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Relationship Analysis of Whole Body Vibration (WBV) with Musculoskeletal Disorder (MSDs) complaints on heavy equipment operators at the Trans Sumatra Toll Road Construction Project at PT. Adhi Karya Tbk

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Abstract

The use of heavy equipment in the construction field is very helpful in the process of a project. Heavy equipment operators exposed to the Whole Body Vibration due to a machine that can be transmitted through a seat or on the floor. These vibrations at certain intensities can lead to Musculoskeletal Disorder. This study aimed to analyze the relationship of Whole Body Vibration with the occurrence of Musculoskeletal Disorder complaints on Heavy Equipment Operators. Methods this study used cross sectional design, with a measuring instrument in the form of an accelerometer type 100A svantek and a Nordic Body Map questionnaire. The research sample was 45 operators with heavy equipment consisting of excavators, bulldozers, motorgrade, vibro compactors and dump trucks. WBV data retrieval is done when the operator works,, the tool is placed in the seat where the operator sits. Results of the study can be obtained through exposure to WBV based on ISO 2631: 1 15 heavy equipment operators (33.3%) were in the low WBV exposure category, while 30 operators (66.6%) in the Moderate and High category. Parts of the body which can be categorized as belonging to Work-related is part of Lower Back 99.35% (P Value 0.043; NK_R2 0.304) with BMI (OR 0.925) as the confounding variable. It can be concluded that the complaints Musculoskeletal Disorder (MSDs) in the Lower back may come from the presence of vibration exposure Whole Body Vibration generated from his job as a heavy equipment operator. Advised the company's management can reduce complaint rates by reducing operator exposure received.Keywords: Secondary metabolites, Trichoderma harzianum, Colletotrichum capsici, tannin

Keywords : Heavy Equipment Operators, Whole body Vibration, Musculoskeletal disorder complaints, Work-related

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1. Introduction

World Health Organization (WHO) states that musculoskeletal disorders can be caused by the contribution of various risk factors (Multifactorial). These risk factors can be classified as physical factors, individual factors and environmental factors. One relatively dangerous physical factor in the workplace and comes from work equipment used is vibration. Vibration generated from the equipment (machines) may cause adverse health effects. Trans Sumatra toll road construction project used approximately 100 heavy equipment and their heavy equipment operator plunged into this process, namely, 4 Bulldozers as purifier field; 24 excavators act as diggers, transporters and loaders; 51 dump trucks used by transportation equipment; 16 roller compactors are used as compaction devices and 5 Motor graders as surface forming tools. Heavy equipment can cause mechanical vibrations the operator who drives it. Mechanical vibrations caused by this heavy equipment vehicle engine may cause increased noise

levels and vibration effects on the operator's entire body as a vibration (Whole Body Vibration) and can cause adverse effects on the health of the operator.

Whole Body vibration transmitted through the seat or legs operator who rides heavy equipment or other work vehicles. Surface rough and uneven is the stimulus of vibration caused. The vibrations produced by the vehicle's engine when exposed for a long time and with a long duration will cause adverse effects on health. Prolonged exposure that can improve whole-body vibration intensity so as to cause a nuisance especially disorders of the skeletal muscle we call Musculoskeletal Disorder (Suma'mur, 2009). Large ignorance of exposure Whole Body Vibration the heavy equipment operator as well as data and information the incidence of musculoskeletal disorders due to exposure to vibration produced by the machine (heavy equipment) is not available. Such data are required by the K3 to prevent health impacts like musculoskeletal disorders. Based on this background, it is necessary to conduct further research on the relationship between Whole Body Vibration (WBV) and Musculoskeletal Disorders (MSDs) the heavy equipment operators on this Trans Sumatra toll road construction project we will do further research.

2. Materials and Methods

2.1 Design and sample

This study was an observational study with cross sectional analytical survey approach. This design can provide a illustration of the study population and the relationship between the variables to be studied. This study uses primary data to be obtained through vibration checks Whole Body Vibration using the Accelerometer tool and for MSDs complaints the Nordic Body Map (NBM) questionnaire was used which was distributed to heavy equipment operators.

2.2 Location and Time of Research

This research was conducted at the site of highway construction projects trans-Sumatran package 3 zones 1 through Brati Kotabaru limit as far as ± 16 km. Implementation of this research was conducted in March 2018.

