The work-related musculoskeletal disorders

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The Work-related Musculoskeletal Disorders (WMSDs) Symptoms on the Worker Exposed to Hand-Arm Vibration (HAV) of An Impact Wrench and A Demolition Hammer

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Abstract. The spun pile manufacture process was carried out in several stages, including the product's setting, stressing, and demoulding using an impact wrench and a demolition hammer as vibration tools. The WMSDs initiated by the excessive HAV produced the nerves, muscles, and supporting structures disorders. This research aimed to identify WMSDs complaints about workers exposed to hand-arm vibration and examined the relationship between WMSD complaints and the vibration intensity, age, and length of work of a person using the Chi-Square statistical test. This research found a significant relationship between age and complaints of WMSDs in the Hand/Wrist of 0.034, while the relationship between age and complaints of WMSDs in the low back was 0.035 because of the decreased bone and nerve function in the back with age. There was also a significant relationship between HAV and complaints of HAVS, with the p-value being 0.01. Meanwhile, the length of work did not have a significant relationship with the presence of WMSDs complaints. Whereas in the WMSDs complaint in the form of HAV, there was a significant relationship with Arm Vibration due to mechanical vibrations that attack the nervous system in the hands and arms of workers.

INTRODUCTION

The production process in the concrete manufacturing industry has several stages to produce products that provide quality standards. One of the most ordered products is the spun pile. The spun pile production process includes opening the product using an assistive tool in the form of an impact wrench machine and a demolition hammer. The impact wrench machine generates 3800-6300 rpm, while the demolition hammer's finishing process produces 3000-5000 rpm. Consequently, mechanical vibrations occur to initiate excessive vibrations that impact the surrounding environment, especially for humans [1], such as hand and arms syndrome [2].

Work-Related Musculoskeletal Disorder (WMSDs) is a symptom of musculoskeletal disorders (MSDs) that is caused by the work environment and certain job performance, which can affect the nerves, muscles, and supporting structures of the body [3]. WMSDs complaints, including pain, numbness, tingling, swelling, stiffness, shaking, sleep disturbances, and burning sensation, appeared in the exposed body part [4], generally in the upper and lower extremities of the human body[5]. Common upper limbs (upper-limb disorder) are the shoulders, elbows, wrists, and hands.

Utilization of the upper limb is carried out by the impact wrench and demolition hammer operator by lifting the machine while operating. Based on Luttman's research in the World Health Organization (WHO) journal, it is stated that intensive weight lifting can cause upper-limb disorder [6]. Measurements related to the intensity of vibration exposure to workers at several stages of the spun pile production process are needed to determine the magnitude of the risk of vibration intensity with symptoms of WMSDs. Dimi *et al*. [7], in their research on the relationship of vibration intensity with MSDs complaints on paving blockwork, found that there was a significant

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Relationship between age, years of work, exercise habits, and work attitudes with MSDs.Based on that research, it was not found that there was a relationship between vibration and MSDS. Research by Hagberg[8]shows a relationship between jobs that use vibration-generating machines and MSDs, which are at high risk of experiencing musculoskeletal disorders. However, the scientific evidence that vibration itself is a risk factor for musculoskeletal disorders is weak despite strong evidence that work tasks with vibrating machines are associated with musculoskeletal disorders.

This study aims to determine the relationship between workers' WMSD complaints and the variable intensity of exposure to hand and arm vibrations, age, and length of service for the impact wrench operator and demolition hammer needs to be done to determine the presence of WMSDs complaints. This research uses the Standardized Nordic Questionnaire (SNQ) to assess the level of musculoskeletal complaints of workers exposed to Hand and Arm Vibration.

THE MATERIALS AND METHOD

The type of research carried out was in the form of research analytic observational. The analytic observational study design would be carried out using a cross-sectional study. All eligible members at the time of the study are taken as sample members without considering their exposure status or disease. Research related to complaints about the intensity of exposure to hand and arm vibration uses the Modified Standardized Nordic Questionnaire, which refers to the research of The Standardized Nordic Questionnaire Applied to Worker Exposed to Hand-Arm Vibration by Kaewboonchoo *et al*. [9], which was modified according to concrete manufacturing industry workers.

The Steps of Research

The stages that will be carried out in this study were depicted in Figure 1.

