age, gender, weight and height, the body mass index (BMI) as well as the general health status of the conductors are also important risk factors associated with WMSDs [2, 3, 4].

In India, the working conditions of bus conductors are poor and stressful. However, this problem

The authors express their sincere gratitude to all those bus conductors who rendered immense co-operation during the completion of this study.

Correspondence and requests for offprints should be sent to Somnath Gangopadhyay, 13, Katua Kuthi Lane, Bhowanipur, Kolkata, 700 025 India. E-mail: ganguly1961@yahoo.com.

has not been investigated. The purpose of this study was to investigate the prevalence and characteristics of WMSDs and the extent of stress among urban bus conductors in Kolkata.

2. METHODS

2.1. Public Buses and Conductors

Among the different types of buses in Kolkata, public buses are significant. There are primarily two types: the Bangla Body bus (the older type) and the Euro bus. This study was conducted in those buses. They seat 38 passengers each.

These buses are staffed by two conductors and a driver. The conductors operate at the front and rear doors of the bus. Since these buses constitute the backbone of local transportation, they run throughout the city on various routes. Consequently, many people work as conductors.

The regular work schedule of these conductors is alarming. They work continuously up to 16–18 h each day and there is no system of weekly time off for them. They work as long as their body permits and the duration may vary from 15 to 20 days at a stretch followed by a break of 4–5 days. They begin their work in early morning and end almost at midnight. They undertake 5–6 trips each day, where one trip means a to and fro journey, i.e., starting at the depot, going to the final destination and returning to the depot. They do not get a fixed salary. Rather, their income depends on the number of passengers, i.e., it is commission-based, whereby every rupee they collect earns them 24 paise. The conductors do not work at a fixed door. They alternate at both doors of the bus.

Moreover, the bus conductors perform a number of tasks when they are on duty. In addition to selling tickets to passengers by approaching them, they are also involved in other tasks. Initially, just after the bus begins its journey from the depot, the conductor stands on the stairs of the front door of the bus and constantly screams out the exact route that the bus will cover, particularly mentioning the important locations to draw the commuters' attention. Usually, to attract more passengers, he even communicates individually with people on the road to find out their exact destination. The conductor also performs another significant function: he announces loudly the bus stops at very frequent intervals, thereby making it easier for passengers to get off the bus at their destination.

Assisting the driver when passing through congested roads and junctions is an additional source of stress. The conductor has to be very careful when people are getting on or off the bus and he has to remain at the door for this purpose, particularly for children, women and aged people. In between, he has to strictly monitor that all the passengers have bought tickets. He also has to maintain periodic communication with his fellow conductor at the other door. After conducting such hazardous tasks involving constant standing for hours, he most often gets into arguments with passengers on different issues, e.g., tendering exact fares and the slow speed of the bus. All this makes the conductor's work extremely hectic and stressful.

2.2. Selection of Subjects

One hundred male conductors, with over 5 years of experience each, participated in this study. They were selected randomly from two short-distance buses.

One of the buses (No. 30C/1) traversed from Hatiara to Babughat covering 18 km within Kolkata. Thus, one full trip of the bus involved 36 km. The origin and the destination of the other bus (No. 30C) were identical; however, the routes were different. The total distance was 20 km within the city. Thus, one full trip of the bus involved covering 40 km.

2.3. Questionnaire Study

A detailed study based on the modified Nordic questionnaire [5] was performed on the experimental group. The questionnaire consisted of a series of objective questions with multiple-choice responses. A face-to-face interview was thought to be more reliable in obtaining accurate information from the bus conductors as they were from a wide range of backgrounds with different educational levels. The questions were grouped in three major sections:

- general information on the workers, i.e., their age, years of experience, etc.;
- work organization and work behaviors;
- assessment of stress at work and detailed questions on physical disorders caused by the working environment.

2.4. Physical Parameters

The height and weight of the bus conductors were measured with a Martin anthropometer (Takei, Japan) and a Crown weighing machine (Raymon Surgical, India), respectively. The body surface area (BSA) [6] and BMI [7, 8] of all the subjects were also computed.