2.3 Research Samples

The samples in this study was using the sample formula according to Lemeshow (1977), as follows:

$$n = \frac{Z^2{}_{1-\alpha/2}P(1-P)}{d^2}$$

n = number of samples
$z^2{}_{1-\alpha/2}$ = 1,96
P = 0,305 (Dharma,2008)
d = limit of error or precision specified = 0,1

By using the formula, the number of sample results obtained by the sample is 45 people

2.4 Sampling Technique

The technique for sampling in this study uses nonprobability with accidental sampling techniques. NBM covers 28 sections of skeletal muscle in both right and left sides of the body. Starting from the upper limbs, namely the neck muscles to the very bottom, the muscles in the legs.

Assessment using the NBM questionnaire resulted in an NBM score. This NBM score is obtained from the sum of the complaint levels and the frequency of complaints felt by the operator. In the assessment using scoring.

2.5 Data Analysis

Data analyzed by univariate, bivariate and multivariate. Univariate analysis is intended to describe the characteristics of each variable studied. The analysis done by cross analyzing are two variables that were related or influential namely between the independent variable and the dependent variable using the Chi-Square test. The statistical test used the Chi-Square test with a confidence level of 95%. If the p-value is <0.05, the statistical calculation shows that there is a significant influence between the independent variable and the dependent variable.

1. Multivariate analysis
a. Multiple linear regression

Multivariate analysis here is intended to show the association between the main variables such as vibration measurement results Whole Body Vibration with dependent variable Complaints MSDs based on scores Nordic Body Map (NBM). Because the dependent variable is a numerical type, the analysis used is multiple linear regression. This analysis is a continuation of bivariate analysis, namely the correlation test where the purpose of this analysis is to obtain a regression equation model, namely:

$$Y = a + b_1X_1 + b_2X_2 + ... + b_kX_k + e$$

The above equation model can provide information about the regression model that best describes the related factors, predict or estimate the value of the dependent variable and identify the relationship of the independent variable with the dependent variable. Assumptions or requirements performed to show whether or not the equations produced are valid, including the Assumption test, the Independence test, the Multicollinearity test, the Heteroscedasticity test, the Normality test and the Linearity test.

b. Multiple logistic regression

Multivariate analysis here is intended to show the association between the main variables such as vibration measurement results Whole Body Vibration with dependent var iables Complaints of MSDs per body part and calculating probability because the dependent variable is the type of data category, the analysis used the Multiple Logistic Regression test.

3. Results and Discussion

Univariate Analysis

Table 1 Characteristics of Operators

Variable	Mean	Median	SD	Min	Max
Age (years)	35	35	8.301	20	60
BMI (Kg/m^{2})	22.31	21.80	2.989	17.63	29.41
Work Period (Month)	24.07	28.00	6.950	12	32
WBV (m/s^{2})	0.60	0.58	0.226	0.21	1.16
Score NBM	89.44	85	20.68	55	139

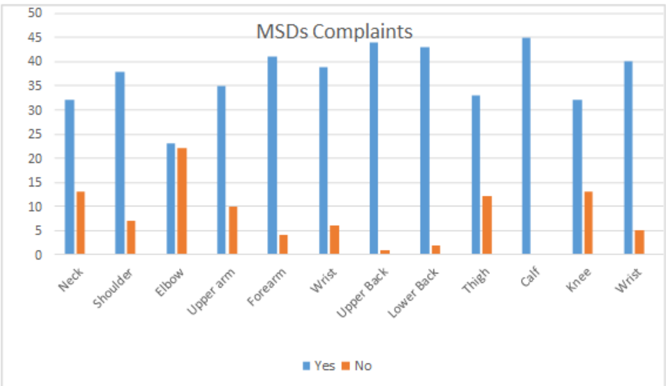


Figure 1 Distribution of Frequency of MSDs Complaints Based on Body Parts of Heavy Equipment Operators in PT.X in 2018

Table 1 shows univariate analysis carried out by analyzing the frequency distribution of each of the variables examined which consisted of Age, Body Mass Index (BMI), Work Period, Whole Body Vibration (WBV), Smoking habits, and Nordic Body Map Score (NBM)

Bivariat Analysis

Table 2 Relationship of WBV exposure intensity to MSDs complaints on each limb on PT.X Heavy Equipment Operators in 2018

Variabel	MSDs Complaints Medium n	%	Weight n	%	Total n	%	PR (95%)	P_{Value}
Age								
≥ 35 Years old	4	8.9	22	48.9	26	57.7	1.46	0.623
< 35 Years old	4	8.9	15	33.3	19	42.2	(0.31-6.79)	
Body Mass Index								
Abnormal	2	4.4	10	22.2	12	26.6	0.90	0.906
Normal	6	13.3	27	60	33	73.3	(0.15-5.21)	
Working period								
≥ 24 Month	1	2.2	26	57.8	27	60	16.545	0.004
< 24 Month	7	15.6	11	24.4	18	40	(1.81-150.93)	
WBV ISO								
Moderate_High	1	2.2	29	64.4	30	66.6	0.039	0.000
Low	7	25.6	8	17.8	15	33.3	(0.00-0.36)	

