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ANALYSIS OF THE CAUSAL FACTORS OF MUSCULOSKELETAL DISORDERS COMPLAINTS IN CRANE OPERATOR WORKERS

Zsa Zsa Dwita Sari Batubara[1)*], Gerry Silaban [2)], Isyatun Mardhiyah Syahri [3)]
[1] Master Student, Faculty of Public Heath, Universitas Sumatera Utara, Medan, Indonesia
[2,3] Faculty of Public Heath, Universitas Sumatera Utara, Medan, Indonesia
email: zsazsadwitas@gmail.com

Abstrak

Gangguan muskuloskeletal menyebabkan kerusakan yang terjadi pada otot, tendon, ligamen, saraf perifer, sendi, tulang rawan dan/atau pembuluh darah pendukung. Kondisi tersebut diperburuk oleh keadaan kerja. Penelitian ini bertujuan untuk menganalisis faktor penyebab terjadinya keluhan gangguan muskuloskeletal. Penelitian ini merupakan penelitian kuantitatif dengan metode deskriptif analitik dan pendekatan cross-sectional. Besar sampel 63 orang dipilih dengan purposive sampling. Data keluhan gangguan muskuloskeletal dikumpulkan dengan kuesioner survei keluhan GOTRAK oleh SNI 9011:2021, penilaian postur kerja menggunakan SNI 9011:2021 Pengukuran dan evaluasi potensi bahaya ergonomi di tempat kerja, getaran menggunakan alat human vibration meter, aktifitas fisik menggunakan kuesioner PAL dan kelelahan menggunakan alat ukur reaction timer. Data dianalisis menggunakan uji spearman untuk melihat korelasi dan regresi linier berganda. Nilai koefisien postur kerja sebesar 0,264 p < 0,001, getaran sebesar 0,440 p < 0,001) berpengaruh positif terhadap gangguan muskuloskletal. Faktor risiko pekerjaan dengan gangguan muskuloskletal, interaksi getaran dengan aktifitas fisik memiliki nilai koefisien paling penting yaitu 3,128, diikuti oleh postur kerja dengan usia sebesar 0,250. Ada hubungan yang searah antara postur kerja dan getaran terhadap keluhan gangguan muskuloskeletal serta semua faktor moderasi.

Kata kunci: *gangguan muskuloskeletal, operator crane, postur kerja, getaran, GOTRAK*

Abstract

Musculoskeletal disorders cause damage to muscles, tendons, ligaments, peripheral nerves, joints, cartilage, and supporting blood vessels. The condition is exacerbated by working conditions. This study aimed to analyze the factors that cause complaints of musculoskeletal disorders. This research was quantitative research with an analytic descriptive method with a cross-sectional approach. A sample of 63 people was selected by purposive sampling. Data on complaints of musculoskeletal disorders were collected using the GOTRAK complaint survey questionnaire by SNI 9011:2021, assessment of work posture using SNI 9011:2021 Measurement and evaluation of potential ergonomic hazards in the workplace, vibration using the human vibration meter, physical activity using the PAL questionnaire, and fatigue using reaction timer measuring device. Data were analyzed using the Spearman test to see a correlation and multiple linear regression. The work posture coefficient 0.264 p<0.001, and vibration 0.440 p<0.001) had a positive effect on musculoskeletal disorders. The occupational risk factors with musculoskeletal disorders and vibration interactions with physical activity had the most important coefficient value of 3.128, followed by work posture with an age of 0.250. There is a direct correlation between work posture and vibration on complaints of musculoskeletal disorders and all moderating factors.

Keywords**:** *musculoskeletal disorders, crane operators, work posture, vibration, GOTRAK*

1. INTRODUCTION

Musculoskeletal disorders (MSD) are described as injuries or conditions that involve structures of the body's musculoskeletal system such as tendons, bones, muscles, ligaments, nerves, discs, and blood vessels (Emerson & Finch, 2021). While the Bureau of Labor Statistics defines an occupational MSD with a specific diagnosis, together with exposure-related terms namely the musculoskeletal system and connective tissue diseases and disorders, when the event or exposure causes injury or illness fatigue and bodily reactions, cause unspecified; exhaustion involving outside

sources; repetitive movements involving micro-tasks; some exertion or bodily reaction; and rubbed, eroded, or shaken by vibration (Bureau of Labor Statistics, 2016).

