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Research Article

The Effect of Work Posture and Body Mass Index on Work Productivity through Musculoskeletal Disorders Complaints in Operators

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ABSTRACT

Introduction: Work productivity is the ratio between output, which is the result achieved against input, which is the resources used. Companies need to realise that the workforce as human resources is an important asset that must be maintained. The factors that directly affect work effectiveness and production efficiency are aspects of Occupational Safety and Health (K3). One of the occupational diseases that has a significant impact on productivity is Musculoskeletal Disorders (MSDs).

Objectives: The aims of this study were to analyzed the direct and indirect effects between work posture and body mass index on work productivity through MSDs complaints in operators.

Methods: This type of research is quantitative research with an analytical observational approach using a cross sectional study design conducted in January - February 2025. The total sample in the study was 170 operators consisting of RTG, QCC, RS, and HT operators. Data analysis used SPSS to analyze univariate, bivariate, and multivariate.

Results: The results showed that there was no direct effect between work posture and IMT on work productivity (p = 0.830 and 0.775), there was a direct effect of work posture and IMT on MSDs complaints (p = 0.000), there was a direct effect of MSDs complaints on work productivity (p = 0.009), there was a direct effect of work posture and IMT on work productivity through MSDs complaints (p = 0.009 and 0.042).

Conclusions: The recommendation for the company is to conduct ergonomics training for operators to raise awareness of the importance of good work posture and operators routinely carry out stretching exercises between work hours, conduct periodic BMI checks regularly, implement a regular diet by controlling eating emotions and consuming nutritious foods, and conduct continuous and more accurate ergonomic evaluations from certain parties.

Keywords: Work Posture; Body Mass Index; Work Productivity; MSDs Complaints; Operators.

INTRODUCTION

Productivity is a mental attitude and work ethic that focuses on efforts to continuously improve quality, efficiency, and effectiveness in creating added value in a sustainable manner [1]. Work productivity is the comparison between output, which is the result achieved against input, which is the resources used [2]. In an effort to increase productivity, companies need to realize that the workforce as human resources is an important asset that must be maintained [3]. One of the factors that directly affects work effectiveness and production efficiency is the Occupational Safety and Health (OHS) aspect.

Based on data from the Indonesian Ministry of Manpower [4] in the National K3 Profile in 2022, it is stated that Indonesia has 1,123 cases of occupational diseases. According to Yuliani and Zhafirah [5] one of the occupational diseases that has a significant impact on productivity is Musculoskeletal Disorders (MSDs). Work-related MSDs disorders have become a global health problem affecting billions of people worldwide [6]. MSDs are a series of

complaints felt by workers located in muscles, bones, joints, nerves, and connective tissue [7]. MSDs can arise when muscles are exposed to the same load repeatedly in a monotonous position for a long period of time [8].

Complaints related to musculoskeletal disorders (MSDs) are one of the most common public health problems faced by workers. It is ranked as the second most common occupational disease worldwide. According to data released by the World Health Organization (WHO), approximately 1.71 billion people worldwide experience musculoskeletal disorders [9]. Based on the Health, Safety and Environment (HSE) Report 2023, in the UK it was reported that 473. 000 workers experienced work-related musculoskeletal disorders. As a result, a loss of 6.6 million working days occurred in 2022-2023. This situation makes musculoskeletal problems one of the leading causes of disability worldwide [10].

According to the National Basic Health Research Report released in 2018 by the Ministry of Health of the Republic of Indonesia, the prevalence of musculoskeletal complaints in the country reached 7.3%. Aceh province recorded the highest rate with a prevalence of 13.26%, followed by Bali with 10.46%, Bengkulu with 12.11%, and East Java with 6.72%. At the regional level, South Sulawesi is in fifth position with a percentage of musculoskeletal complaints of 6.39% [11]. In addition, if we refer to the Profile Data at the Makassar City Hajj Hospital for the category of Most Common Diseases (Outpatient) in 2018, it can be seen that low back pain is included in the top ten most common diseases. The data shows that the number of patients experiencing this condition reached 561, which means that there are one to two patients per day who come for treatment [12].

According to Tarwaka [13] in his book, the author explains several factors that can lead to complaints in skeletal muscles that have a direct impact on work productivity. These factors include excessive muscle stretching, repetitive activities, unnatural work attitudes, and secondary factors such as pressure and vibration. In addition, there are also combined causes that include age, gender, smoking habits, physical condition, body strength, and anthropometric aspects. Risks to musculoskeletal disorders (MSDs) can be grouped into three categories, namely work-related factors, individual characteristics, and psychosocial factors [7].

Based on a report from the Centers for Disease Control and Prevention (CDC), it is known that operators, assemblers, laborers, technical workers, and sales and administrative staff accounted for 58% of MSDs cases [14]. This is in line with research conducted by Darabad et al [15] that overhead crane operators face a higher risk of MSDs complaints due to prolonged sitting position in a state of bending forward to monitor the load lifted from the cabin as high as 12 meters above ground level. This study aimed to identify the prevalence of MSDs symptoms and assess body posture during one full work shift in 120 overhead crane operators. The results showed that the highest prevalence of musculoskeletal complaints was detected in the lower back area (85.8%), followed by the neck (75.8%), and knees (68.3%).