2.5. Physiological Parameters

Heart rate was measured before and just after a trip with a 10-beats method from the carotid pulse [9]. The subjects' blood pressure was measured with a Diamond (India) sphygmomanometer and a Diamond stethoscope before and just after a trip.

2.6. Working Posture

The bus conductors' working postures were analyzed with REBA (rapid entire body assessment) [10] to assess posture for risk of WMSDs.

The critical tasks of the job were analyzed and posture factors were assessed for each task by assigning a score to each region. The scores for group A (trunk, neck and legs) and group B (upper arms, lower arms and wrists) postures for the left and right sides were worked out. For each region, there was a posture scoring scale plus adjustment notes for additional consideration. Then, the load/force and coupling factors were evaluated. The scores from table A for group A postures and from table B for group B postures were assigned. Score A was the sum of table A score and the load/force score. Score B was the sum of table B score and the coupling score for each hand. Score C was read from table C, by entering it with scores A and B. The REBA score was the sum of score C and the activity score. The degree of risk was found in the REBA decision table.

2.7. Subjective Musculoskeletal Symptoms

In this part of the questionnaire, the subjects were interviewed about any kind of discomfort felt in the body, such as hands, shoulders, lower back and legs, etc. The intensity of pain or discomfort was measured with the body part discomfort scale [11]. Body parts were rated on a scale from 1 to 10 to indicate the level of discomfort. The 14 workers with no feeling of discomfort were not including in this rating.

2.8. Work Study of Entire Work Process

A work study of the entire process of a bus conductor was performed and analyzed in the form of a flow process chart and a string diagram [12].

In the work process method, a period of 10 min, from the total of 1 h 20 min that the journey from the depot to the final destination took, was recorded. For the flow process chart, the normal activities of bus conductors (operation, transport, delay, inspection) were plotted in connection with respective descriptions of work in the 10-min period analyzed. Finally, the number of different activities was calculated to evaluate the working conditions.

2.9. Statistical Analysis

Means and standard deviations of the selected physical and physiological parameters were calculated. A one-tail Student *t* test was also used to find out whether there was a significant difference between the physiological parameters before and after work for the chosen level of significance ($p < .05$) [13].

3. RESULTS

One hundred subjects successfully completed the questionnaire and physical assessment. The questionnaire showed that the bus conductors worked 16–18 h a day and rested for ~10–15 min between each trip. They worked 20–22 days a month. The bus conductors' experience ranged from 5 to 28 years.

The results showed that the bus conductors' mean (*SD*) age was 34 (11.57) years, height 163.4

(6.29) cm and weight 59 (7.50) kg (Table 1). The mean values of BSA and BMI were 1.66 m^2 and 20.3 kg/m^2, respectively, which showed that all conductors had a normal range of BSA and BMI.

TABLE 1. Physical Characteristics of Bus Conductors (*N* = 100)

	Bus Conductors	
Characteristic	***M***	***SD***
Age (years)	34.0	11.57
Height (cm)	163.4	6.29
Weight (kg)	59.0	7.50
BSA (m^2)	1.66	0.15
BMI (kg/m^2)	20.3	2.20

Notes. BSA = body surface area, BMI = body mass index.

Table 2 lists mean blood pressure (before and after a trip) and heart rate (before and after a trip). The analysis of physiological parameters showed that blood pressure increased after a trip, followed by heart rate.

The questionnaire study showed that all workers complained of discomfort in different parts of the body. The subjects reported most discomfort at rest and at work (Figure 1). In this study, 86.6% workers suffered from severe pain at rest and 66.7% at work.

Figure 2 shows that the predominant type of discomfort was pain throughout the body (100%) followed by tingling (83.3%), numbness (50.0%), stiffness (33.3%) and swelling (10%). According to the respondents, pain was greatest at work and also at rest. Due to prolonged standing, they also experienced tingling and numbness mainly in the leg region, followed by the hand region.