The survey results in European Union countries by European Working Conditions Survey show that 60% of workers identified as experiencing MSD complaints in the age range of 15-64 years who have worked for more than 12 months. In 2015, there were 31,612 cases of workers experiencing MSD complaints including 29% in lower limbs, 41% in shoulders, neck, or upper limbs, 43% back, and one or more MSD complaints 58% (European Agency for Safety and Health at Work, 2019).

The results of another survey by the Labor Force Survey in 2020/2021 show that 470,000 workers in the UK have identified MSD complaints related to their work with a prevalence rate of 1,420 per 100,000 workers. This complaint comprised 16% (76,000) of cases lower limb, back in 39% (182,000) cases, and upper limb or neck in 45% (Health and Safety Executive, 2021). The results of Basic Health Research in 2018 showed the prevalence of MSD in Indonesia was (7.3%) with the majority of the age group >75 years experiencing MSD at (18.95%) and the minority occurring in the age group 15-24 years of (1.23%). Based on the characteristics of work, the highest group with a prevalence of MSD, namely farmers (9.86%), fishermen (7.36%), and others (7.31%) (Kementerian Kesehatan RI, 2019).

MSD occurs slowly over time due to repeated wear and tear or micro trauma to the tissue. Prolonged exposure to physical work risk factors such as awkward and static postures, pressure, repetitive movements, and vibration can cause permanent damage and debilitating conditions. Some factors cannot directly cause MSD, namely frequency, duration, and working environment conditions but can contribute to the development of MSD. In addition, individual risk factors, such as physical condition, existing health problems, gender, age, work techniques, hobbies, and organizational factors (eg, job autonomy, quotas, and deadlines) are also factors that may contribute to the development of MSD but do not cause MSD. However, they can cause other unwanted health conditions (Stack et al., 2016).

Based on previous research conducted by Azmi et al. (2019) states that operators over the age of 40 are less likely to suffer from Low Beck Pain (LBP) when compared to younger operators, namely 31-40 years, and are 3 times more likely to suffer from LBP. Those who have worked more than 5 years 7 times ($p< 0.001$) are more likely to stop working because of LBP and about 6 times more likely ($p<0.001$) to suffer from LBP within 7 days when compared to operators who worked less than 5 years. Apart from exposure duration, postures such as sitting for hours ($p<0.001$) and bending over ($p<0.001$) were also found to be significantly associated with LBP. The prevalence of LBP at 12 months and 7 days tends to decrease with increasing body mass index (BMI). Likewise, operators who carry out sports activities experience lower LBP in the last 12 months and within 7 days.

The results of a study related to crane operator posture in the steel industry by Khademian et al. (2018) showed a significant difference between the overhead crane model and the risk factors for MSD in the upper extremities, such as the shoulders, arms, back, neck, wrists and hands in 45 workers ($p=0.011$). Of the 45 overhead crane operators, the highest prevalence of musculoskeletal symptoms was in the upper back (33.3%), lower back (83.3%), neck (71%), and knees (62.6%) in crane operators. Awkward body and neck postures in static situations and dynamic hand and arm movements to control levers and vibration in the cabin (whole-body vibration) are the main causes of this disorder (Khademian et al., 2018).

Several studies have found that the incidence of musculoskeletal disorders in crane operators requires full attention to overcome them because the work process is static and requires workers to behave non-ergonomically in work to know possible causes that can affect the occurrence of musculoskeletal disorders. Therefore the purpose of this study was to analyze the factors that cause MSD complaints in crane operator workers.

2. RESEARCH METHOD

This study was quantitative research using descriptive analytics with a cross-sectional approach. This study was conducted

on crane operators at PT Terminal Petikemas Belawan from 02 November 2021 to 30 June 2023. 63 workers involved in this study were selected by purposive sampling. Inclusion criteria: 1) crane operators who have complaints of MSD based on the assessment of SNI 9011-2021 Survey of complaints of MSD with a minimum of 2 segments of complaints experienced by workers with medium and high-risk assessment levels; 2) crane operators who do not have a history of illness related to pain in the neck, upper back, shoulders, lower back before becoming a crane operator; and 3) crane operators who have no history of injury or accidents such as falling, slipping, being crushed.