The results of a study conducted by Kim [16] explained that the mismatch between height and body size of operators, coupled with non-ergonomic work postures, can contribute to the occurrence of musculoskeletal disorders (MSDs). The results of research conducted by Darvishi et al [17] In a study involving 350 office workers, path analysis showed that individual characteristic factors had both direct and indirect effects on work-related musculoskeletal disorders. Among these factors, body mass index was the one with the strongest relationship with the risk of MSDs.

One of the work sectors that has a high risk of musculoskeletal disorders (MSDs) is the operation of lifting and transporting equipment. In this case, the lifting equipment consists of 31 units of Rubber Tyred Gantry (RTG), 10 units of Quay Container Crane (QCC), and 7 units of Reach Stacker (RS). Meanwhile, the transportation equipment used is 39 units of Head Truck (HT). Based on the information obtained, there are a total of 246 operators of lifting and transporting equipment, of which 147 people work in terminal 1 and 99 people in terminal 2. All operators are male and work for 8 hours per shift.

RTG and QCC operators are often in non-ergonomic working positions. This is due to the need to constantly look down, which makes the back muscles have to bear some of the body's weight. In addition, the neck also plays an important role because during RTG and QCC operations, operators must support the head in a bent position [18]. Furthermore, during machine operations, operators often have to look back when driving backwards. This can increase the risk of neck and lower back pain, as well as muscle contractions, potentially leading to various other

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trauma disorders [19]. HT operators have limited access to perform their duties, especially since they spend long periods of time in a seated position. This situation makes them vulnerable to musculoskeletal disorders [20].

OBJECTIVES

Based on a series of problems related to MSDs risk factors, researchers felt compelled to conduct a study on work posture and Body Mass Index (BMI). In-depth research on the effect of work posture and BMI on work productivity with MSDs as an intervening variable in operators can be an important step in determining appropriate interventions to improve work productivity. The conceptual framework can be seen in the following framework (Figure 1).

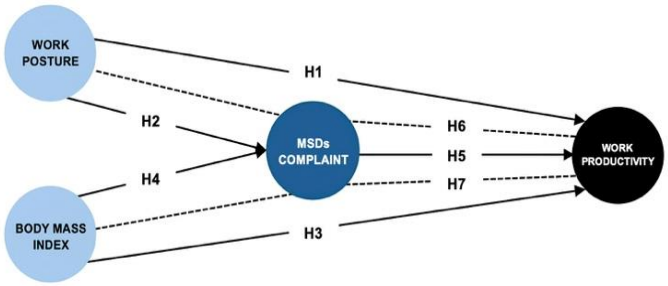

Figure 1. The Research Conceptual Framework

Based on the concept framework, then the general objective of this study is to analyze the effect of work posture and BMI on work productivity through MSDs complaints in operators. Therefore, the hypotheses in this study are as follows:
H1 = The effect of work posture on work productivity in operators.
H2 = The effect of work posture on MSDs complaints in operators.
H3 = The effect of BMI on work productivity in operators.
H4 = The effect of BMI on MSDs complaints in operators.
H5 = The effect of MSDs complaints on work productivity in operators.
H6 = The effect of work posture on work productivity through MSDs complaints in operators.
H7 = The effect of BMI on work productivity through MSDs complaints in operators.

METHODS

This type of research is quantitative research with an analytic observational approach using a cross sectional study design. This design aims to examine the dynamics of the relationship between work posture and Body Mass Index (BMI) as independent variables and work productivity as the dependent variable. In addition, this study also considered musculoskeletal complaints (MSDs) as an intervening variable affecting operators. This research was conducted in January - February 2025.

3.1. Participants

Population is the whole subject that is the focus of research and has certain characteristics. In this study, the intended population is the operators who totaled 246 people. The sample is part of the population that is considered to represent the entire population. To determine a representative sample size, we can use the Slovin Formula. This formula helps in getting a sample that is more accurate and closer to the actual characteristics of the population. The details of the number of operators consist of 92 RTG operators, 10 CC operators, 17 RS operators, and 127 HT operators.

3.2. Data

In this study, primary data was collected through observation using a Rapid Entire Body Assessment (REBA) sheet to assess the operator's work posture. In addition, interviews were conducted to collect information regarding the characteristics of respondents, Body Mass Index (BMI), as well as filling out the Nordic Body Map (NBM) questionnaire. Secondary data is data obtained indirectly through various sources of literature relevant to the research, such as reports, profiles, guidebooks, journals, theses, as well as data from companies and other sources.