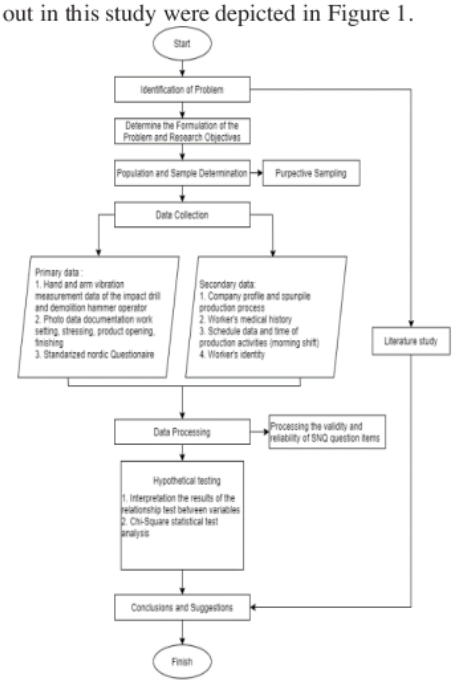

FIGURE 1. The Flowchart of Research

Determination of the Population and Sample Size

Purposive sampling was a sampling technique following research needs. This research took a population of workers at impact wrench machine operators who operated in the setting, stressing and opening of products, and demolition hammer machine operators operating in the finishing section with a total population of 27 people

working on spun pile products in concrete manufacturing companies. The samples of this study were impacted wrench machine operator workers who operated in the setting (6 people), stressing (9 people), and product opening (9 people), and demolition hammer machine operators (3 people) who operate in the finishing section.

Data Collection

The intensity of Hand-Arm Vibration was conducted using Human Vibration Meter, especially in the HVM 100 that was calibrated before being operated. The hand and arm vibration intensity was measured using a hand and arm vibration meter that adhered to SNI 7054-2019. The workers were exposed to hand-arm vibration, filling out the Modified Standardized Nordic Questionnaire.

The Modified Standardized Nordic Questionnaire (MSNQ) was modified to fit the needs of the concrete manufacturing industry in this study, which was referred to Kaewboonchoo *et al*. [9]. The MSNQ was employed to determine The WMSDs complaints by interviewing the respondents. The process of collecting MSNQ data was carried out on the same day with alternating times for each group of workers. To facilitate the process of filling in MSNQ, MSNQ was also provided as an example for workers who did not understand the procedures for filling in MSNQ. The results of the MSNQ are then recapitulated based on the complaint indicators that are on the MSNQ. Based on Kaewboonchoo *et al*. [9], complaint indicators are divided into 11 complaints of WMSDs on the human body. These indicators include HAVS, complaints of White Finger Syndrome, and complaints in 9 major parts of the human body. Recapitulation of data from field observations can be seen in this study containing the answers in the category of no complaints and no complaints based on research by Kaewboonchoo *et al*. [9]. The study poses three main questions regarding the complaints of WMSDs. The third question contains complaints of Hand Arm Vibration Syndrome according to the symptoms experienced by workers. The fourth question number contains complaints of White Finger Syndrome, which are described according to the physical appearance of the research subject. Question number five lists the nine main parts of the body that can experience musculoskeletal disorders.

The Definition of Operational Variables

The variables' operational definitions were shown in Table 1.

TABLE 1. Variable Operational Definitions

No	Variables	Conceptual definition	The Measurement Method and Data Classification	Data Scale	Ref
1	Age	From birth through the period of study, the number of years of life Questionnaires Interview	a. Late Adolescence (12 – 25 years old) b. Adult (26-45 years old)	Ordinal	[10]
2	The duration of the service tenure	The number of years the worker has been worked	Questionnaires interview a. Latest (<3 years) b. Old (>3 years)	Ordinal	[7]
3	Mechanical Vibration Intensity in the Hand and Arm	Vibration exposure in the hand and arm region (meters per second^2)	Vibration Meter a. High (≥5 m/s^2) b. Low (≤5 m/s^2)	Ordinal	[11]
4	Work-Related Musculos keletal Disorder Complaints	Pain, tenderness, tingling, and numbness in the skeletal area are disorders or symptoms	Modified Standardized Nordic Questionnaire (SNQ) a. There are complains b. There are no complains	Nominal	[9]

The Statistical Analysis

All data series were analyzed using SPSS 21.0. The normality data test was determined with a Kolmogorov-Smirnov test. Chi-Squared Test analyzed the relationship between variables.