Complaints of MSD were collected using the GOTRAK complaint survey questionnaire by SNI 9011:2021 Measurement and evaluation of potential ergonomic hazards in the workplace. The assessment and observation of the respondents' work postures referred to the SNI 9011:2021 method. Measuring and evaluating potential ergonomic hazards in the workplace, especially using a checklist of potential ergonomic hazards. Vibration data collection (whole body vibration) was carried out using a human vibration meter with a transducer circuit in the area between the bodies as a seat for crane operator workers. The measurement refers to the procedure of SNI 8186:2009 The method of measuring the vibration acceleration of the whole body in a sitting working attitude. Data collection and calculation of physical activity using the Physical Activity Level (PAL) form. Fatigue assessment data collection was assessed using a reaction timer measuring tool that was given to the crane operator. The collection of data on individual and occupational characteristics was carried out by interviewing and administering a questionnaire covering the age characteristics and smoking behavior of crane operator workers. This study was analyzed using Spearman rank correlation and Moderated Regression Analysis (MRA). This research passed the ethical test at the Health Research Ethics Commission, the University of Prima Indonesia with number 103/KEPK/UNPRI/X/ 2021.

3. RESULT AND DISCUSSION

The following presents the characteristics of the respondents based on age, body mass index, working period, types of crane tools, work posture, vibration (whole body vibration), physical activity, fatigue, and smoking behavior.

Table 1. Characteristics of Respondents

Variables	n	%
Age (years)		
<30	4	6.35
>30	59	93.6
Body mass index		
<18 (thin)	1	1.59
18.1-25 (normal)	18	28.6
25.1-27 (overweight)	20	31.7
>27 (obesity)	24	38.1
Working period (years)		
1-5	8	12.7
5-10	4	6.34
>10	51	81
Types of crane tools		
Rubber tyred gantry	37	58.73
Container crane	25	40
Harbour mobile crane	1	1.58
Work posture		
Safe working conditions	0	0
Conditions that require further observation	0	0
Dangerous workplace conditions	63	100
Vibration (whole body vibration)		
Exceeds the threshold value	0	0
Does not exceed the threshold value	63	100
Physical activity		
Mild	2	3.17

Variables	n	%
Moderate	23	36.5
Severe	38	60.3
Fatigue		
Normal	12	19
Mild fatigue	39	61.9
Moderate fatigue	12	19
Severe fatigue	0	0
Smoking behavior		
Not smoking	37	58.7
Mild smoker	2	3.17
Moderate smoker	18	28.6
Severe smoker	6	9.52

According to Table 1, the results showed that the majority of 59 (93.6%) crane operators were in the age group above 30 years. The body mass index of the majority of 24 (38.1%) crane operators was in the obesity category. The majority of respondents have worked for more than 10 years, 51 people (81%). The majority of types of crane equipment used a rubber-tired gantry, 37 people (58.73%). The majority of crane operators' work postures, with all 63 workers (100%) having hazardous working conditions. The majority of whole-body vibration is the point of the crane tool not exceeding the Threshold Value of 63 people (100%). The majority of respondents have a severe category of physical activity 38 people (60.3%). Fatigue among crane operator respondents, the majority of operator respondents were 39 (61.9%) experiencing mild work fatigue. Smoking behavior The majority of crane operator respondents were 37 (58.7%) not smoking.

Table 2. Correlation of Work Factors with Complaints of MSD

Correlation	count	p-value
Work posture		
Dangerous workplace conditions with complaints of MSD	0.563	0.001
Vibration (whole body vibration)		
Does not exceed the threshold value with complaints of MSD	0.521	0.001

Table 2 showed that the correlation between work posture and hazardous workplace conditions and complaints of MSD shows a positive correlation number of +0.563, this means that complaints of MSD of workers depend on the work posture of crane operators or show a strong correlation between work posture and complaints of MSD. Based on the results of the correlation of vibration (whole body vibration) which does not exceed the threshold value for MSD complaints, it shows a positive correlation number of +0.521, this means that workers' complaints of MSD depend on the vibration (whole body vibration) felt by the crane operator while working or showed a strong correlation between vibration (whole body vibration) and crane operator complaints of MSD.

