Statistical Analysis of Musculoskeletal Disorders (MSD) and Risk Factors of Public Transport Bus Drivers of India

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Article Info
Page Number: 622 - 638
Publication Issue:
Vol 72 No. 1 (2023)

Abstract
Professional public transport drivers are prone to musculoskeletal disorders (MSDs), Several researchers have investigated how certain work environments can create musculoskeletal disorders in professional drivers. The majority of drivers reported that the back, knee, neck, and shoulder pains as a stressor. Postural stress, vibration, noise, frequent tasks, and high traffic density put drivers at high risk of MSDs.

This study focused on 312 drivers from five different types of public transport (town buses, city buses, interstate buses, suburban buses and luxury buses) buses in the state of Telangana, India, to predict the MSDs, through the Modified Nordic Musculoskeletal Questionnaire (MNMQ) survey, over the course of a year. ANOVA, Chi-square statistical test and SPSS software were used to analysis the questionnaire data.

The result showed that a higher risk reported in upper back pain was 71.70 % for super luxury buses, 68.9% for Suburban buses, 66.10% for buses city, 65.20% for interstate buses and 49.20% for town bus drivers compared with other MSDs. However, the results showed that there is a significant difference between upper back and types of bus.

The results suggest that MSDs can affect anyone as a result of poor seating posture and long periods of driving per shift. It is important to educate the drivers about how to reduce work-related MSDs by implementing ergonomics in the work environment.

Article History
Article Received: *15 October 2022*
Revised: *24 November 2022*
Accepted: *18 December 2022*

Keywords: Nordic Musculoskeletal Questionnaire; musculoskeletal pain prevalence; musculoskeletal disorders; Telangana bus drivers; Ergonomics.

1. Introduction

1.1 The epidemiological evidence, health issues and work conditions on MSDs

The health and risk of a driver have always been connected to work-related difficulties. The workforce is affected by musculoskeletal disorders (MSDs) because of prolonged sitting hours and poor posture. Drivers are more susceptible to experiencing neck, back, and leg pain from extended sitting positions and vibrations from the vehicle. The term MSDs is used to define a range of disorders that impact the muscles, joints, and bones [1]. In Philippines, major deaths and injuries causing by bus related accidents is because the majority of bus drivers are exposed to hazardous working conditions such as lack of sleep, fatigue, long working hours, road racing and over

speeding [2]. Professional drivers also experience health risks such as low back pain, knees pain, shoulders pain and fatigue due to noise, vibration, postural stress, and high traffic density. [3]. Another study examines the relationship between stress related condition and risky driving behaviour. With the help of a driver behaviour questionnaire, it was found that drivers are impacted by working hours and social support that can make their conditions easier [4]. The majority of heavy vehicle drivers in Hong Kong city are suffering from work related musculoskeletal disorders like back pain problems, it have been found that high occurrence rates in urban bus drivers.[5].To reduce the low back pain while driving, working hours should be reduced from 18 hours to 10 hours in each shift and taking regular breaks while driving will also reduce the low back pain. [6]. High low back pain frequency in urban taxi drivers was associated with frequent bending, long driving time, job stress, twisting jobs and job dissatisfaction while driving. [7]. The implementation of Ergonomics and driver postural analysis are required to decrease musculoskeletal disorders among the drivers. Regular exercise and ergonomics related training programs can significantly help to reducing MSD's [8]. Professional drivers have often experienced back pain on a regular basis. The factors that cause the discomfort are different and might include poor postures, prolonged sitting, experience to whole-body vibration and other non-driving aspects such as poor diet, heavy load lifting, and other psychosocial aspect [9]. To evaluate seat pressure distribution and to identify the comfort and discomfort felt by the driver in a seated position is measured by a pressure sensor placed in the middle of the disc of the driver. It was observed that the pressure in most comfortable posture is 0.5 bar [10]. Through investigations through questionnaire and statistical analysis, it was found that number of working hours was the only variable associated with the occurrence of lower back pain [11].

1.2 Objective and Hypothesis

The objective of this study is to predict the musculoskeletal disorders of professional public transport drivers in the state of Telangana, India through a questionnaire survey and to evaluate the existing working environment of the drivers in order to recommend ergonomic suggestions that minimise the MSDs (neck, shoulder, upper back, elbows, wrist/hands, low back, hips/thighs, knees and ankles/feet)

1st Hypothesis: To predict that there is statistical significance relationship between the two variables (age, weight, height, driving experience, driving hours per day and driving hours per week) and different public transport bus drivers.

2nd Hypothesis: To predict that there is NO statistical significance relationship between the two variables (Age, Weight, height, driving experience, driving hours per day and driving hours per week) and different public transport bus drivers.

2. Methods and Materials

2.1 Participants

Study samples comprise of data from 312 male Telangana professional public transport (63- Town, 62- City, 66- Interstate, 51- suburban and 60- Super luxury) bus drivers with an average age of 43

years (SD = 8.39), average weight of these drivers was 72.7 kg (SD = 11.5), average height these drivers was 168 cm, average driving experience of these drivers was 19 years (SD = 2.27), average number of hours worked per day is 10 hrs. (SD = 2.27) and average number of work hours per week is 42 hrs. (SD = 6.2).

