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The Impact of Ergonomics Driving Risk Factors on Musculoskeletal Health of Malaysian Express Bus Drivers

Yusof Hashim and Zahari Taha

Abstract

The purpose of this paper is to assess the impact of ergonomics driving risk factors on musculoskeletal health of Malaysian express bus drivers. A survey research was carried out among express bus drivers operating in Kuantan, Pahang and several major cities in West Coast. This is to determine the prevalence of musculoskeletal pain and to identify ergonomic driving risk factors that are likely to increase the risk of neck, shoulder or lower back pains. Seventy-nine bus drivers were selected and interviewed in the survey. The study instrument was based on the Occupational Factors, Ergonomic Driving Risk Factors and Nordic Musculoskeletal Questionnaires. The SPSS version 17 was used to analyze the descriptive characteristics of the demographic information of the respondents, while the relationships between the latent constructs were analyzed by SmartPLS software. The finding of the research showed that there is a significant and positive relationship between ergonomic driving risk factors and musculoskeletal pains. However, the occupational factor is not significantly correlated with ergonomic risk factors. In conclusion, this study is of particular relevance and importance for a specific government agency as accidents that involved the public transports in Malaysia are increasing.

Keywords: Musculoskeletal pain, express bus drivers, ergonomic risk factors

1.0 INTRODUCTION

The musculoskeletal health of Malaysian express bus drivers has not been studied as extensively as other professional drivers, despite a number of workload factors that can cause musculoskeletal problems. The aim of this study is to assess the prevalence of musculoskeletal pain (MSP) among express bus drivers commuting from the city of Kuantan in the state of Pahang to major cities in other states in West Coast and examine the ergonomic driving risk factors (EDRF). The Ergonomic driving risk factors examined were instrumentations and panel layout in the driver's cabin, adjustability of the driver's seat, forwards and reverse visibility, in cabin temperature, noise and vibration exposure, environmental factors, baggage handling, hours driving per shift, hours driving per week and demographic variables.

The likelihood that express drivers are at high risk for MSP is strongly supported by epidemiological evidence. Driving larger vehicle for a significant part of the day is related to MSP in numerous studies (such as Anderson, 1992; Burdorf and Zondervan, 1990; Boshuizen et al., 1992; Krause et al., 1997b, 1998, 2004; Magnusson et al., 1996). This is basically explained by the high intensity of whole-body vibration induced by heavy vehicles. More recently, substantial driving of smaller vehicles has also demonstrated the possibility of inducing harmful whole-body vibration (Chen et al., 2004; Funakoshi et al., 2004). Since the time spent behind the wheel is usually longer among express bus drivers than other professional drivers, the working hours are likely to be a risk factor for MSP among express bus drivers as supported by a study of bus drivers in Taiwan (Chen et al., 2005). In this study it was reported that there is a strong relationship between high rates of low back pain (LBP) and working hours per shift. Driving a bus for long distances for many hours is also related to self-reported neck, shoulder and LBP among drivers (Pietri et al., 1992; Skov et al., 1996. A number of studies have shown that working activities like lifting, carrying, pulling and pushing of passenger's luggage are also related to MSP (Anannontsak & Puapan, 1996; Hoozemans et al., 1998; Macfarlane et al., 1997; Magnusson et al., 1996).

Modern express buses have an increasing amount of instrumentation as a result of a combination of factors, including the motivation of vehicles manufactures, advances in technology, and consumer demands. However, this added information raises significant ergonomic concerns for the bus driver's mental workload distraction, and ultimately driving task performance. A range of studies has observed that a reduced awareness of surrounding traffic and events (Kass et al., 2007), an increased tendency to miss traffic light signals and signs and increased response time to roadways event (Burns et al., 2002; Lee et al., 2001) and reduction in time spent checking instruments and adjusting side and rear mirrors (Nunes & Recarte, 2002), are all due to increased risks of ergonomic driving factors. In this study, the ergonomic factors in the cabin such as instrument panel layout, driver's seat adjustability, in cabin air temperature, driver's forwards and reverse visibility, noise and vibration exposure are investigated. Occupational factors such as age, job status, passenger baggage handling and physical exercise are also explored.