Table 3. Linear Regression Model of Work Posture and Vibration (whole body Vibration) with Complaints of MSD in Crane Operators.

Variable	B	t	p-value
(Constant)	0.416		
Work posture			
Dangerous workplace conditions with complaints of MSD	0.264	4.158	0.001
Vibration (whole body vibration)			
Does not exceed the threshold value with complaints of MSD	0.440	5.191	0.001

Based on the results of linear regression calculations, it can be seen that the value of α is 0.416 which means that if the work posture and vibration (whole body vibration) of 0 or not affected, the value of complaints of MSD in crane operators is 0.416. A positive value on the regression coefficient indicates that there is a unidirectional correlation between X1 and Y. For the value of the regression coefficient (B1), the work posture variable is 0.264, meaning that if the vibration (whole body vibration) is felt by the crane operator fixed value, then every work posture with hazardous workplace conditions experienced by workers will increase complaints of MSD in crane operators by 0.264. Furthermore, the value of the regression coefficient (B2) for the vibration variable (whole body vibration) is 0.440, meaning that if the work posture experienced by the crane operator is fixed, then every vibration (whole body vibration) felt by the worker will increase complaints of MSD in the crane operator by 0.440 (Table 3).

Table 4. Moderated Regression Analysis (MRA) Test Results for Influence or Priority as a Moderating Variable

Model	Code	B
Vibration (whole body vibration)*physical activity	VPA	3.128
Vibration (whole body vibration)*age	VAG	0.443
Vibration (whole body vibration)*smoking behavior	VSB	0.330
Vibration (whole body vibration)*fatigue	VFG	0.306
Work posture*age	WPA	0.250
Work posture*fatigue	WPF	0.194
Work posture*smoking behavior	WSB	0.131
Work posture*physical activity	WPA	0.036

*P < 0.05

Based on the results of hypothesis testing in regression X1 X2 has a positive effect on Y and all moderating factors strengthen the effect of the independent variable on the dependent. Among the two main categories of occupational risk factors for MDS, vibration (whole body vibration) is the most important factor, followed by work posture. The ranking of the coefficient values of the different sub-factors of work factors for complaints of MDS in crane operators is VPA>VAG>VSB>VGF>WPA>WPF>WSB >WP (Table 4).

Based on the results of the regression analysis, it shows that work posture influences complaints of MSD, as indicated by the positive value on the regression coefficient which is positive 0.264. In addition, the direct effect of the work posture variable on MSD is shown at a value of 54% in the adjusted R-Square. This shows that the remaining influence of 46% is influenced by other factors. Several research results obtained the same results as those found by Russeng et al. (2021) the effect of work posture variables on musculoskeletal disorders has a p-value of 0.001<0.05, this indicates that work posture variables have a significant positive effect on complaints of MSD with a coefficient value of 0.569. Research by Candan et al. (2019) discussed MSD and the correlation between pain severity related to MSD and work posture at a Candlenut factory with a DMQ-TR-s score (CI 10.51-22.44, p=0.001) where the majority of complaints experienced in the lower back (61.4%) and followed by the neck (57.9%). Because the posture of the worker's shoulder during the selection of hazelnut is in protraction due to thoracic kyphosis, which affects the length-tension correlation of the shoulder girdle muscles and can cause pain.

While the findings of a literature study by Joseph et al. (2023) stated strong evidence that awkward postures (such as non-neutral postures, bending, twisting the body, and twisting the neck) have a weak correlation with work-related MSD among professional drivers including operators. The same result was found in the study by Njaka et al. (2021) stated that out of 266 workers, 235 workers had awkward postures at work

1.37 (CI 0.44-4.25, p=0.591), there was no significant correlation between work posture and complaints of MSD experienced by workers.