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3.3. Statistical Analysis

Data analysis is carried out using statistical tests on the SPSS program using multivariate analysis. Multivariate analysis is carried out to understand the effect of two variables by controlling other variables, as well as measuring the extent of the effect of these variables. This process is carried out using the SPSS application or software. In multivariate analysis, the test used is path analysis.

RESULTS

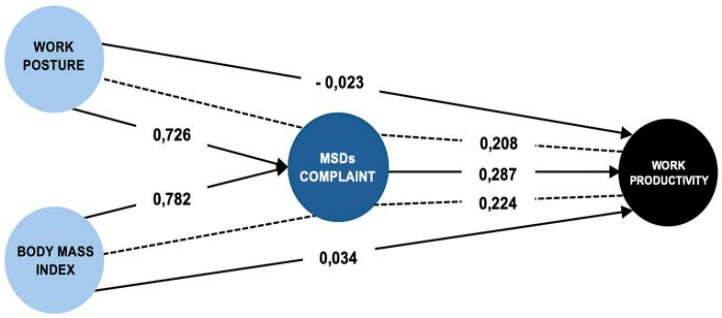

Figure 2. The Results of Path Analysis of Research Variables

Table 1. The Direct Effect

Hypothesis	Variables	Direct Effect		
		P value	**Estimate**	**Conclusion**
H1	Work Posture ⟶ Work Productivity	0,830	-0,023	Not significant
H2	Work Posture ⟶ MSDs Complaints	0,000	0,726	Significant
H3	BMI ⟶ Work Productivity	0,775	0,034	Not significant
H4	IMT ⟶ MSDs Complaints	0,000	0,782	Significant
H5	MSDs Complaints ⟶ Work Productivity	0,009	0,287	Significant

Table 1 shows that there is no direct effect of work posture and BMI on work productivity with p-values of 0.830 and 0.775, respectively. However, there is a direct effect between work posture and BMI on MSDs complaints with a p-value of 0.000, as well as a direct effect of MSDs complaints on work productivity with a p-value of 0.009.

Table 2. The Indirect Effect

Hypothesis	Variables	The Indirect Effect		
		P value	***Indirect Effect***	***Total Effect***
H6	Work Posture ⟶ MSDs Complaints ⟶ Work Productivity	0,009	0,208	0,185
H7	IMT ⟶ MSDs Complaints ⟶ Work Productivity	0,042	0,224	0,258

Table 2 shows that the analysis of the indirect effect of work posture on work productivity through MSDs complaints can be seen by multiplying the estimated value of the direct effect of the variables on H2 and H5 (0.726 x 0.287 = 0.208). These results show that the direct effect (-0.023) < indirect effect (0.208), so it can be said that the indirect effect of the work posture variable through MSDs complaints is greater than the direct effect of work posture on work productivity, so the actual effect is indirect. In addition, to see the indirect effect of BMI on work productivity through MSDs complaints, it can be seen by multiplying the estimated value of the direct effect of the variable on H4 and H5 (0.782 x 0.287 = 0.224). These results show that the direct effect value (0.034) is less than the indirect effect (0.224), so it can be said that the indirect effect of the BMI variable through MSDs complaints is greater than the direct effect of BMI on work productivity, so the actual effect is indirect.

As for determining whether the relationship involving a mediating variable significantly acts as a mediator in the relationship, testing can be done using the Sobel Test using the Sobel calculator. The results of the Sobel Test on the

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work posture variable show a z-value of 2.58 > 1.96 (absolute z) or it can be interpreted that the MSDs complaint variable as an intervening variable can mediate the work posture variable on work productivity. Similarly, the Sobel Test results on the BMI variable show a z-value of 2.02 > 1.96 (absolute z) or it can also be interpreted that the MSDs variable as an intervening variable can mediate the BMI variable on work productivity.

DISCUSSION

4.1. The Direct Effect of Work Posture on Work Productivity

Based on the results of multivariate analysis on the direct effect of work posture on work productivity, the p value obtained is 0.830 (p> 0.05), this means that H0 is accepted and Ha is rejected. Based on the analysis conducted, it can be concluded that there is no direct effect between work posture and work productivity in operators. The value of the effect of work posture on work productivity was recorded at -0.023, which indicates that the relationship between the two is negative.

This happens because based on the researcher's assumption from direct observation, the operator's work productivity is highly dependent on the volume of loading and unloading of ships that must be served at any given time. Container loading and unloading activities are quite heavy, considering that operators are required to operate their work tools for 8 hours per shift with limited rest time in a static position, namely sitting. In addition, container ships must leave the port immediately, so the container loading and unloading process must be done quickly.

This is in line with the argument put forward by Laksana and Srisantyorini [21], namely that if customer demand increases, in this case consumers, the demand for services and goods will become the background for the need to accelerate the production process. In this case, the operator will override the work posture formed while operating the tool in order to complete the production target. In addition, the operator also feels that the work he is currently doing has added to his skills, so the production process continues as it should.