1.1 Theoretical Framework

Theoretical framework developed for this study was based on related research works in the literature. This is shown in the Figure 1.

Based on the theoretical framework in Figure 1, the following research hypotheses were formulated:

HA1: There is a significant and positive relationship between occupational factors and ergonomic driving risk factors.

HA2: There is a significant and positive relationship between ergonomic driving risk factors and musculoskeletal pains.

HA3: There is a significant and positive relationship between occupational factors and musculoskeletal pains.

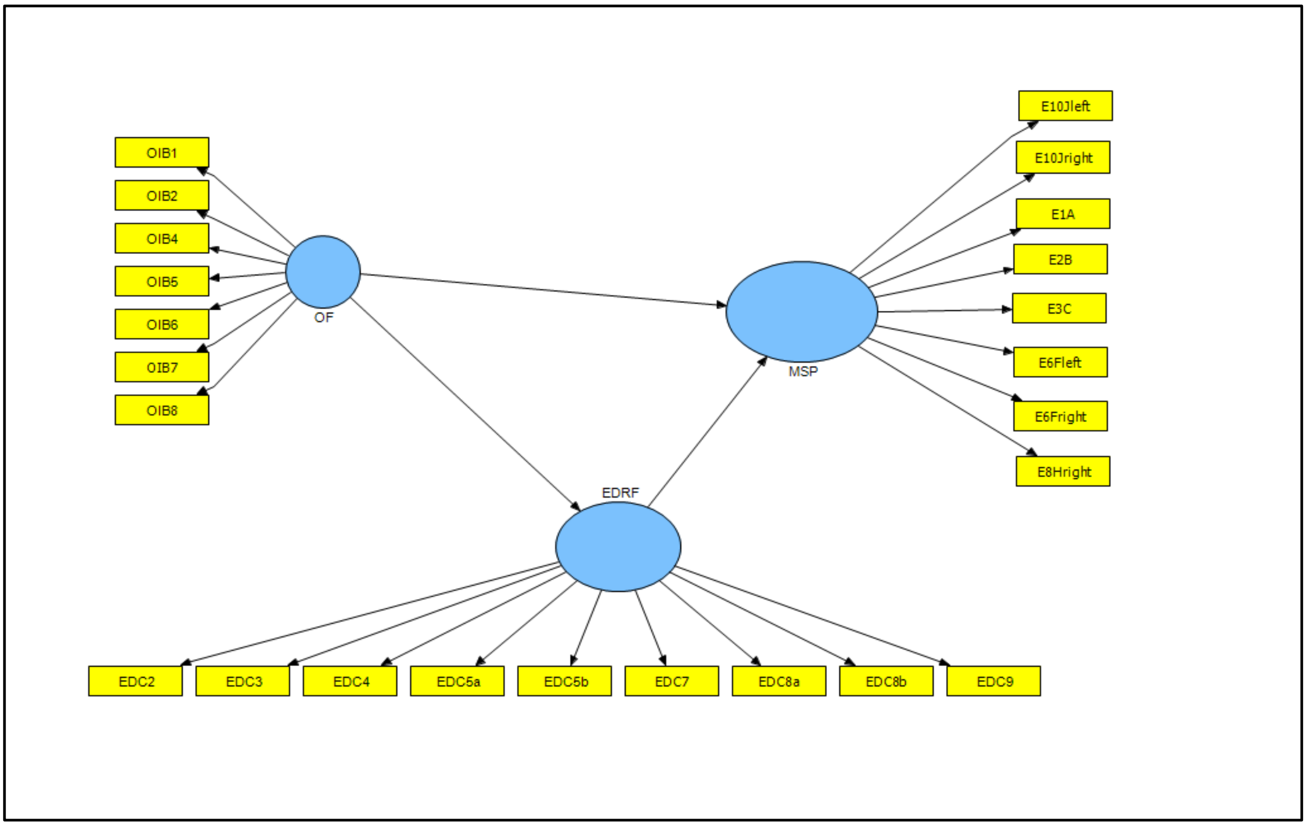

Figure 1: Hypothesis Model of factors correlated to Musculoskeletal Pain (MSP)