Fig.1. Shows the data collection from bus drivers

2.2 Procedure

The demographic data were collected from the state of Telangana, India from 312 public transport drivers (TSRTC) as shown in figure 1 deployed at different bus depots driving an array of heavy vehicles such as Town and City buses (20-30 km/trip), Interstate buses (60-220 km/trip), suburban buses (65-200 km/trip) and Super luxury buses (160-600 km/trip). A protocol was developed for the drivers that included collection of physical parameters such as height and weight measurements, and an oral investigation involving 30 questions at their regular work place.

2.3 Instruments

A modified Nordic musculoskeletal questionnaire (MNMQ) was used to collect demographic data [7, 12]. To measure the height of the participant height measuring scale Stadiometer (210 cm) and to measure weight beat XP gravity flora digital weight machine thick tempered glass with LCD display were used.

2.4 Data analysis

The study began with analysis of variance (ANOVA) statistical test to calculate the relationship between bus type variables and demographic data variables such as age, weight, height, driving experience, driving hours per day and driving hours per week. Then the Chi-square statistical test is used to compare between bus type and MSDs such as neck, shoulder, upper back, elbows,

wrist/hands, low back, hips/thighs, knees and ankles/feet. The data was analysed using IBM SPSS software.

3. Results

3.1 Reliability analysis

Table .1 Data used in the present study

S.No	Bus name	Number of drivers	Age	Weight	Height	Experience	Driving hours per day	Driving hours ner week	Neck	Shoulder	Upper back	Elbows	Wrist/hands	Low back	Hips/thighs	Knees	Ankles/feet
			Means						Number of drivers with MSDs								
1	Town	63	45.7	73.0	167.8	21.5	8.0	48.0	7	2	31	1	1	20	0	11	1
2	City	62	43.2	73.3	169.1	18.0	8.9	47.4	8	6	41	3	2	18	2	19	3
3	Interstate	66	42.3	70.6	166.7	19.8	11.3	38.0	19	0	43	1	1	16	0	10	0
4	suburban	61	36.8	71.9	168.2	14.2	10.8	39.4	10	1	42	0	2	15	0	14	1
5	Super Luxury	60	44.6	74.6	168.4	21.5	11.9	37.0	9	0	43	1	5	20	5	17	0

3.2 Analysis of variance (ANOVA) Test.

An ANOVA statistical test is done to predict the statistical relationship between bus type variables and demographic data variables such as age, weight, height, driving experience, driving hours per day and driving hours per week.

Table 2 Summary of ANOVA test between the bus types and age

Bus Type	Sum of Squares	DF	Mean Square	F	Sig.
Between Groups	2909.931	4	727.483	11.743	.000
Within Groups	19018.374	307	61.949		
Total	21928.304	311			

From the above ANOVA test, we observe that the F-calculated value is 11.743 at $p=0.000 < 0.05$. It is greater than the table value (2.40) with (4,307) degrees of freedom at 5% level of significant and hence there is a significance difference between bus types and age.

Table 3. Summary of ANOVA test between the bus types and weight

Bus Type	Sum of Squares	DF	Mean Square	F	Sig.
Between Groups	561.839	4	140.460	1.053	.380
Within Groups	40941.737	307	133.361		

Total	41503.576	311			

From the above ANOVA test shows that F-calculated value of 1.053 at p=0.380 > 0.05 is less than the table value (2.40) with (4,307) degrees of freedom at 5% level of significant and hence there is no significance difference between bus types and weight.

Table 4. Summary of ANOVA test between the bus types and height

Bus Type	Sum of Squares	DF	Mean Square	F	Sig.
Between Groups	203.357	4	50.839	1.797	.129
Within Groups	8687.264	307	28.297		
Total	8890.620	311			

From the above ANOVA test shows that F-calculated value is 1.797 at p=0.129 > 0.05 is less than the table value (2.40) with (4,307) degrees of freedom at 5% level of significant and hence there is no significance difference between bus types and height.

Table 5. Summary of ANOVA test between the bus types and experience

Bus Type	Sum of Squares	DF	Mean Square	F	Sig.
Between Groups	2256.855	4	564.214	8.852	.000
Within Groups	19566.731	307	63.735		
Total	21823.587	311			

From the above ANOVA test shows that F-calculated value is 8.852 at p=0.000 < 0.05 is greater than the table value (2.40) with (4,307) degrees of freedom at 5% level of significant and hence there is a significance difference between bus types and driving experience.

Table 6. Summary of ANOVA test between the bus types and hours per day

Bus Type	Sum of Squares	DF	Mean Square	F	Sig.
Between Groups	849.608	4	212.402	85.034	.000
Within Groups	766.840	307	2.498		
Total	1616.449	311			

From the above ANOVA test shows that F-calculated value is 85.034 at p=0.000 < 0.05 is greater than the table value (2.40) with (4,307) degrees of freedom at 5% level of significant and hence there is a significance difference between bus types and hours per day.