However, the results of this study are not in line with research conducted by Wang et al [22] The study showed that changes in work posture, especially from sitting to sitting-standing, can increase productivity by up to 6.5%. This difference in results may be influenced by the context of the study, the method of measuring productivity, or the characteristics of the respondents involved. In the study, switching to a dynamic work posture (sit-stand) can provide variety in movement, potentially reducing muscle fatigue as well as improving blood circulation, thus having a positive impact on productivity levels.

Furthermore, the findings from Putri, Jayanti and Kurniawan [23] the impact of static work postures on the body provides a physiological understanding that explains why non-ergonomic work postures can cause health problems, such as muscle pain caused by lactic acid buildup. Although this study shows that work posture does not directly affect productivity, the long-term effects of poor posture can result in a decrease in the quality of workers' health, which in turn can negatively impact productivity indirectly.

Referring to the operators' arguments during the field interviews, one of the important factors contributing to increased productivity is tenure. Longer tenure increases experience and skills in meeting the demands of their job. Therefore, the longer a person works, the higher productivity they can achieve [24]. Therefore, although the statistical analysis did not find a direct effect, it is very important to still consider the application of ergonomic work postures as part of efforts to maintain the health and welfare of workers.

Overall, these findings emphasize the importance of a holistic approach in improving work productivity. Work posture is just one of the various factors that need to be considered. Further research can be conducted to explore how work posture interacts with work productivity, including aspects such as tenure, rest periods and job demands. In addition, it is important to consider the specific context of each work environment as factors affecting productivity may vary depending on the type of work and the characteristics of the workers.

4.2. The Direct Effect of Work Posture on MSDs Complaints

Based on the results of multivariate analysis of the direct effect of work posture on MSDs complaints, the p value obtained is 0.000 (p < 0.05), this means that H0 is rejected and Ha is accepted. So it can be concluded that there is a direct effect of work posture on MSDs complaints in operators the value of the effect of work posture on work productivity is 0.726. This shows that the direction of the relationship between work posture and MSDs has a positive direction of 72.6%.

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The results of this study are in line with several studies, such as research conducted by Sani and Widajati [25] the factor causing MSDs that has the strongest relationship is unergonomic work posture, with an r value of 0.632. This shows that the more unergonomic a work posture is, the higher the risk of workers experiencing complaints related to MSDs. Another study conducted by Djaali, Prahastuti and Zen [26] showed a similar thing where the results of the Logistic Regression Test obtained an OR value of 4.419, which means that workers with risky ergonomics will have a 4.419 times greater chance of developing MSDs compared to workers with non-risky ergonomics.

However, the results of this study are not in line with several studies such as, research conducted by Botto, Doda and Ratag [27] entitled "Relationship between Work Posture and Musculoskeletal Complaints in Laborers at Manado Port" This study shows that there is no significant relationship between work posture and musculoskeletal complaints in loading and unloading workers at Manado Port. This is due to the existence of various other factors that can affect MSDs complaints, apart from the work posture itself. In addition, research conducted by Dahlan, Nengsih and Setiawan [28] revealed that the results of statistical tests using the Chi Square Test showed no relationship between unnatural work postures and MSDs complaints with a significance level of p 0.559 (p> 0.05).

Based on observations in the field, lift and transport operators often carry out their tasks in a sitting position. Although sitting is considered a stable working position because it can reduce the load on the legs, this posture is actually prone to musculoskeletal complaints. The sitting position can cause the abdominal muscles to become weak and the spine tends to curve, which if habituated can cause workers to feel muscle fatigue [29]. This is in line with the theory expressed by that sitting for too long is one of the activities that is often reported as a low risk category for pain in the back area [30].

Research revealed by Kharat and Bhandare [31] confirmed that prolonged sitting time will affect workers, ranging from fatigue, blood pressure above 140/90 mm/Hg, to MSDs complaints in the shoulders, lower back, thighs, and knee areas. In addition, ergonomic posture will increase comfort for workers, improve concentration, and benefit health, especially in the back area, so it is highly recommended for workers to change their work posture.

When workers carry out work activities in an unergonomic sitting position, asymmetrical loads on the spinal structures may arise due to improper tensile and compressive forces [32]. If an operator maintains a static working posture, blood flow will be obstructed, resulting in that area of the body being deprived of oxygen and glucose supply. As a result, the body will undergo anaerobic oxidation, which produces metabolic waste in the form of lactic acid. This process can eventually cause pain in the muscles [23].

In line with this, the etiological factors involved in MSDs were first identified in the early 18th century by an Italian doctor known as the father of occupational medicine, namely Bernardino Ramazzini (1633-1714), Ramazzini linked occupational factors and clinical conditions that he was handling at that time. In his important work entitled "De Morbis Artificum Diatriaba", Ramazzini wrote, "I attribute it to certain violent and irregular movements and unnatural postures, so that the natural structure of the machinery of life is greatly disturbed and causes serious diseases to gradually develop from it [33].