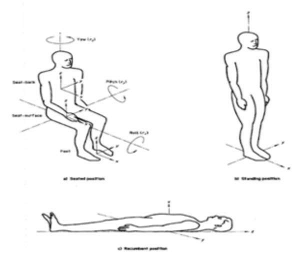
Multivariate Analysis

Table 3 Final model of Linear Regression

Variabel	B	*p-value*	R^2	*p-value* (ANOVA)
WBV	82.208	0.000		
Age	1.343	0.000		
Cigarettes	0.043	0.849	0.716	0.000
Work Period	-0.123	0.844		
(Constant)	-5.196	0.644		

Table 4 Linear Regression Equations
NBM score = -5.196 + 82.208 WBV + 1.343 Age + 0.043 Cigarettes – 0.123 Working period

Source: personal documentation
Figure 2 Accelerometer tool



Source taken from ISO 26312-1:1997 (E)
Figure 3 orthogonal axis body axis orientation X, Y, Z

In table 4 explains the WBV regression coefficient is positive, meaning that when the WBV value is increase, the NBM score will also increase. Age regression coefficient is positive, meaning that when the age is increase, the NBM score will also increase. The cigarette regression coefficient is positive, meaning that when the number of cigarettes consumed increase, the value of the NBM score will also increase. The working period regression coefficient is negative, meaning that when the working period increases, the NBM score will decrease.

Table 5 Relationship between WBV exposure intensity and MSDs complaints on lower Back

	Lower Back				P_{Value}
	Yes		No		
	n	%	n	%	
WBV					
Moderate-High	30	66.6	0	0	0.041
Low	13	28.9	2	4.4	

Table 6 Results of lower back logistic regression analysis.

Lower Back	**OR**	P_{Value}	**NK_R²**	**Probability**
WBV	13.985	0.043	0.304	99.35%
Age	-			
BMI	0.925			
Working period	-			

Which means that the increase in WBV value of 1 m/s2 will increase the NBM score by 82.208 and vice versa, The increase in the age of 1 year will increase the value of NBM score of 1.343, and vice versa, The increase in the number of cigarettes consumed by 1 cigarette will increase the value of the NBM score by 0.043 and vice versa, The addition of a work period of 1 month will reduce the NBM score by 0.123 and vice versa, assuming that the other independent variables of the regression model is fixed. The coefficient of determination (R2) in Table 3 of .716 means that four independent variables can explain the variable score NBM 71.6% while the rest is explained by other variables.

In the Lower Back body part (table 5) it was found that there were 30 (66.6%) operators experiencing complaints of Musculoskeletal Disorder (MSDs) with WBV exposure at moderate-high intensity, there were 13 (28.9%) operators who experienced Musculoskeletal Disorder (MSDs) complaints with low intensity WBV exposure. The results of statistical tests obtained the value of P Value = 0.041, it can be concluded that there is a significant relationship between WBV exposure to moderate-high intensity with WBV exposure at low intensity.

The results of multivariate analysis found that the most dominant MSDs complaints were influenced by WBV which is part of the body Lower Back with OR 13.985 which exposure to WBV with intensity Moderate-High risk 13 times that of low intensity, with the confidence level of 95%, OR is stated to be significantly meaningful and can represent the entire population.

Complaints on the Lower Back can be caused by compressive strength which is the largest in the spine. Working in a sitting position itself has provoked fatigue in the abdominal muscles and hips, and increasing the pressure on the spine. Compression pressure can be generated as a result of one of them retain body bent forward position.

WBV exposure in a long time will cause degenerative changes in the spine. First, vibration results in an acceleration of vertebral end plate failure, followed by the formation of scars that have the effect of reducing the area of nutrient diffusion into the disc. Second, the nucleus prolapse that causes bending or rotational loading in the intervertebral joints. Third, the mechanism can cause acceleration of the degenerative nucleus and disc annular fibers (Tiemessen, 2008).

4. Conclusion

Based on the results of research that has been done, it can be concluded that : Most heavy equipment operators who have complaints MSDs due to exposure to Whole Body Vibration (WBV) in moderate-high intensity. Body parts based on MSDS whose influence is the most dominant of the main variables, namely Whole Body Vibration (WBV) is the Lower Back, with an OR value of 13.985 and an incidence probability of 99.35%.

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With the magnitude of risk arising from exposure to vibration, expected the operators and the companies work together to minimize the grievances raised and focused on ways to reduce exposure.

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