Table 7. Summary of ANOVA test between the bus types and hours per week

Bus Type	Sum of Squares	DF	Mean Square	F	Sig.
Between Groups	6964.168	4	1741.042	103.912	.000
Within Groups	5143.781	307	16.755		
Total	12107.949	311			

From the above ANOVA test shows that F-calculated value is 103.912 at $p=0.000 < 0.05$ is greater than the table (2.40) value with (4,307) degrees of freedom at 5% level of significant and hence there is a significance difference between bus types and hours per week.

3.3 Chi-square statistical test.

This study performed a Chi-square statistical test to predict the statistical comparison between bus type and MSDs such as neck, shoulder, upper back, elbows, wrist/hands, low back, hips/thighs, knees and ankles/feet.

Table 8. Summary of Chi square test between the bus types and neck pain

Bus Type		Neck		Total	Chi-Square	DF	Table Value	P-Value
		Without MSD	With MSD					
Town	N	56	7	63	8.977	4	9.488	0.062 > 0.05
	%	88.9%	11.1%	100.0%				
City	N	54	8	62				
	%	87.1%	12.9%	100.0%				
Interstate	N	47	19	66				
	%	71.2%	28.8%	100.0%				
Suburban	N	51	10	61				
	%	83.6%	16.4%	100.0%				
Super Luxury	N	51	9	60				
	%	85.0%	15.0%	100.0%				
Total	N	259	53	312				
	%	83.0%	17.0%	100.0%				

From the above chi-Square test shows that calculated value is 8.877 at $p=0.062 >0.05$ less than table value 9.488 at 4 degrees of freedom and hence there was a significant difference between the types of bus and neck pain. According to Figure 2, 28.8% of interstate bus drivers had the highest prevalence in the neck pain.

Table 9. Summary of Chi square test between the bus types and shoulder pain

Bus Type		Shoulder		Total	Chi-Square	DF	Table Value	P-Value
		Without MSD	With MSD					
Town	N	61	2	63	14.311	4	9.488	0.006<0.05
	%	96.8%	3.2%	100.0%				
City	N	56	6	62				
	%	90.3%	9.7%	100.0%				
Interstate	N	66	0	66				
	%	100.0%	0.0%	100.0%				
Suburban	N	60	1	61				
	%	98.4%	1.6%	100.0%				
Super Luxury	N	60	0	60				
	%	100.0%	0.0%	100.0%				
Total	N	303	9	312				
	%	97.1%	2.9%	100.0%				

From the above chi-Square test shows that calculated value is 14.311 at $p = 0.006 < 0.05$ greater than table value 9.488 at 4 degrees of freedom and hence there was a no significant difference between the types of bus and shoulder pain. According to Figure 3, 9.7% of city bus drivers had the highest prevalence in the shoulder pain.

Table 10. Summary of Chi square test between the bus types and upper back pain

Bus Type		Upper Back		Total	Chi-Square	DF	Table Value	P-Value
		Without MSD	With MSD					
Town	N	32	31	63	8.307	4	9.488	0.081>0.05
	%	50.8%	49.2%	100.0%				
City	N	21	41	62				
	%	33.9%	66.1%	100.0%				
Interstate	N	23	43	66				
	%	34.8%	65.2%	100.0%				
Suburban	N	19	42	61				
	%	31.1%	68.9%	100.0%				
Super Luxury	N	17	43	60				
	%	28.3%	71.7%	100.0%				
Total	N	112	200	312				
	%	35.9%	64.1%	100.0%				

From the above chi-Square test shows that calculated value is 8.307 at p = 0.081 > 0.05 less than table value 9.488 at 4 degrees of freedom and hence there was a significant difference between the types of bus and upper back pain. According to Figure 4, 71.7% of super luxury bus drivers had the highest prevalence in the upper back pain.

Table 11. Summary of Chi square test between the bus types and elbows pain

Bus Type		Elbows		Total	Chi-Square	DF	Table Value	P-Value
		Without MSD	With MSD					
Town	N	62	1	63	4.107	4	9.488	0.392 > 0.05
	%	98.4%	1.6%	100.0%				
City	N	59	3	62				
	%	95.2%	4.8%	100.0%				
Interstate	N	65	1	66				
	%	98.5%	1.5%	100.0%				
Suburban	N	61	0	61				
	%	100.0%	0.0%	100.0%				
Super Luxury	N	59	1	60				
	%	98.3%	1.7%	100.0%				
Total	N	306	6	312				
	%	98.1%	1.9%	100.0%				

From the above chi-Square test shows that calculated value is 4.107 at p = 0.392 >0.05 less than table value 9.488 at 4 degrees of freedom and hence there was a significant difference between the types of bus and elbows pain. According to Figure 5, 3 % of city bus drivers had the highest prevalence in the shoulder pain.