***Key Notations**:*

Occupational factors (OF)

OB1: Job status
OB2: Employed duration
OB4: Work shift schedule
OB5: Driving experience
OB6: Total hours driving per shift
OB7: Total hours driving per week
OB8: Total distance travelled per year

Ergonomic Driving Risk Factors (EDRF)

EDC2: Comfort ability and adjustability of driver's seat,
EDC3: Air control panel
EDC4: Air condition control panel
EDC5a: Forwards visibility
EDC5b: Reverse visibility through side mirror and back mirror
EDC7: Vibration exposure
EDC8: Billboard illumination
EDC8b: Illumination due to oppositely incoming vehicles

Musculoskeletal Pain (MSP)

E1A: Head/neck /eyes
E2B: Upper/mid back
E3C: Lower back/pelvis
E6Fleft: Left forearm/wrist
E6Fright: Right forearm/wrist
E8Hright: Right upper leg/pelvis
E10Jleft: Left lower leg/foot,
E10Jright: Right lower leg/foot

2.0 METHODOLOGY

2.1 Participants

To examine MSP in express bus drivers, a questionnaire was administered to representative samples of express bus drivers at the Bus Terminal in Kuantan city in the state of Pahang, Malaysia. Most of the drivers are commuting from Kuantan to other major cities in West Coast. Seventy-nine bus drivers from different bus companies were interviewed. In the interview session, questions were asked based on items/indicators prepared in the questionnaire. The interview sessions were carried out early in the morning at the bus depot before their departure to other cities in West peninsular of Malaysia and during their lunch time upon their arrival from others cities at the bus terminal.

2.2 Survey Questionnaire

The questionnaire consists of four sections, namely, Sections A, B, C, and D. Section A includes demographic information of seven (7) items; age, gender, ethnic, measurement of height and body mass, marriage status and academic qualification. Section B consists of multiple choice questions on occupational information of eight (8) items; job status, working experience with the organization, driving experience as express bus drivers with the organization, driving shift schedule, driving hours per shift and driving hours per week and total kilometer distances travelled per year. Section consists of ten (10) questions (1: very good, 2: good, 3: satisfactory, 4: neutral, 5: not satisfactory, 6; very not satisfactory and 7: poor) on ergonomic driving risk factors at drivers workplace (cockpits) adapted from Ergonomic Driving Questionnaire to collect data on possible risk factors; instruments panel layout, adjustability of driver's seat, in cabin air temperature, air circulation in the drivers cabin, forwards and reverse visibility, engine noise and drivers exposure due to bus's vibration, environmental road hazards, passengers baggage handling and physical fitness. While, Section D consists of ten (10) questions with responses (0: no fatigue feeling, 1: slight fatigue feeling, 2: moderate fatigue feeling, 3: obvious fatigue feeling, 4: feeling of fatigue and numbness) adapted from standard Nordic Musculoskeletal Questionnaire (NMQ) (Kournika et al., 1987). Data collected from Nordic Musculoskeletal Disorders Questionnaire (NMQ) are not as valid as a clinical examination. However, the questionnaire is widely used and has been tested for reliability and validity (Baron et al., 1996; Bjorkstein et al., 1999).

2.3 Methods of Analysis

The items in the questionnaire are tested for reliability by using Statistical Package (SPSS) for Social Sciences version 17. A descriptive analysis was carried out on the express bus drivers' demographic information. The correlation between the latent constructs; occupational information (OF), ergonomic risk driving factors (ERDF) and musculoskeletal disorder symptoms (MSP) are obtained using Structural Equation Modelling (SEM) analysis. The SEM is based on Partial Least Square (PLS) estimation technique which is less sensitive to non-normal data and relatively small sample size (Wold, 1985; Chin, 1998). The statistical SmartPLS version 2 (Ringle & Hock, 2005) was used to analyze the relationship.