Based on the previous discussion, the results of this study prove the theory that one of the risk factors associated with the appearance of MSDs complaints is work posture [34]. The more unergonomic the work posture, the greater the risk of MSDs complaints. Therefore, simple interventions are needed, such as stretching exercises. This activity can be done independently in between work hours. While stretching exercises are not the ultimate solution, they can be a beneficial routine if scheduled as part of a break [35].

4.3. The Direct Effect of BMI on Work Productivity

Based on multivariate analysis of the direct effect of BMI on work productivity and the p value obtained is 0.775 (p> 0.05), this means that H0 is accepted and Ha is rejected. So it can be concluded that there is no direct effect of BMI on work productivity in operators The value of the effect of BMI on work productivity is 0.034. This shows that the direction of the relationship between BMI and work productivity has a positive direction but only by 3.4%.

This study is in line with the results of research by Ilmi, Marji and Ekawati [36] who found evidence that the IMT variable with the work productivity variable obtained a significance result of 0.857 for the normal IMT category and 0.708 for obese IMT. This indicates that there is no significant relationship between the IMT variable and work productivity. In line with this, research proposed by Tona, Russeng and Amqam [37] found the fact that there was no direct effect between IMT and work productivity with a significance level of p value = 0.481.

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However, these results are not in line with research conducted by Maedah et al [38] entitled "*Nutritional Status, Breakfast Habits, with* The *Work Productivity of Jakarta Startup Employees*" where the study showed that the nutritional status variable (IMT) on work productivity obtained a *p* value = 0.005 which can be interpreted that nutritional status (IMT) is related to the work productivity of *startup* employees. In addition, the OR value of the IMT variable is 8.007 which means that abnormal nutritional status is 8 times more likely to cause workers to be unproductive compared to employees with normal nutritional status.

In theory, one of the risk factors that affect work productivity is the nutritional status of workers, known as BMI. Work nutrition is one way to achieve optimal health status. Excess or deficient nutritional conditions will affect health conditions and ability to work which have an impact on work *output*, namely labor productivity. This is because workers with abnormal BMI, especially in the case of high BMI, cannot work dexterously because the weight they support will be affected. For this reason, when the company wants to optimize its productivity, it has human resources with good occupational health and nutritional status as well [38].

According to Dimkatni [39] low productivity due to abnormal nutritional status is caused by the amount of energy obtained from daily food. If a company wants to optimize its work productivity, it must ensure the health of its workers. One way is to implement work nutrition management. Work nutrition management is part of the occupational health aspect that focuses on nutritional needs in the work environment in order to fulfill the nutritional status of workers who contribute to work productivity. The way this is done is by calculating nutritional needs, procuring healthy food, surveillance of worker nutrition, and monitoring and evaluating the nutritional status of workers in the work environment.

However, the results of this study describe that focusing solely on the Body Mass Index (BMI) indicator may not be sufficient to provide a complete picture of work productivity. As such, these findings suggest that BMI is not the sole factor determining work productivity. It is important to consider other contexts, such as other enabling factors when analyzing the effect between BMI and work productivity. A holistic approach is needed to include evaluation of various dimensions of health, such as diet, sleep habits, physical activity levels, nutrition management, lifestyle, and other factors that theoretically affect individual performance. In addition, the work environment also plays a crucial role. This includes organizational support, workload, workplace ergonomics, and the availability of health and welfare facilities for workers.

4.4. The Direct Effect of BMI on MSDs Complaints

Based on the results of multivariate analysis of the direct effect of IMT on MSDs complaints and the *p value* obtained is 0.000 ($p < 0.05$), this means that H_o is rejected and H_a is accepted. So it can be concluded that there is an effect of IMT on MSDs complaints in operators The value of the effect of IMT on MSDs is 0.782. This shows that the direction of the relationship between BMI and MSDs complaints has a positive direction of 78.2%.

This research is in line with several studies, such as research conducted by Laksana and Srisantyorini [21] which shows that there is a significant relationship between BMI and MSDs with $p = 0.023$ ($p < 0.05$) in manufacturing welding operators at PT X in 2019. Other relevant research was also revealed by Cheisario and Wahyuningsih [40] getting an OR value of 0.536 which can be interpreted that respondents with abnormal IMT have a 0.5-fold risk of experiencing MSDs complaints compared to workers with IMT not at risk.

Although in theory IMT is one of the risk factors for MSDs, the results of research by Umima and Utami [41] (2022) show that there is no relationship between IMT and MSDs complaints with a *p* value = 0.789 (*p* value> 0.05). Similarly, research conducted by Rika and Dwiyanti [42] on RTG operators using the Spearman Correlation Test where the *p* value = 0.585 (p> 0.05), so it can be interpreted that there is no significant relationship between BMI and MSDs complaints and the relationship formed is very weak and unidirectional, This discrepancy can occur due to other factors that are not measured in the study.