Table 12. Summary of Chi square test between the bus types and wrist pain

Bus Type		Wrists		Total	Chi-Square	DF	Table Value	P-Value
		Without MSD	With MSD					
Town	N	62	1	63	5.585	4	9.488	0.232>0.05
	%	98.4%	1.6%	100.0%				
City	N	60	2	62				
	%	96.8%	3.2%	100.0%				
Interstate	N	65	1	66				
	%	98.5%	1.5%	100.0%				
Suburban	N	59	2	61				
	%	96.7%	3.3%	100.0%				

Super Luxury	N	55	5	60				
	%	91.7%	8.3%	100.0%				
Total	N	301	11	312				
	%	96.5%	3.5%	100.0%				

From the above chi-Square test shows that calculated value is 5.585 at p =0.232 >0.05 less than table value 9.488 at 4 degrees of freedom and hence there was a significant difference between the types of bus and wrists pain. According to Figure 6, 5 % of super luxury bus drivers had the highest prevalence in the wrist pain.

Table 13 Summary of Chi square test between the bus types and low back pain

Bus Type		Low Back		Total	Chi-Square	DF	Table Value	P-Value
		Without MSD	With MSD					
Town	N	43	20	63	2.066	4	9.488	0.724>0.05
	%	68.3%	31.7%	100.0%				
City	N	44	18	62				
	%	71.0%	29.0%	100.0%				
Interstate	N	50	16	66				
	%	75.8%	24.2%	100.0%				
Suburban	N	46	15	61				
	%	75.4%	24.6%	100.0%				
Super Luxury	N	40	20	60				
	%	66.7%	33.3%	100.0%				
Total	N	223	89	312				
	%	71.5%	28.5%	100.0%				

From the above chi-Square test shows that calculated value is 2.066 at p = 0.724 > 0.05 less than table value 9.488 at 4 degrees of freedom and hence there was a significant difference between the types of bus and low back pain. According to Figure 7, 20% of city bus and super luxury drivers had the highest prevalence in the low back pain.

Table 14. Summary of Chi square test between the bus types and hips pain

Bus Type		Hips		Total	Chi-Square	DF	Table Value	P-Value
		Without MSD	With MSD					
Town	N	63	0	63	14.779	4	9.488	0.005<0.05
	%	100.0%	0.0%	100.0%				

City	N	60	2	62				
	%	96.8%	3.2%	100.0%				
Interstate	N	66	0	66				
	%	100.0%	0.0%	100.0%				
Suburban	N	61	0	61				
	%	100.0%	0.0%	100.0%				
Super Luxury	N	55	5	60				
	%	91.7%	8.3%	100.0%				
Total	N	305	7	312				
	%	97.8%	2.2%	100.0%				

From the above chi-Square test shows that calculated value is 14.779 at p=.005 >0.05 greater than table value 9.488 at 4 degrees of freedom and hence there was a no significant difference between the types of bus and hips pain. According to Figure 8, 5% of super luxury drivers had the highest prevalence in the hip pain.

Table 15. Summary of Chi square test between the bus types and knees pain

Bus Type		Knees		Total	Chi-Square	DF	Table Value	P-Value
		Without MSD	With MSD					
Town	N	52	11	63	6.435	4	9.488	0.169>0.05
	%	82.5%	17.5%	100.0%				
City	N	43	19	62				
	%	69.4%	30.6%	100.0%				
Interstate	N	56	10	66				
	%	84.8%	15.2%	100.0%				
Suburban	N	47	14	61				
	%	77.0%	23.0%	100.0%				
Super Luxury	N	43	17	60				
	%	71.7%	28.3%	100.0%				
Total	N	241	71	312				
	%	77.2%	22.8%	100.0%				

From the above chi-Square test shows that calculated value is 6.435 at p=0.169 > 0.05 less than table value 9.488 at 4 degrees of freedom and hence there was a significant difference between the types of bus and knee pain. According to Figure 9, 19 % of city bus drivers had the highest prevalence in the knees pain.

Table 16. Summary of Chi square test between the bus types and ankles pain

Bus Type		Ankles		Total	Chi-Square	DF	Table Value	P-Value
		Without MSD	With MSD					
Town	N	62	1	63	6.170	4	9.488	0.187> 0.05
	%	98.4%	1.6%	100.0%				
City	N	59	3	62				
	%	95.2%	4.8%	100.0%				
Interstate	N	66	0	66				
	%	100.0%	0.0%	100.0%				
Suburban	N	60	1	61				
	%	98.4%	1.6%	100.0%				
Super Luxury	N	60	0	60				
	%	100.0%	0.0%	100.0%				
Total	N	307	5	312				
	%	98.4%	1.6%	100.0%				

From the above chi-Square test shows that calculated value is 6.170 at p = 0.187 >0.05 less than table value 9.488 at 4 degrees of freedom and hence there was a significant difference between the types of bus and ankle pain. According to Figure 10, 3 % of city bus drivers had the highest prevalence in the ankle pain.