In the questionnaire study, most bus conductors reported experiencing discomfort mainly in the legs (93.3%). They experienced more pain in the left leg than in the right one as their prolonged standing posture in the buses exerted excessive pressure on the left leg. The other regions that were affected included the knees (83.3%), ankles (83.3%), feet (83.3%), shoulders (80%), wrists (70%), hands (63.3%) and lower back (56.7%). Because of carrying heavy side bags (2.0–2.5 kg) on their left shoulders, the discomfort in body parts located on the left side of the body seemed more predominant. Amongst the different body

TABLE 2. Physiological Characteristics of Bus Conductors (*N* = 100)

		Bus Conductors				
		Before Trip		After Trip		
Physiological Characteristic		***M***	***SD***	***M***	***SD***	***t***
Blood pressure (mm/Hg)	systolic	119	5.53	136	6.24	10.19
	diastolic	80	3.50	97	3.91	6.86
Heart rate (beats/min)		82	6.90	96	11.35	4.51

Notes. All parameters show significant difference at $p < .05$.

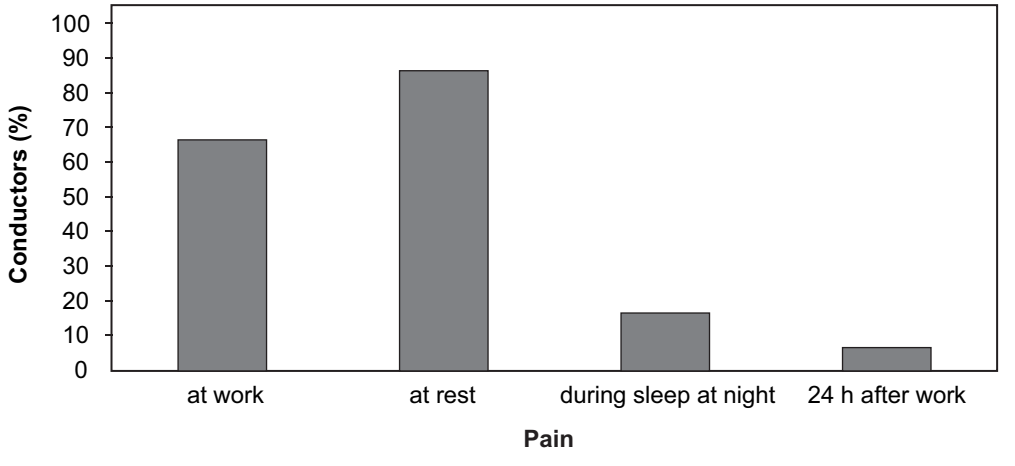


Figure 1. Discomfort (pain) at different times among conductors.

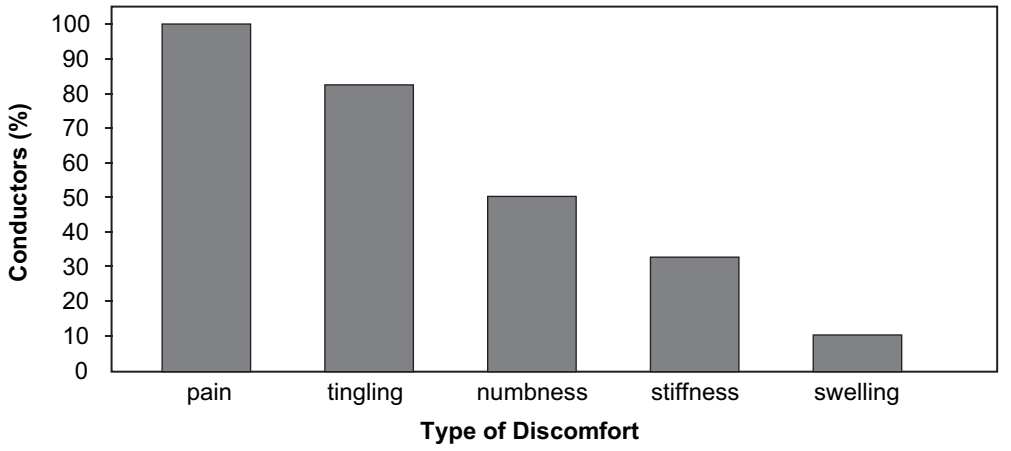


Figure 2. Type of discomfort among conductors.