According to Ayunindya et al [43] the higher or abnormal a person's BMI, the greater the likelihood of experiencing MSDs complaints. Abnormal BMI, be it in the *underweight*, *overweight*, or obese category can affect body balance, posture while working, and load distribution during activities. This in turn increases the risk of muscle strain and *musculoskeletal* disorders. Therefore, this factor becomes very important to consider in the work environment, especially for operators who perform repetitive physical tasks for a long time.

BMI is a determining point whether a person will experience the risk of suffering from complaints to certain diseases. This is because BMI is closely related to the health condition of workers. When having a large BMI, it tends to affect

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the endurance of the worker's body which can lead to complaints [39]. In the case of operators, they work in a *shift* situation, so that meal times will adjust to operational hours. The researcher's assumption is that this can cause erratic meal times for operators. This behavior will indirectly affect the operator's diet. For this reason, controlling diet and doing activities is believed to control the body to remain ideal [44].

In line with the results of the Basic Health Research in 2018, it was found that the physical activity of the Indonesian people was still classified as having sufficient physical activity 66.5%, while the remaining 35.5% were classified as lacking [45]. Therefore, to reduce the prevalence of obesity among workers is to implement a balanced physical activity pattern. We can create a balance between incoming and outgoing energy through physical activity. Activities such as exercising can play a role in controlling the energy intake we consume [46]. Research conducted by Iriandi, Baruna and Tarmiah [47] draws the conclusion that there are benefits from counseling activities and *exercise* education training, especially before and after activities to reduce MSDs complaints.

Physical activity that can be done is by doing B-Fit exercises. B-Fit exercise is an exercise that is done while sitting on a chair. This exercise is in accordance with the working conditions of RTG and QCC operators in a wider cabin compared to RS and HT operators. Meanwhile, RS and HT operators can stretch between work hours. There are several benefits of B-Fit Gymnastics related to BMI and MSDs, namely increasing energy, preventing disease (obesity), reducing stress, and increasing focus so that it is more productive [48].

4.5. The Direct Effect of MSDs Complaints on Work Productivity

Based on the results of multivariate analysis of the direct effect of MSDs complaints on work productivity and the *p value* obtained is 0.009 ($p < 0.05$), this means that H_0 is rejected and H_a is accepted. So it can be concluded that there is a direct effect of MSDs on work productivity in operators. The value of the effect of MSDs complaints on work productivity is 0.287. This shows that the direction of the relationship between MSDs complaints and work productivity has a positive direction but only 28.7%.

The results of this study are in line with research conducted by Albeeli et al [49] which shows the results that there is a significant relationship between the prevalence of MSDs with productivity characterized by loss of working days with a *p value of* 0.001. The body parts that are often complained about are the back (58.5%), shoulders (48.5%), and neck (43.0%).

MSDs are considered as one of the costly occupational disorders due to their impact on workers' health and productivity in the workplace [50]. MSDs complaints have implications for decreased work productivity, increased *absenteeism*, and company losses [51]. The effect of MSDs will significantly limit the movement and dexterity of workers, thereby reducing the quality of life and health [52].

Based on the findings in the field, almost all operators claimed to experience complaints on several parts of their body, both during work and shortly after. Frequently complained about areas categorized as "Somewhat Sore" include the upper neck, pelvis, right elbow, left wrist, right wrist, and right hand. Meanwhile, for the "Pain" category, the most common complaints appear in the lower neck, back, right upper arm, waist, and buttocks. The presence of MSDs complaints can be a major cause of loss of worker productivity because it can cause functional damage, reduce the ability and willingness to work until retirement [53].

MSDs disorders have been given many names over the years that describe the nature of these disorders, such as musculoskeletal disorder, musculoskeletal injury, overuse injury, repetitive strain injury, repetitive motion injury, cumulative trauma disorder, overuse syndrome, soft tissue disorder, and occupational overuse syndrome. MSDs complaints affect muscles, nerves, blood vessels, ligaments and tendons. Workers in various industries can be exposed to risk factors arising in the workplace, such as lifting, bending, reaching, pushing, pulling, working in non-ergonomic posture conditions, and performing repetitive motions [33].

In preventing the onset of MSDs complaints, it adopts the experimental method in research conducted by Pristianto et al [54] where this study shows that implementing the program will be effective in reducing the risk of MSDs complaints and relieve the level of pain experienced. The method applied includes providing information through simulation of *stretching* movements and fitting postures in accordance with the training. In addition, workers also followed a comprehensive physiotherapy program, which included exercise techniques, therapy, and education on ergonomic work postures. The program was monitored for two weeks to evaluate the workers' improved understanding of good work postures in addressing their pain.

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Therefore, further research is needed that can integrate various risk factors to provide a more comprehensive understanding of the causes of MSDs complaints in workers in various industrial sectors. A multidisciplinary approach involving ergonomics, occupational health, industrial psychology, and work environment engineering will be very helpful in formulating more effective prevention strategies, so as to reduce the incidence of MSDs and improve the welfare of workers.