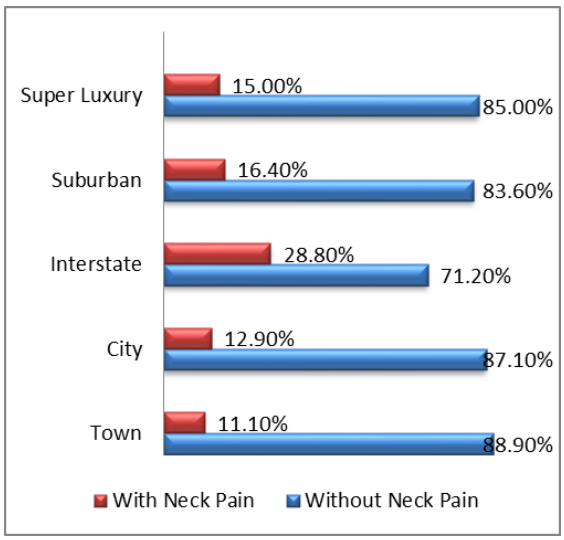


Fig.2.Shows the prevalence of Neck Pain

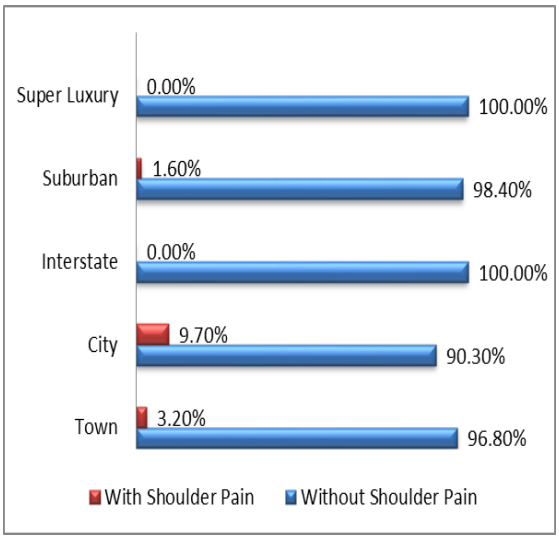


Fig.3.Shows the prevalence of Shoulder Pain

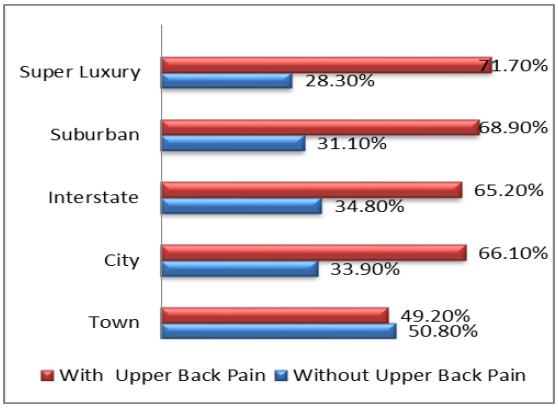


Fig.4.Shows the prevalence of Upper Back Pain

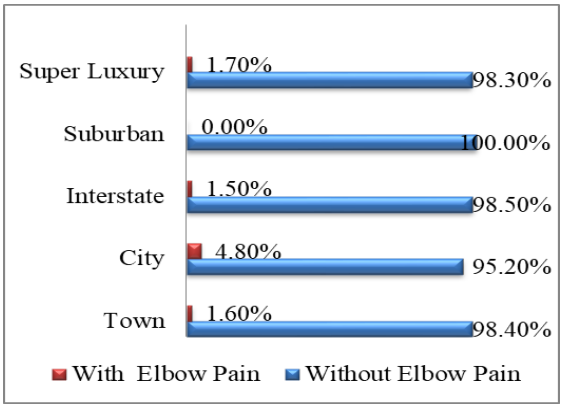


Fig.5.Shows the prevalence of Elbow Pain

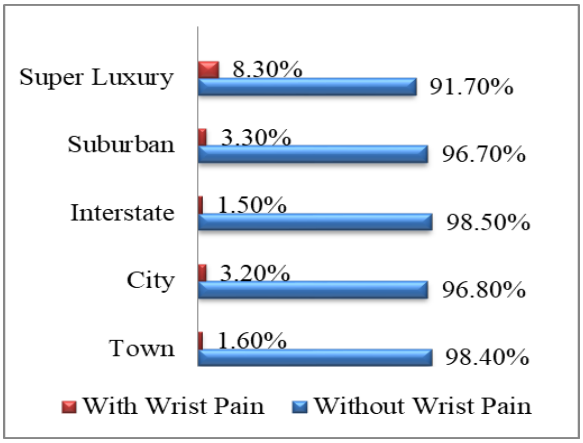