There are two models that have to be measured, namely, the outer model or measurement model and the inner model or structural model. The outer model is assessed in terms of item loading and reliability coefficients, composite reliability, as well as the convergent and discriminant validity. Individual item loading greater than 0.70 are strongly recommended for convergent validity. The average variance extracted (AVE) measures the variance captured by the indicators relative to measurement errors, and it should be greater than 0.50 to justify using the constructs (Barcaly et al., 1995). An AVE value of at least 0.50 indicates sufficient convergent validity, meaning that a latent variable is able to explain more than half of the variance of its indicator on average (Gotz et al., 2009). The discriminant validity is the degree to which items differentiate among constructs or measures (distinct concepts) and is assessed by examining the correlation between the measures of potentially overlapping constructs. Assessment of the inner model or structural model is used to test the correlation between construct, significance and R-square of a research model. The structural model is evaluated by using R-square in the dependent constructs.

3.0 RESULTS AND DISCUSSIONS

3.1 Demographic Characteristic

A total of 79 express bus drivers were interviewed at the bus terminal in Kuantan, Pahang. During the interview, a survey questionnaire was completed. The demographic data collected from the survey questionnaire is shown in Table 1.

Table 1: Descriptive analysis of demographic information

Factors	Frequency	Percent (%)
Organization:		
Government/Government agencies	41	51.9
Private sectors/industry	33	41.8
Self employed	5	6.3
Gender:		
Male	79	100
Female	-	-
Age:		
18 - 30 yrs	5	6.3
31 - 40 yrs	32	46.8
41 - 50 yrs	19	27.5
Height:		
165 cm & below	11	13.8
166 cm - 175cm	46	57.5
176 cm & above	22	27.5

Weight:		
45 kg & below	1	1.3
46 kg - 55 kg	4	5.0
56 kg - 65 kg	11	13.8
65 kg & above	63	78.8
Bus driving experience:		
Less than 10 yrs	39	49.4
11 - 15 yrs	12	15.2
16 - 20 yrs	15	19.0
21 - 25 yrs	6	7.6
More than 25 yrs	8.9	8.9
Driving hours/shift:		
2 - 6 hrs	17	21.3
6.1 - 8 hrs	22	27.5
8.1 - 24 hrs	40	50.0
Hours driving /week:		
5 - 30 hrs	6	7.5
31 - 70 hrs	29	36.3
71 - 110 hrs	44	55.0

Most of the respondents are in the 31-40 (46.8%) age group. They were comprised of 77 married male (96.3%) and only 2 (2.5%) single. Most of the respondents were educated up to SPM levels (58.8%). 50.7%of the bus drivers have more than 10 years of driving experience and 50.0% of the bus drivers have more than eight hours of driving per shift.

3.2 Data analysis using Partial Least Squares (PLS)

The data on occupational factors, ergonomic driving risk factors and musculoskeletal pain were analyzed by using SmartPLS.

3.2.1 Assessing Outer Model

In assessing the outer model, convergent validity, composite Reliability and discriminant validity should be looked into. Convergent validity of a measurement model (using reflective indicators) is measured based on the correlations between item scores. The reflective individual loading is considered high if the correlation is higher than 0.70 with the associated constructs. On the other hand, according to Chin (1998), the newly developed research measurement scale, any loading value of 0.50 to 0.60 is considered sufficient.