Based on the results of the regression analysis, it shows that vibration (whole body vibration) influences complaints of musculoskeletal disorders, as indicated by the positive value of the regression coefficient which is 0.440. In addition, the direct effect of variable vibration (whole body vibration) on complaints of musculoskeletal disorders is shown at a value of 54% in the adjusted R-Square. This shows that the remaining influence of 46% is influenced by other factors. Whole body vibration (WBV) can cause fatigue, insomnia, stomach problems, headaches, and "shakiness" immediately after or during exposure. Bus and truck drivers find that exposure to WBV in the workplace can cause several circulatory, intestinal, respiratory, muscular, and back disorders. The combined effects of posture, postural fatigue, dietary habits, and WBV are possible contributors to this disorder. Studies show that WBV can increase heart rate, oxygen uptake, and respiratory rate and can produce changes in the blood and urine. Many studies have reported a decrease in the performance of workers exposed to WBV (Ostrom, 2016).

Based on priority ranking in the study of Sharma et al. (2022) using the ordinal priority approach method is used for calculating MSD risk factor weights associated with professional drivers. That vibration is the main factor cause of the severity of each MSD risk factor in the group of professional heavy equipment drivers with a significance level of the weight criteria, namely 0.0253. In the study of Kumar et al. (2022) vibration on the operator in the coal mine shows a daily vibration dose value of 93.6% where the operator is under a possible risk and only a little 6.4% is under the potential risk zone. The OR examination revealed that the case group was prone to low back pain by 2.52 times (95% CI 1.19, 5.31) compared to the control group. The case group of miners-2 was 2.0 times (95% CI 0.98, 4.08) more vulnerable to vibration hazards than the group of miners-3.

The study by Njaka et al. (2021) showed vibration (OR 0.45, CI 0.27, 0.74, P=0.002) remained a significant predictor of MSD complaints of low back and elbow. Similar to research by Upadhyay et al. (2022) stated the result that WBV exposure was higher among dumper operators who experienced upper back pain cases (SD=7.1 (1.91), controls (SD=5.7 (1.91), ($p<0.01$) and low back pain (SD=6.63 (2.10)), control (SD=5.55 (1.71), ($p<0.01$) compared to those without MSD. While the study of Joseph et al. (2023) supported strong evidence showing a weak correlation between WRMSD (Work-Related Musculoskeletal Disorder) and WBV among professional drivers. Of the 20 studies reviewed, 19 were consistent with showing a positive association with ORs ranging from 1.3 to 4.9.

Based on the results of the MRA analysis, it shows that work posture and vibration (whole body vibration) interact with age giving a coefficient value of 0.250 and 0.443, significant at 0.001 and 0.001, that the age variable is a pure moderator. This shows that the age variable reinforces the work factor for complaints of MDS in crane operators at PT Terminal Petikemas Belawan. And for every increase in the age of the crane operator, will cause an increase in the effect of work posture by 0.250 and vibration (whole body vibration) by 0.443 on complaints of MDS. Maximum muscle strength occurs between the ages of 20–29 years and will decrease by 20% at the age of 60 years in addition to other factors due to non-ergonomic attitudes which result in complaints of MDS (Tarwaka et al., 2016). The results are in line with several studies by Njaka et al. (2021) the effect of age was still significantly related to workers' MSD complaints (OR 1.14, 95% CI 1.07, 1.23; $p<0.001$). Other results showed a positive correlation between age and MSD complaints in the upper extremities (OR 1.05 1.02, 1.07; $p<0.05$) (Keyaerts et al., 2022).