4.6. The Indirect Effect of Work Posture on Work Productivity through MSDs Complaints

In this study, work posture describes the position of the operator's body while performing tasks, focusing on the back, neck, arms, and legs measured using the REBA method. Work posture is an important aspect in analyzing the effectiveness of a job. If the work posture applied by the operator is good and meets ergonomic criteria, the results obtained will also be satisfactory. Conversely, if the work posture is not ergonomic, this will have a negative impact on the operator's work productivity.
Based on the results of the statistical path analysis test, it is found that there is an indirect effect of work posture on work productivity through MSDs. The Sobel Test results show a z-value of 2.58> 1.96 (absolute z) or it can be interpreted that the MSDs variable as an *intervening* variable can mediate the work posture variable on work productivity. The *p value* obtained is $p = 0.019$ ($p < 0.05$), this means that H_0 is rejected and H_a is accepted. So it can be concluded that there is an indirect effect of work posture on work productivity through MSDs as an *intervening* variable in operators.

This research is in line with several studies, such as those conducted by Mayasari et al [51] which revealed that the results of statistical tests showed *p value* = 0.000 ($p < 0.05$), so it can be interpreted that there is an indirect effect between work postures on performance through MSDs in midwives at RSUD H. Jusuf SK Indonesia. This is evident from observations at the hospital where midwives perform their duties with many variations, such as bending, twisting, lifting, and moving continuously.

However, these findings are not in line with research conducted by Lisulangi et al [55] where *musculoskeletal* disorders as *intervening* variables do not have a significant effect on the relationship between work posture and nurse performance at Hermina Hospital Makassar. The *musculoskeletal* disorder variable received a value of 0.588 (p> 0.05) which indicates that the effect is not strong enough to be concluded as significant. This insignificant effect may be caused by other factors that are more dominant in influencing performance.

Based on observations in the field, the work posture taken by the operator when operating his work tool looks non-ergonomic. This causes workers to experience discomfort in some parts of their body, which has the potential to interfere with work productivity. Researchers found that RTG and QCC operators work above the height in the cabin for about 8 hours. During working hours, operators are in a bent position with their heads facing downwards to see the container to be lifted. Their hands move to operate levers and buttons to control the lifting machines, while the bent legs and twisted wrists further aggravate the situation. As a result of these work postures, many operators often complain of pain in the neck, back and waist areas.

Furthermore, both RS and HT operators have a similar seated work posture when driving a car, where their workstation is confined and in a static state. In this position, the hands hold the steering wheel while the feet are on the gas and brake pedals. Some of the areas that RS and HT operators often complain about are the right upper arm, waist and buttocks. When operators constantly maintain this static work posture without the opportunity to relax, these complaints can accumulate, trigger pain, and eventually negatively impact their work productivity.

Looking at the work postures produced by the workers, it can be concluded that most of them require the implementation of significant corrections, including adjustments to the equipment and workspace [56]. One example of work equipment adjustments is the introduction of adjustable seat cushions on QCC and RTG operator chairs that are often used in a slouched position while working. This solution not only improves comfort for operators, but also reduces the risk of *musculoskeletal* injuries (MSDs). In addition, these adjustments have the potential to improve the company's operational efficiency in the future which will ultimately support employee engagement and productivity over a longer period of time.

Work posture is a risk factor that greatly influences the onset of MSDs complaints. This is because prolonged non-ergonomic work postures will cause pain [57]. In line with that, the current work system presents a challenge in evaluating work postures that can cause MSDs [58]. Furthermore, MSDs complaints can have an impact on decreased work productivity. This is because workers who feel complaints will find it difficult to perform tasks and workloads efficiently because they experience delays in completion [59].

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The solution offered in the research conducted by Esmaelli et al [60] found the fact that the right intervention in overcoming unergonomic work postures is to redesign work stations, such as providing ergonomic chairs according to the dimensions of the user's body. In addition, interventions carried out in the study Waongenngarm et al [61] revealed that active rest between work hours can minimize the onset of neck and lower back pain by 55% and 66%, so it can be concluded that active rest is effective in reducing pain and discomfort felt during work.

This finding confirms the importance of applying ergonomic principles in the work environment. In other words, *musculoskeletal* complaints (MSDs) serve as a bridge between work posture and productivity. Physiologically, non-ergonomic postures can cause muscle tension, fatigue, and pain in various parts of the body. This discomfort can in turn reduce work effectiveness, slow down operational pace, and increase the potential for errors. Over time, these conditions can have a significant impact on reducing worker productivity.

4.7. The Indirect Effect of BMI on Work Productivity through MSDs Complaints

Work productivity can be influenced by various things, such as the nutritional status of the workforce which is described in the form of IMT [38]. BMI is body weight in kilograms (kg) divided by the square of height (kg/m²). The measuring instruments used are microtoise and weight scales. The abnormal BMI category is respondents with *underweight* (< 18.5 kg/m²), *overweight* (> 23.0 kg/m(²), and obesity (> 25 kg/m(²). Meanwhile, Normal BMI is workers with BMI results (18.5 - 22.5 kg/m²).