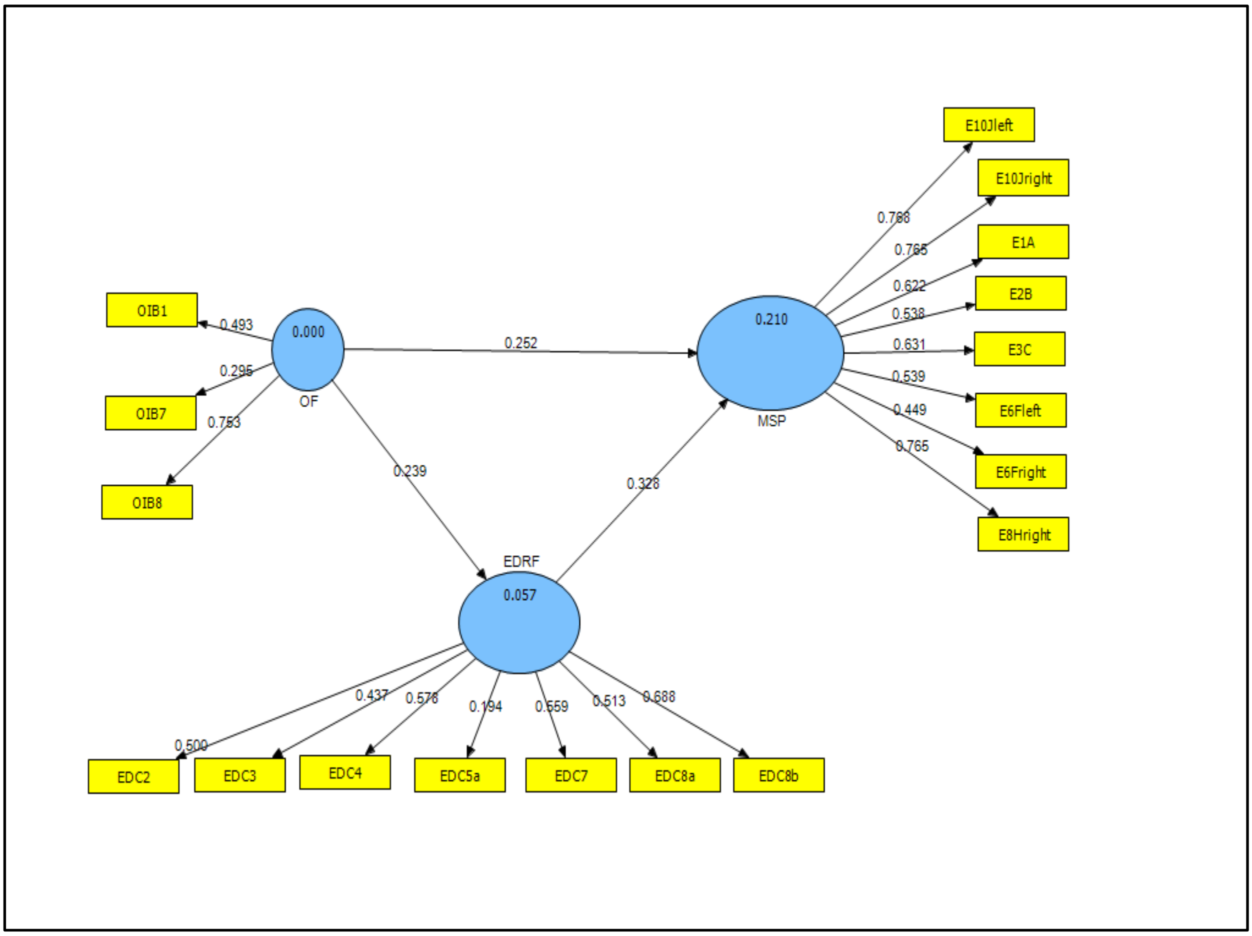

Figure 2: Structural Equation Modeling of factors correlated to musculoskeletal pains

Table 2: Loadings of Measurement Model

Items	EDRF	MSP	OF
E10Jleft	0.0000	0.7679	0.0000
E10Jright	0.0000	0.7647	0.0000
E1A	0.0000	0.6225	0.0000
E2B	0.0000	0.5377	0.0000
E3C	0.0000	0.6314	0.0000
E6Fleft	0.0000	0.5387	0.0000
E6Fright	0.0000	0.4495	0.0000
E8Hright	0.0000	0.7654	0.0000
EDC2	0.5001	0.0000	0.0000
EDC3	0.4374	0.0000	0.0000
EDC4	0.5775	0.0000	0.0000
EDC5a	0.1943	0.0000	0.0000
EDC7	0.5586	0.0000	0.0000
EDC8a	0.5131	0.0000	0.0000
EDC8b	0.6885	0.0000	0.0000
OIB7	0.0000	0.0000	0.2950
OIB8	0.0000	0.0000	0.7534

Table 2 shows each item score and the loadings are considered high if it exceeds 0.70. The loading value of the items is considered sufficient if it lies within 0.50-0.60 as stated by Chin (1998).