Fig.6.Shows the prevalence of Wrist Pain

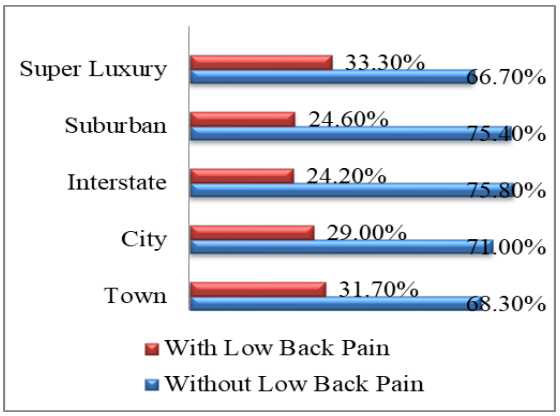


Fig.7.Shows the prevalence of Low Back Pain

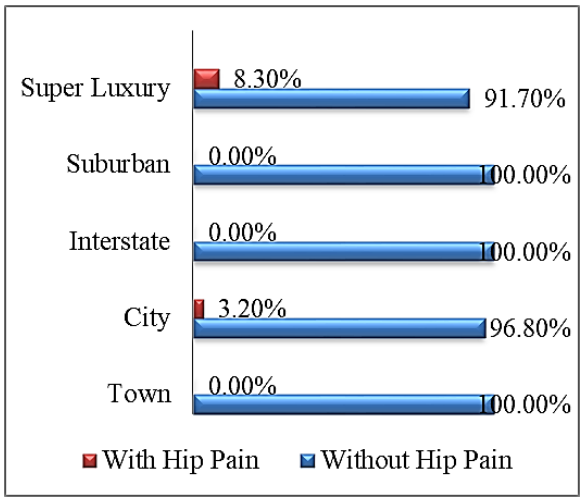


Fig.8.Shows the prevalence of Hip Pain

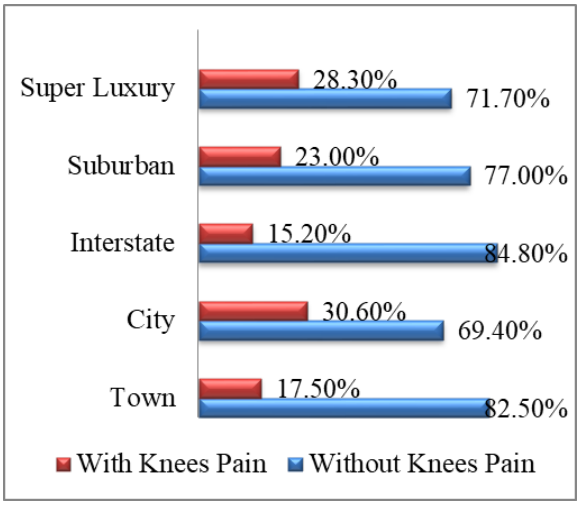


Fig.9.Shows the prevalence of Knees Pain

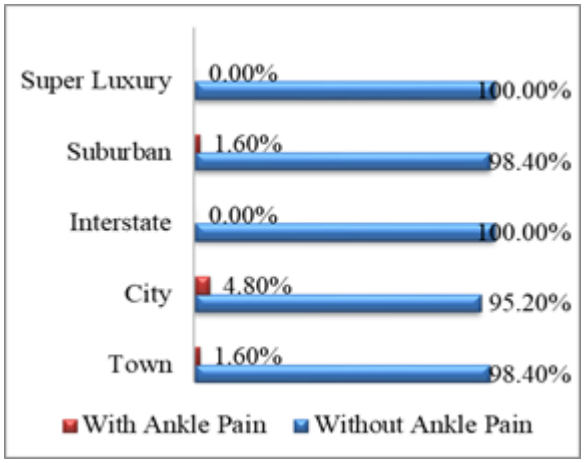
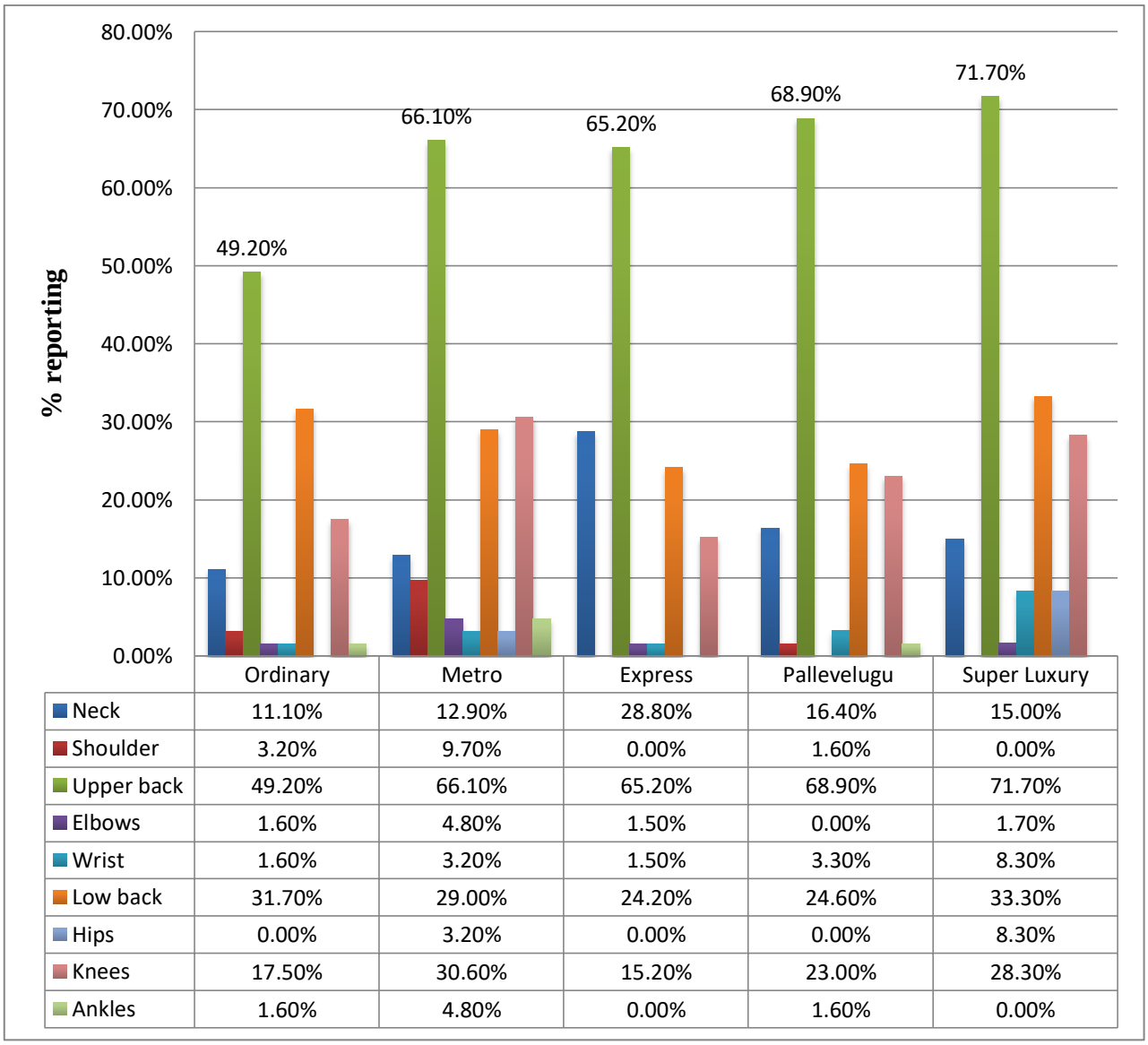