RESULT AND DISCUSSION

The Distribution of Respondent Age

Regarding Figure 2, the proportion between workers in the spun pile production that used demolition hammers and workers using impact wrenches was balanced in the categories of teens and adults. The age range of 12-25 years old was 13 workers (48,15%), and the 26-45 years old were 14 workers (51,85%) that dominated on spun pile production work.

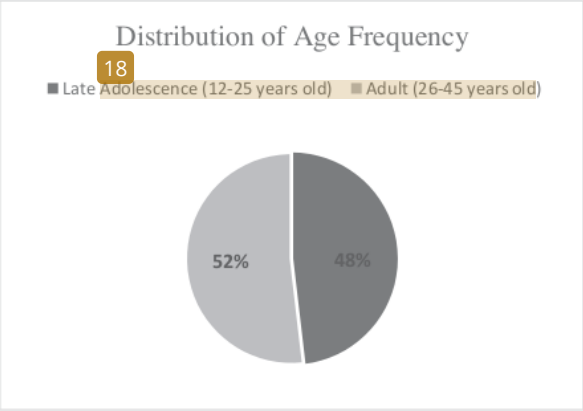

FIGURE 2. The Percentage of Worker According to Age

The Length of Work

This research found that the distribution of the working length was the new worker/latest (<3 years) of 21 workers (77,78%), while the old workers that had the length of work in 3 years were six workers (22,22%). This research object was a concrete manufacturing industry built and started to operate production in 2015, thus the period of employment in 2015 until 2021.

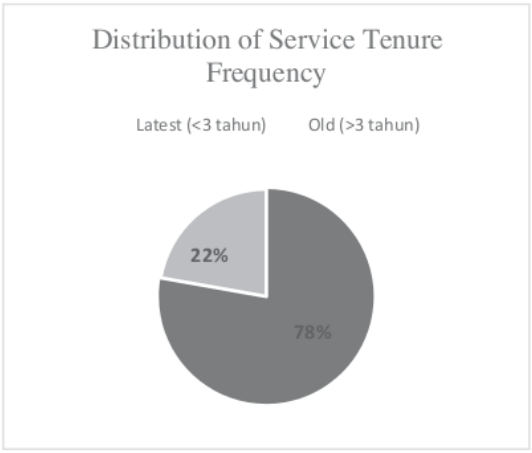

FIGURE 3. The Percentage of Worker According to The Length of Work.

The Intensity of Hand-Arm Vibration

The Figure 4 illustrated that there were 59,26% workers that exposed to Hand-Arm Vibration above the threshold limits regarding to Peraturan Menteri Ketenagakerjaan No 5 Tahun 2018 tentang Keselamatan dan Kesehatan Kerja Lingkungan Kerja. While the workers exposed to below the threshold limit were 40,74% of the total population, the threshold limit value was the exposure value that if the exposures were exceeded this value, it would initiate health disorders [11].

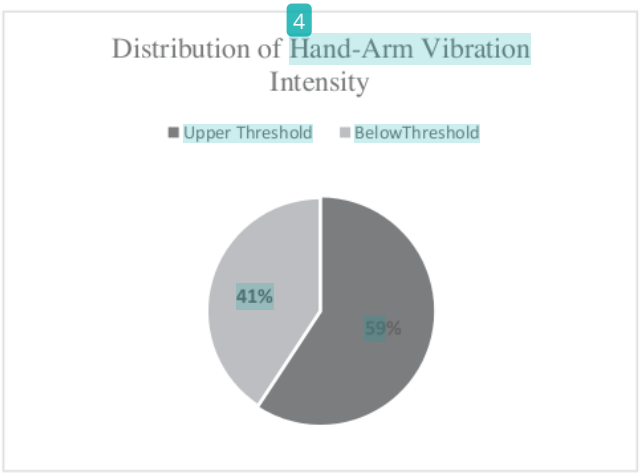

FIGURE 4. The Percentage of Hand-Arm Vibration Intensity

The Complaints of Work-Related Musculoskeletal Disorders (Wmsds)

The complaints of WMSDs of body parts experiencing WMSDs in workers as illustrated in Figure 5.