One of the methods to measure discriminant validity is by assessing the Average Variance Extracted (AVE). The score of a construct's AVE is considered adequate if the score is greater than 0.50 (Fornell & Larcker, 1981). Reliability test is performed based on Composite Reliability (CR) value, in which according to Bagozi and Yi (1988), the construct is reliable if the value of CR is greater than 0.70.

Table 3: The Values of AVE, Composite Reliability, Cronbach's Alpha, Communality and Redundancy

Latent Constructs	**Cronbach's Alpha**	**Composite Reliability**	**AVE**
EDRF	0.6054	0.7008	0.2660
MSP	0.8055	0.8466	0.4160
OF	-0.1051	0.5306	0.2992

Table 3 shows that the AVE values for ERDF and OF are 0.2660 and OF is 0.2992, respectively. These are not adequate as stated by Fornell and Larcker (1981) where these scores of ERDF are less than 0.50. The Composite Reliability of the constructs ERDF (0.7008) and MSP (0.8466) are good according to Bagozi and Yi (1988). The Cronbach alpha values for the construct ERDF (0.6054) and the construct MSP (0.8055) are adequate. However, the Cronbach's alpha for the construct of OF (0.1051) is considered low according to Sekaran (1992).

3.2.2 Assessing Inner or Structural Model

Inner or structural model is used to measure the existence of relationships among constructs. The significance of the relationships is measured by the R-square of the research model and large values of t-statistics of the structural path parameter coefficients.