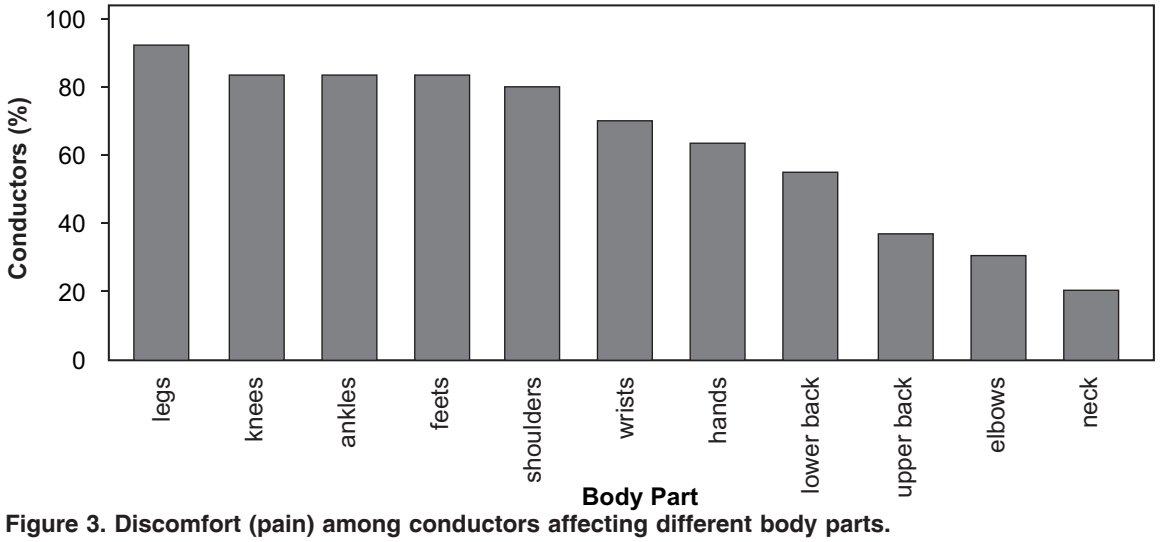
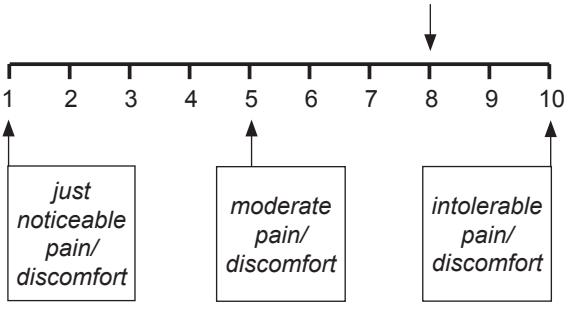


Figure 3. Discomfort (pain) among conductors affecting different body parts.

TABLE 3. Discomfort Feeling (Pain) According to Borg Scale (Whole Body) in Bus Conductors (*N* = 100)

Scale Range	Conductors (%)
1–3	4
4–7	62
8–10	34



parts, the leg region was the most affected, whereas the neck was the least affected (Figure 3). For the major areas of discomfort, the age factor and work experience factors showed that younger age groups or those with fewer years of experience experienced less discomfort than those who were older or had more experience; discomfort (pain) increased year by year.

In this study, the overall average rating among the conductors was 8, which indicated that they experienced great discomfort in different body parts (Table 3).

According to individual rating of body parts on the discomfort scale, the leg region was the most affected (Figure 4). The subject reported more discomfort on their left side than on the right one.