Based on the results of the MRA analysis, it shows that work posture and vibration (whole body vibration) interact with physical activity giving coefficient values of 0.036 and 3.128, significant at 0.001 and 0.002, that the physical activity variable is a pure moderator. This shows that physical activity provides reinforcement of work factors for complaints of MDS in crane operators at PT Terminal Petikemas

Belawan. And for every increase in physical activity on the crane operator it will cause an increase in the effect of work posture by 0.036 and vibration (whole body vibration) by 3.128 on complaints of MDS. Sport has been associated with the prevention and minimization of MSD in various work sectors. Research by Smith et al. (2020) found variations in exercise characteristics have different impacts on MSD. Longer duration, specifically more than 5 hours of moderate physical activity each week, is associated with shoulder and neck MSD. However, vigorous physical activity was found to be protective. Those who engaged in vigorous physical activity for 1 to 5 hours per week outside of work were less likely to report shoulder MSD (OR=0.62, 95% CI: 0.38–1.01, p <0.06); however, significance was at the p <0.10 level. Workers who reported more than 5 hours per week of moderate physical activity were more likely to have neck musculoskeletal symptoms (OR =1.92, 95% CI: 1.01–3.64, p<0.05). Research by Yizengaw et al. (2021) stated that 51% of health service provider workers had MDS complaints where 211 (60.4%) workers had physical activity activities and 83 (39.6%) did not have physical activity activities out of a total of 394 workers.

Based on the results of the MRA analysis, shows that work posture and vibration (whole body vibration) interact with fatigue giving coefficient values of 0.194 and 0.306, significant at 0.001 and 0.001, that fatigue is a pure moderator. This shows that fatigue strengthens the work factor for MDS complaints for crane operators at PT Terminal Petikemas Belawan. And for every increase in crane operator fatigue, it will increase the effectiveness of work posture by 0.194 and vibration (whole body vibration) by 0.306 on MDS complaints. Fatigue contributed to the prediction of worker self-reported disability, even when controlling for pain severity and depression. The findings suggest that fatigue is functionally different from pain severity and depression in terms of its impact on work disability (Yamada et al., 2020). The results of the study are in line with the research of Yamin et al. (2020) found a higher work fatigue score with lower performance and a moderate level correlation value of 0.286 and a significant p=0.003<0.05, which means there is a correlation between fatigue and performance on complaints MSD. The results showed that fatigue symptoms correlated significantly with the severity of pain symptoms of MSD and depression.

Based on the results of the MRA analysis, shows that work posture and vibration (whole body vibration) interact with smoking behavior giving coefficient values of 0.131 and 0.330, significant at 0.021 and 0.001, that smoking behavior is a pure moderator. This shows that smoking behavior strengthens the work factor for MSD complaints in crane operators at PT Terminal Petikemas Belawan. And for every increase in smoking behavior on the crane operator it will cause an increase in the effect of work posture by 0.131 and vibration (whole body vibration) by 0.330 on MSD complaints. Concerning smoking, workers who smoked in the past but currently do not have smoking behavior are 1.56 times more likely to experience neck MSD (OR: 1.56, 95% CI: 0.99–2.46, p= 0.05) compared with never-smokers and exposure to tobacco smoke as a common risk factor for neck pain among the general population and workers (Smith et al., 2020).

In the study of Kumar et al. (2022) vibration exposure to operators in coal mines showing smoking behavior does not have a significant correlation to the variables that contribute to developing MSD pain between the case group 41 (37.3%) and control 30 (27.3%), but the results show that it is based on the coefficient value regression (b) workers are 1.37 times more susceptible to developing MSD in the presence of vibration exposure while working (CI: 0.71 2.63 p=0.345). The results of other studies show that smoking does not have a significant correlation with complaints of musculoskeletal disorders (p=1.000) (Thamrin et al., 2021).

4. CONCLUSION AND SUGGESTION

The results showed that there was a direct correlation between work posture (X1) and whole body vibration (X2) for complaints of MSD with a significant value of 0.001 for X1 and 0.000 for X2. For the value of the regression coefficient (B1) for the work posture variable of 0.264, it means that every work posture with hazardous workplace conditions experienced by workers will increase complaints of MSD in

crane operators by 0.264. Furthermore, the value of the regression coefficient (B2) for the vibration variable (whole body vibration) is 0.440, meaning that every vibration (whole body vibration) felt by workers will increase complaints of MSD in crane operators by 0.440.

Furthermore, the addition of psychosocial variables can be tested in moderation analysis to obtain a comparison of positive or negative effects related to work factors on musculoskeletal disorders experienced by workers.

Conflict of Interest

There is no conflict of interest in this research

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