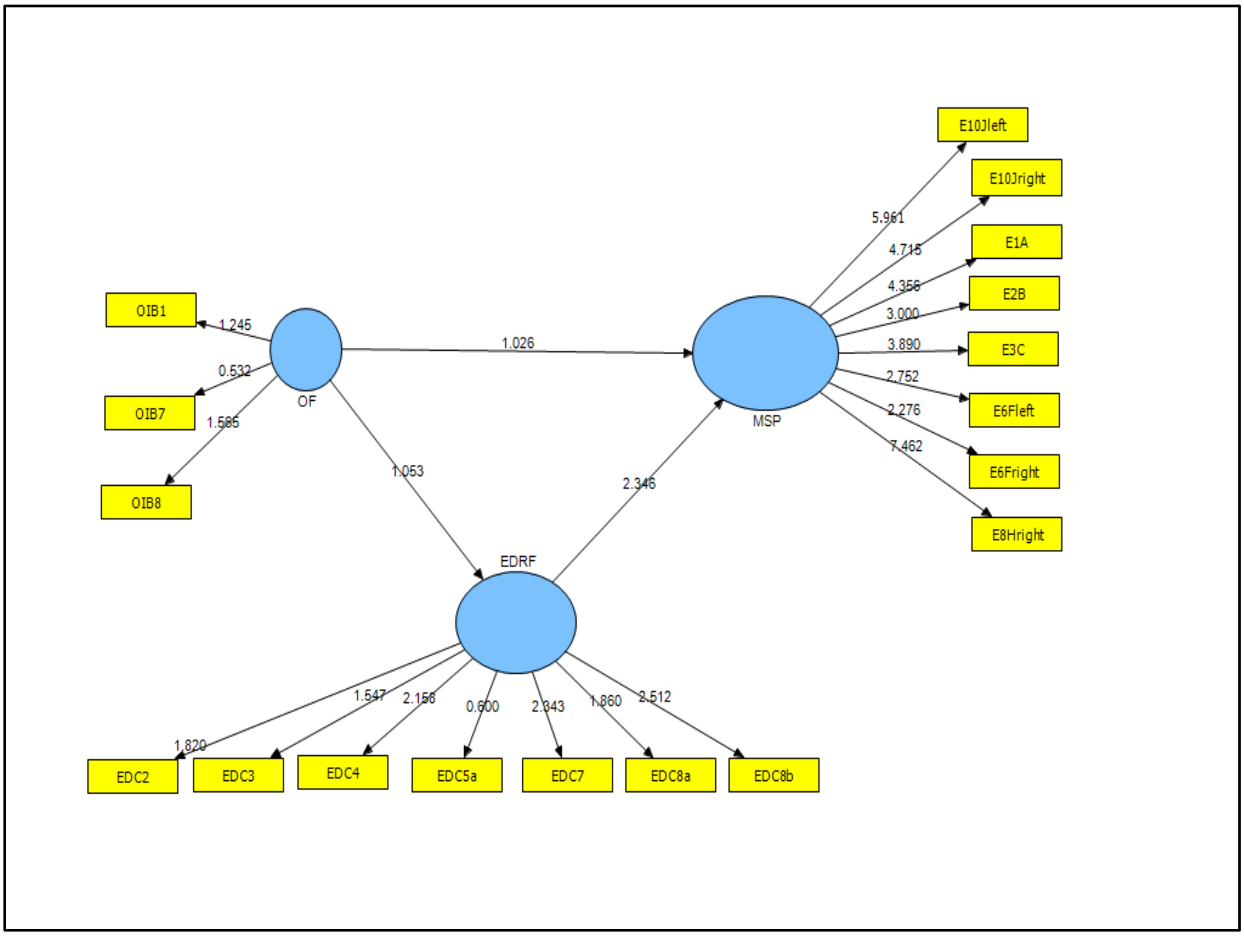

Figure 3: Bootstrapping method on the hypothesized model

Table 4: R-Square of the Constructs

Constructs	R-Square
EDRF	0.507
MSP	0.210
OF	0

According to Table 4 above, the R-square value of ergonomic driving risk factors construct variable is 0.507. This means that 50.7% of ergonomic driving risk factors (EDRF) is explained by musculoskeletal pain variable and occupational factors (OF) variable, the rest is by other variables. While, the R-square value of ergonomic driving risk factors is 0.210. This means that 21.0% of the ERDF variance is explained by occupational factor (OF), while the rest is explained by other variables.

3.2.3 Hypothesis Testing

In order to test the hypothesis proposed, the scores or values of T-statistics are assessed. Estimated parameter significance describes valuable information about the relationship between the research variables.

Table 5: T-statistic estimation in inner weight measurement

Path	Loading	t-value	Hypothesis
EDRF -> MSP	0.3277	2.3464	Accepted
OF -> EDRF	0.2392	1.0529	Rejected
OF -> MSP	0.3302	1.5551	Rejected

Table 5 shows that the hypothesis HA1 i.e. that there is a significant and positive relationship between occupational factors and ergonomic driving risk factors is rejected as the t-value (1.0529) is within ± 1.96 and therefore the null hypothesis (H0) is accepted. The hypothesis HA3 that there is a significant and positive relationship between occupational factors and musculoskeletal pains is also rejected as the t-value (1.5551) is within ± 1.96 and thus the null hypothesis (H0) is accepted. The hypothesis HA2: There is a significant and positive relationship between ergonomic driving risk factors and musculoskeletal pains is accepted as the t-value (2.3464) is more than 1.96.

4.0 CONCLUSION

The findings of this study showed the relationships of ergonomic driving risk factors (EDRF) on the musculoskeletal pain (MSP) variables. It means that the exposure of ergonomic driving risk factors (ERDF) experienced by the express bus drivers for a long duration will escalate the musculoskeletal pain (MSP) on the express bus drivers. Thus, reducing ergonomic driving risk factors by improving drivers' work place (in cabin condition) will reduce the symptoms of musculoskeletal pain (MSP). These results are in line with the findings of many research works in this area (Krause et el., 2004; Gyi, 2002; Krause et al., 1997b; Skov et al., 1996; Brage & Bjerkdal, 1996; Han et al., 1997; Heir & Eide, 1996; Leino-Arjas et al., 1998; Linton, 1990).

In future research, it is of import to add more variables, especially independent variable in the research model such as the safety climate in the organization, psychological factors and stress at the workplace. In this study, the researcher only discussed three musculoskeletal related variables.

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The authors

Yusof Hashim
Faculty of Industrial Sciences & Technology
Universiti Malaysia Pahang (UMP)
Pahang.
e-mail: yusof@ump.edu.my

Zahari Taha
Faculty of Manufacturing Engineering,
Universiti Malaysia Pahang (UMP)
Pahang.