It was evident from the analysis of posture that most postures adopted at work were awkward and hazardous and required immediate corrective

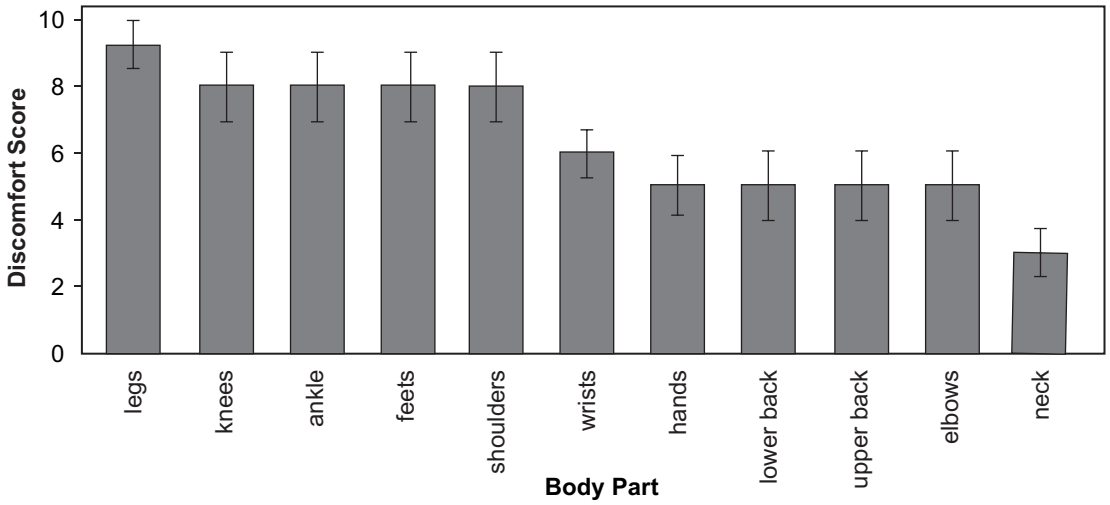
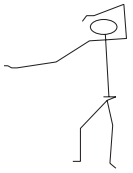
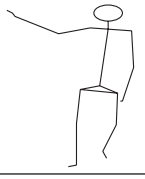
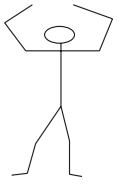
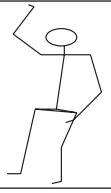
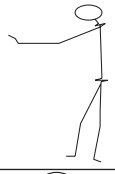


Figure 4. Discomfort (pain) according to Borg's scale in different body parts (*SD*).

TABLE 4. Analysis of Bus Conductors' Working Posture.

Figure	REBA Score	Risk Level	Action Category
	7	medium	necessary
	9	high	necessary soon
	8	high	necessary soon
	10	high	necessary soon
	9	high	necessary soon
	7	medium	necessary

Notes. REBA = rapid entire body assessment [10].

TABLE 5. Work Study of the Entire Activity of a Bus Conductor

TWO-CONDUCTOR PROCESS	SUMMARY				TWO-CONDUCTOR PROCESS
	ACTIVITY	METHOD		ACTIVITY	
		CONDUCTOR 1	CONDUCTOR 2		
ACTIVITY OF FRONT-DOOR CONDUCTOR 1	OPERATION ○	3	3	○ OPERATION	ACTIVITY OF REAR-DOOR CONDUCTOR 2
	TRANSPORT ⇨	3	4	⇨ TRANSPORT	
	DELAY D	2	1	D DELAY	
LOCATION LOCAL SHORT-DISTANCE BUS	INSPECTION □	1	1	□ INSPECTION	LOCATION LOCAL SHORT-DISTANCE BUS
	COMBINA-TION ◯	2	2	◯ COMBINA-TION	
	TOTAL TIME (s)	11	11	TOTAL TIME (s)	

WORK DESCRIPTION CONDUCTOR 1 (FRONT DOOR)	TIME (s)	○	⇨	D	□	◯	◯	□	D	⇨	○	TIME (s)	WORK DESCRIPTION CONDUCTOR 2 (REAR DOOR)
MOVE TOWARDS DOOR	65.2											92.0	MOVE TOWARDS DOOR
INSPECT BUS AND SEATS	42.3											31.7	INSPECT BUS AND SEATS
CALL PASSENGERS	148.2											917.0	CALL PASSENGERS
STAY IN DOOR	150.0											170.9	STAY IN DOOR
MOVE FROM DOOR TO PASSENGERS	10.8											15.4	MOVE FROM DOOR TO PASSENGERS
ASK FOR TICKET	5.5											8.9	ASK FOR TICKET
SEARCH FOR BALANCE	17.2											22.8	SEARCH FOR BALANCE
RETURN BALANCE AND TICKET	15.2											22.9	RETURN BALANCE AND TICKET
RETURN TO DOOR	15.5											14.0	RETURN TO DOOR
INSPECT AND INSTRUCT DRIVER TO STOP	89.8											82.8	INSPECT AND INSTRUCT DRIVER TO STOP
STAY IN DOOR	40.3											54.9	STAY IN DOOR
TOTAL	10.0 min	3	3	2	1	2	2	1	1	4	3	10.0 min	TOTAL