Fig.10.Shows the prevalence of Ankles Pain



	Ordinary	Metro	Express	Pallevelugu	Super Luxury
Neck	11.10%	12.90%	28.80%	16.40%	15.00%
Shoulder	3.20%	9.70%	0.00%	1.60%	0.00%
Upper back	49.20%	66.10%	65.20%	68.90%	71.70%
Elbows	1.60%	4.80%	1.50%	0.00%	1.70%
Wrist	1.60%	3.20%	1.50%	3.30%	8.30%
Low back	31.70%	29.00%	24.20%	24.60%	33.30%
Hips	0.00%	3.20%	0.00%	0.00%	8.30%
Knees	17.50%	30.60%	15.20%	23.00%	28.30%
Ankles	1.60%	4.80%	0.00%	1.60%	0.00%

Fig.11. shows the prevalence of MSD's results.

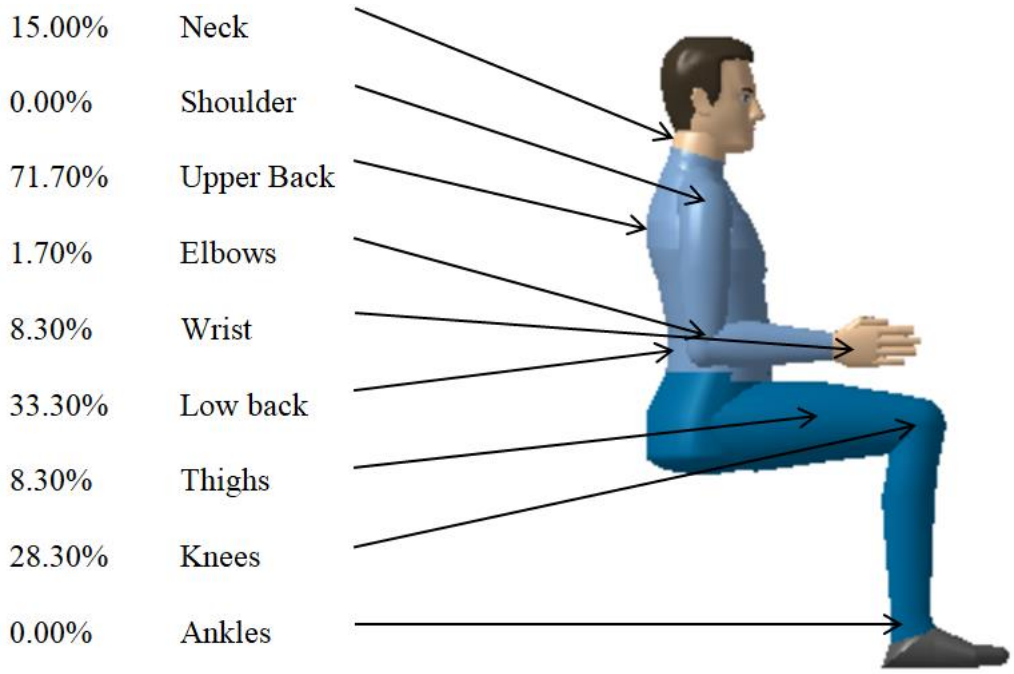


Fig.12. shows the prevalence of MSD's results for Super luxury bus.