Based on the results of the statistical path analysis test, it was found that there is an indirect effect of IMT on work productivity through MSDs complaints. The Sobel Test results show a *z-value* of 2.02> 1.96 (absolute z) or it can be interpreted that the MSDs variable as an intervening variable can mediate the IMT variable on work productivity. The p value obtained is 0.042 ($p < 0.05$), this means that H_o is rejected and H_a is accepted. So it can be concluded that there is an effect of IMT on work productivity through MSDs complaints as an *intervening* variable in operators.

This research is relevant to the findings of Nugraha et al [62] the direction of the relationship between BMI and MSDs complaints shows a positive influence. This means that when BMI increases, MSDs complaints experienced by librarians at Airlangga University also tend to increase. This phenomenon can be explained by body weight and height that are not ideal or exceed normal limits, which indicates that the burden on the body has exceeded its carrying *capacity*. This certainly increases the risk of experiencing *musculoskeletal* problems. In addition, the findings in this study are in line with previous research conducted by Tona, Russeng and Amqam [37] showing a direct effect between BMI and work productivity through *Low Back Pain* (LBP) with a significance level of *p value* of 0.000.

Nutritional status is closely related to productivity. The nutritional status described in BMI can consist of two, namely abnormal and normal BMI. Abnormal BMI is a nutritional status with excess or lack of body weight. In workers with abnormal BMI, it is very likely to experience MSDs complaints. This is because abnormal BMI, especially overweight, can damage the body structure which triggers pain and tension in the joint and muscle areas. Meanwhile, workers with BMI underweight cause reduced mechanical loads and hormone production in the body, thus triggering new bone formation which can interfere with bone mass defense [63].

Field observations showed that out of 170 operators, 70 operators or 41% of them were obese. This obesity condition can affect their ability to perform daily tasks. While there is no specific theory that explains these limitations, there are some challenges that obese individuals may face in the workplace. For example, they may struggle in jobs that require additional physical demands, working in confined areas, using ladders or *platforms* at heights, as well as performing tasks that hold great responsibility [64].
Being overweight can limit a worker's range of motion, as the increased weight puts additional strain on the body. This can cause unstable pressure on the spine [65]. The theory put forward by Tarwaka [13] reveals that nutritional status, including weight, height, and body mass play an important role in the emergence of certain diseases related to work productivity, such as MSDs complaints.

To minimize the risk of *musculoskeletal* complaints caused by BMI, it is important for operators to adopt a healthy lifestyle. Operators who have a normal nutritional status are expected to maintain their health, so that they can achieve optimal work productivity. On the other hand, for operators with poor nutritional status, it is highly recommended to organize and maintain food consumption in accordance with the body's nutritional needs, in order to achieve normal nutritional status and improve their work productivity.

These findings suggest that physical health factors, especially those related to nutritional status and the risk of muscle or joint injury, have a very important role in creating work productivity. Therefore, managing workers' health including maintaining a balanced BMI and making efforts to prevent *musculoskeletal* disorders is a crucial aspect to increase productivity in the work environment. One of the simplest ways that can be applied is by providing education about healthy lifestyles to workers [66].

Interventions in the form of nutrition and health education, meal replacements, supplements, and physical activity can have a significant effect on improving anthropometric indices, such as reducing BMI, body fat, arm circumference, thigh circumference, calf circumference, mid-arm circumference, biochemistry, and reducing pain intensity. Another intervention that can be done is the provision of food portions with controlled calories, making it suitable to be applied to overweight workers in controlling calorie intake [67].

In addition, research proposed by Busono, Herpandika and Pratama [68] revealed that physical activity is a key factor affecting workers' BMI. This is supported by research revealed by Viswanatha and Adiatmika [69] where exercise habits will greatly affect the level of physical fitness because exercise is a structured, planned, and repeated body movement as an effort to improve physical fitness. If workers experience *musculoskeletal* complaints, it is due to decreased muscle flexibility. Thus, exercise can effectively reduce work-related skeletal muscle disorders and simultaneously improve quality of life [70].

CONCLUSIONS

Based on the results of the above research, it can be concluded that there is no direct effect between work posture and IMT on work productivity (p = 0.830 and 0.775), there is a direct effect of work posture and IMT on MSDs complaints (p = 0.000), there is a direct effect of MSDs complaints on work productivity (p = 0.009), there is a direct effect of work posture and IMT on work productivity through MSDs complaints (p = 0.009 and 0.042). Suggestions for companies are to conduct ergonomics training for operators to foster awareness of the importance of good work postures and operators routinely carry out stretching exercises between work hours, conduct periodic BMI checks regularly, implement a regular diet by controlling eating emotions and consuming nutritious foods, and conduct continuous and more accurate ergonomic evaluations from certain parties.

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