measures (Table 4). The bus conductors frequently adopted these types of work postures throughout the day and they maintained them for 10 s to 3 min at a time.

The flow process chart of the work study showed that the bus conductors performed different types of activities (Table 5). This chart illustrated a period of 10 min out of the total work of 1 h 20 min that the journey from the depot to the final destination involved. Such work of 10 min was done almost 8 times in the period of 1 h 20 min. The bus conductors repeated the same tasks day in and day out.

It was observed that the existing procedure of the bus conductors at the front door involved 3 operations, 3 transports, 2 delays, 1 inspection and 2 combinations. On the other hand, the conductor at the rear door performed 3 operations, 4 transports, 1 delay, 1 inspection and 2 combinations.

Figure 5 shows the design of the interior of a Bangla Body bus, including the arrangement of the seats. The work areas of front-door and rear-door conductors are marked.

The string diagram, which shows the movement activity of short-distance bus conductors, revealed that they traversed a considerable distance each trip at a very high frequency (Table 6). The rear-door conductor covered a distance of almost 585 m; whereas, the front-door conductor covered almost 582 m during every trip.

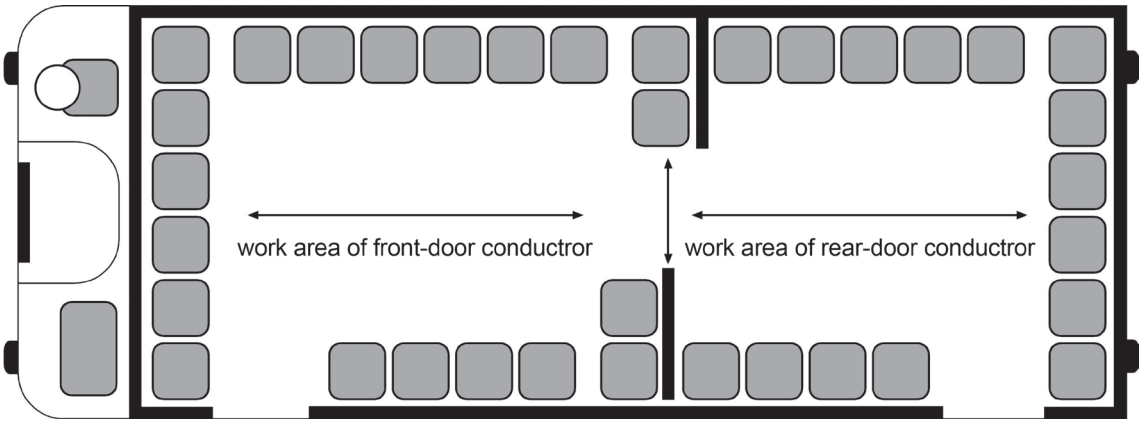


Figure 5. Interior of a Bangla Body bus.