4. Discussion

The present study reports that the significance between bus types and demographic data (i.e. age, weight, height, driving experience, driving hours per day and driving hours per week) were significant and inverse in cases. There was a positive and direct relationship between bus types, age, experience, work hours per day and hours per week ($P < 0.05$). The results found that there is a no significant relationship between bus types and weight, bus types and height.

This study also reports the significant between bus types and MSD's (i.e. neck, shoulder, upper back, elbows, wrist/hands, low back, hips/thighs, knees and ankles/feet). There was a positive and direct significant difference between bus types, neck, upper back, elbows, wrist/hands, low back, knees and ankles/feet .The results found that Town bus drivers are having high prevalence of upper back (49.20%), low back (31.70%), knee pain (17.50%) and neck pain (11.10%) among nine body parts. City bus drivers are observed to have a high prevalence of upper back (66.10%), low back (29%), knees (30.60%) and neck (12.90%) among nine body parts. Interstate bus drivers are having high prevalence of upper back (65.20%), low back (65.20%), knees (15.20%) and neck (28.80%) among nine body parts. Suburban bus drivers are having high prevalence of upper back (68.90%), low back (24.60%), knees (23.00%) and neck (16.4%) among nine body parts. Super luxury bus drivers are having high prevalence of upper back (71.70%), low back (33.30%), knees (28.30%) and neck (15.00%) among nine body parts as shown in figure 11. This means that majority of the drivers facing serious discomfort in upper back plain and low back pain. The statistical analysis shows that super luxury bus drivers face much discomfort and have a high prevalence of back pain (71.70 %) in relation to other bus drivers due to driving more than 12 hours per shift without taking adequate breaks as shown in figure 12.

The outcome of this study were consistent with the investigation done by Funakoshi et al. 284 taxi drivers in japan to predict the MSD's and found that 45.8 % of taxi drivers were facing back pain among eight MSD's [6]. Chiuan et al. examined MSD's from 1242 taxi drivers in Taiwan and found that 51%of drivers were exposed to higher prevalence of back pain in the past twelve months [7].Porter et al., reported that driving more than 12 hours per week for shift was associated with high prevalence of back pain among 600 divers in UK [12]. Anker et al., studied to predict diseases a mong professional heavy vehicle drivers in Denmark and reported that back pain were more common problem faced by professional drivers [13].According to Grace et al., 60% of discomfort was reported near low back pain among 481 bus drivers in Hong Kong city [14]. Shamsul et al., determined that 60.4% of 760 Malaysian vehicle drivers involved in high prevalence of low back pain [15]. Olanrewaju et al., investigated 80 city bus drivers with questioner and concluded that the drivers spend 60% of daily time actually in driving, due to improper seating posture and vibration the majority of drivers associated with serious injuries near lower back[16]. Masabumi et al., found that 50.3% among 181 drivers were reported prevalence of low back pain and concluded that an development in working environments reduces the occurrence of low back pain [17].Mansfield et al., Investigated 118 participants through Nordic questionnaire and found that 91% of participants reported MSD's, prevalence in the lower back (70%) was the most common among other MSD's [18]. Ruth et al., conducted a survey among 1500 taxi drivers in Norway to predict MSD's with the Nordic musculoskeletal disorder questionnaire, found that majority of drivers were reported MSD's and concluded that work-related health and safety organisation should carried out like reducing driving time, everyday exercise and eating habits to reduce health effects in professional drivers[19]. Olanrewaju et al., Investigated 64 drivers with validated questionnaire and found that low back pain was the common prevalent among drivers [20].Emre et al., Examined 382 drivers through quick exposure check questioner tool and found that the occupational discomfort were produced with improper seating postures, vibration, and working stress. Essential ergonomic environment are necessary to eliminate discomfort in professional drivers [21].

The limitations of the studies: First, dimensions of the workstation were not considered. Second; the data were collected in the state of Telangana, India, some of the result not applicable worldwide.

5. Conclusion

The present results show a higher prevalence of back pain in all types of bus drivers. The study based statistical databases that can be useful in reducing the occurrence of MSDs. Postural evaluations and ergonomic interventions are needed to decrease disorders among drivers. Physical activity programmes focusing on ergonomics and daily exercises can significantly reduce the discomfort associated with MSDs, particularly back pain.

Future studies to design new seat cushions for all types of buses based on the drivers' demographic data and anthropometric characteristics.

Acknowledgments

The authors wish to acknowledge TSRTC drivers who contributed in this study. We would like to thank MVSR Engineering College Principal, AED HOD and Staff for continuous support and encouragement. We would like to thank Dr. B. Ravi Kumar and Dr. Krishna Kishore who have assisted in the data collection and analysis process.

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