TABLE 6. String Diagram: Study of the Movements of Bus Conductors

TWO-CONDUCTOR PROCESS	SUMMARY								TWO-CONDUCTOR PROCESS
	MOVEMENT POINTS	METHOD						MOVEMENT POINTS	
		CONDUCTOR 1			CONDUCTOR 2				
STUDY OF MOVEMENTS OF CONDUCTOR 1		DISTANCE (m)	FREQUENCY (times/trip)	TOTAL DISTANCE (m)	DISTANCE	FREQUENCY	TOTAL DISTANCE (m)		STUDY OF MOVEMENTS OF CONDUCTOR 2
	A–B	0.9	113	101.7	120	98	117.6	A–B	
	B–C	1.2	142	170.4	30	118	35.4	B–C	
LOCATION LOCAL SHORT-DISTANCE BUS	C–D	0.6	80	48.0	60	102	61.2	C–D	LOCATION LOCAL SHORT-DISTANCE BUS
	D–E	0.3	180	54.0	120	202	242.4	D–E	
	E–A	1.2	173	207.6	90	142	127.8	E–A	
	TOTAL	4.2	688	581.7	420	662	584.4		

WORK DESCRIPTION CONDUCTOR 1 (FRONT DOOR)	TIME (s)	A	B	C	D	E	E	D	C	B	A	TIME (s)	WORK DESCRIPTION CONDUCTOR 2 (REAR DOOR)
	65.2											91.0	
	42.3											31.2	
	148.2											91.7	
	150.0											170.2	
	10.8											14.4	
	5.5											8.4	
	17.2											22.3	

4. DISCUSSION

The questionnaire used in this study was formulated to function as a sensitive, rapid screening tool to identify work-related activities and other factors. The analysis of the questionnaire showed that the bus conductors' work required skill.

From the observation of the working conditions of the bus conductors, it was evident that, at work, the conductors were usually exposed to a noise level of ~90–100 dB(*A*). They also experienced high ambient temperature and high humidity in summer with a radiant heat level of ~40–42 °C.

The bus conductors worked when there was a demand; more work provided them with the opportunity to earn more. It was evident that all conductors suffered from great discomfort in different body parts, mainly in the leg region. This can be attributed to their prolonged working hours that involved repetitive work.

The statistical analysis of blood pressure and heart rate measured before and just after a trip, using Student's *t* test, showed that there was a significant difference between those two physiological parameters (Table 2). The enhanced post-activity heart rate and blood pressure can be the result of severe physiological stress generated by enormous workload.

When age was examined as a factor for the areas of musculoskeletal discomfort or pain, it was found that the older age groups tended to show higher prevalence rates. This study examined the bus conductors' musculoskeletal discomfort in all body areas. The results showed that, in addition to the leg and knee regions, the shoulder and back areas were also affected. Some of the discomfort or pain experienced in the leg region may possibly be referred pain caused by prolonged standing hours. It may have a local origin in the mechanical loading of these joints associated with sustained postures and repetitive movements. The prevalence rates for these four major body areas in this study can be considered high or comparable to figures reported in previous studies from other countries. The high prevalence rates of musculoskeletal discomfort in the leg, knee, shoulder, back and neck areas may be related to occupational factors contributing to undue stress on the various body parts. The results also showed that a large proportion of these complaints had been experienced for over one year, with many subjects experiencing prolonged discomfort for 5 years or more. However, most of those with discomfort were still able to continue with their work.

The problem of mechanical vibration has often been reported as a major factor affecting professional transportation workers [14]. This problem may also be prevalent in Kolkata buses because of improper or poor engineering designs.

Awkward working posture is mainly associated with the development of musculoskeletal disorders [15]. The analysis of the bus conductors' posture during work reveals for most postures correction is necessary soon, as indicated by REBA action categories. Thus, it is evident that these conductors, who work in awkward postures for a prolonged time throughout the day, suffer from musculoskeletal disorders.

An analysis of the flow process chart shows that the conductors at the front and rear doors of the bus do the same work (Table 6). However, in addition to the regular activity, a front-door conductor also carries out certain activities that make his job even more strenuous. He has to maintain constant contact with the driver and instruct him. Unlike the rear-door conductor, he also has to scream to attract passengers. At the same time he has to be cautious while collecting fares and issuing tickets. He also has to be aware of the road conditions, the amount of traffic on the road and other obstacles. The distance covered by the bus conductors is very long, and it is multiplied many times during the several trips that they make each day. Thus, it is clear that they have highly strenuous jobs and all the factors mentioned here make their jobs even more stressful.

5. CONCLUSION

From this study, it can be concluded that the bus conductors work continuously for long periods and their severe workload may result in the development of musculoskeletal disorders. Further examination revealed that the musculoskeletal problems are generated primarily by constant standing, prolonged working hours and excessive job stress caused by performing multiple tasks at the time.

Thus, the conductors suffer from pain in different parts of their body, particularly the leg, knee, ankle, shoulder and back regions, which hinders their normal work activities. The entire work procedure was also analyzed with a work study. This study provided a fair indication of the causative factors behind the onset of musculoskeletal disorders among the bus conductors. Thus, it can be concluded that the bus conductors are highly stressed in their occupation due to the hazardous working condition and work behavior, which also affects their health and overall work performance.

The limitation of this study is that it examined a sample of 100 bus conductors and it is not known whether this actually represents the true characteristics of the larger population of bus conductors on the whole. It is possible that such a study may have attracted more of those who have problems rather than those who do not. There are also other factors that have not been investigated, such as psychosocial factors, a more comprehensive posture analysis and whole-body vibration. These factors may also have an impact on the workers' musculoskeletal health.

REFERENCES

1. Gangopadhyay S, Das T, Ghoshal G and Biswas P. Questionnaire study to evaluate the predominant causes behind city bus accidents in Calcutta, India. Indian Journal of Physiology and Allied Sciences. 2005; 59(2):33–9.
2. Magnusson ML, Pope MH, Wilder DG, Areskoug B. Are occupational drivers at an increased risk for developing musculoskeletal disorders? Spine (Phila Pa 1976). 1996;21(6):710–7.
3. Massaccesi M, Pagnotta A, Soccetti A, Masali M, Masiero C, Greco F. Investigation of work-related disorders in truck drivers using RULA method. Appl Ergon. 2003;34(4):303–7.
4. Hulshof CTJ, Verbeek JHAM, Braam ITJ, Bovenzi M, van Dijk FJH. Evaluation of an occupational health intervention programme on whole-body vibration in forklift truck drivers: a controlled trial. Occup Environ Med. 2006;63(7):461–8. Retrieved October 1, 2012, from: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2092505/pdf/461.pdf
5. Kuorinka I, Jonsson B, Kilbom Å, Vinterberg H, Biering-Sørensen F, Andersson G, Jørgensen K. Standardised Nordic questionnaires for the analysis of musculoskeletal symptoms. Appl Ergon. 1987;18(3):233–7.
6. Banerjee S, Sen RN. Determination of the surface area of the body of Indians. J Appl Physiol. 1955;7(6):585–8.
7. Poskitt, EM. Body mass index and child obesity: are we nearing a definition? Acta Paediatr. 2000;89(5):507–9.
8. Cole TJ, Bellizzi MC, Flegal KM, Dietz WH. Establishing a standard definition for child overweight and obesity worldwide: international survey. BMJ. 2000;320(7244):1240–3. Retrieved October 1, 2012, from: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC27365/pdf/1240.pdf
9. Åstrand P, Rodahl K. Textbook of work physiology. 3rd ed. New York, NY, USA: McGraw-Hill; 1986.
10. Hignett S, McAtamney L. Rapid entire body assessment (REBA). Appl Ergon. 2000;31(2):201–5.
11. Reynolds JL, Drury G, Broderick RL. A field methodology for the control of musculoskeletal injuries. Appl Ergon. 1994;25(1):3–16.
12. International Labor Office (ILO). Introduction to work study. 3rd revised ed. Geneva, Switzerland: ILO; 1981.
13. Das D, Das A. Statistics in biology and psychology. Kolkata, India: Academic; 1995.
14. Funakoshi M, Taoda K, Tsujimura H, Nishiyama K. Measurement of whole-body vibration in taxi drivers. J Occup Health. 2004;46(2):119–24.
15. Dev S, Gangopadhyay S. Ergonomic study on the development of work related musculo skeletal disorder (MSD) among bus conductors of West Bengal. In: Abhyankar H, Sane SM, Vaidya PR, Kale VM, editors. Humanizing Work and Work Environment (HWWE 2008). International Ergonomics Conference. Pune, India: Vishwakarma Institute of Technology; 2008. p. 258–66.