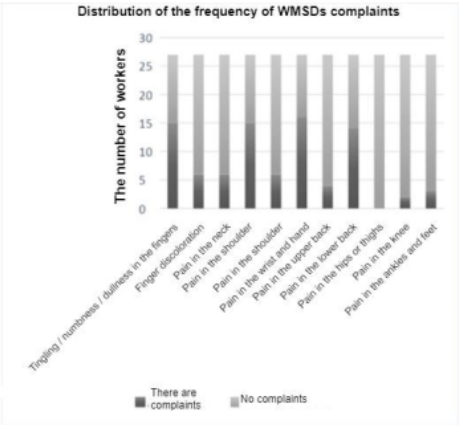

FIGURE 5. Distribution of WMSD Complaints Frequency

The results obtained from the MSNQ data showed that there were workers who experienced complaints of WMSDs in the form of HAVS with complaints of tingling, numbness, and numbness of the fingers and palms experienced by 15 workers (55, 55%). This complaint occurred when the fingers were exposed directly to vibrations from mechanical machines. In addition, 15 workers (55.55%) also experienced shoulder pain complaints where workers had shoulder pain on both sides of the shoulder when operating the impact wrench or demolition hammer. In addition, the workers complained in the hands and arms were experienced by 16 workers (59.26%). At the same time, the workers who had complaints in the form of pain in the lower back were 14 workers (51.85%).

Meanwhile, complaints on other body parts shown on MSNQ had a frequency of ≤ 6 workers in the study with the impact wrench and demolition hammer operator. Workers with an impact wrench and demolition hammer were known to have more indications of WMSDs with complaints of pain in the wrist or hand (hand/wrist troubles). In addition, workers also showed complaints in the form of complaints of numbness, tingling, and dullness in the fingers indicated as HAVS, pain in the shoulders (shoulder troubles), and lower back (low back troubles) as a result of the work being carried out in a manner. Repetitive and standing in the stressing section, opening the product, finishing the product, and the squatting state in the setting section work. Complaints with the largest distribution of workers were then tested for statistical relationships. The Chi-Square test showed that the relationship between the effect of MSDS complaints with age, leg of work, and HAV is obtained as follows in Table 2.

TABLE 2. Relationship Between the Effect of MSDS Complaints with Age, Length of Work, and HAV

Variables	MSDS complaint			
	HAVS	Shoulder	Hand/Wrist	Lowback
Age	p = 0,085	p = 0,863	p = 0,034	p = 0,035
Length of Work	p = 0,662	p = 0,663	p = 0,45	p = 0,648
HAV	p = 0,022	p = 0,452	p = 0,264	p = 0,816

The results of cross-tabulation between age and HAVS in the research data illustrated that 33.3% of workers in the adolescent age category (12-25 years) have complaints. WMSDs included tingling, numbness, and dullness in the fingers and hands. In addition, in the adult category (26-45 years), 66.7% of workers had a predominance of HAVS complaints in carrying out work activities with an impact wrench and demolition hammer. Based on the results of statistical tests with Pearson chi-square, it was found that there was no relationship between age and WMSDs complaints in the form of HAVS experienced by workers. The test results showed p = 0.085, thus indicating no relationship between the age of workers and WMSDs in the form of HAVS.

The results of cross-tabulation between ages and WMSDs complaints in the form of shoulder disorders show that 46.7% of workers in the adolescent age category (12-25 years) had complaints of shoulder pain. Meanwhile, in the category of adult workers (26-45 years), 53.3% of workers experienced complaints of shoulder pain. Regarding the results of statistical tests with Pearson Chi-Square, it was found that there was no relationship between age and shoulder troubles experienced by workers. The statistical test results show that p = 0.863, so there is no relationship between complaints of the worker's shoulders and age.

The results of cross-tabulation between ages and WMSDs complaints in the form of wrists or hands show that 31.3% of workers in the adolescent age category (12-25 years) have complaints of Hand / Wrist Troubles. Workers with the adult category (26-45 years) who have complaints of pain in the wrists or hands as 68.8% of the total workers. Based on the results of the Pearson Chi-Square statistical test, it was found that the value of p = 0.034 where p <0.05, therefore it could be concluded that there was a significant relationship between age and Hand / Wrist Troubles that occurred in the area of spun pile production.

The cross-tabulation results between ages and complaints of WMSDs in the form of Low Back Troubles found that 28.6% of workers in the adolescent age category (12-25 years) experienced complaints of Low Back Troubles. Meanwhile, 71.4% of workers in the adult category (26-45) experienced complaints of Low Back Troubles. Based on the results of statistical tests with Pearson Chi-Square, it was found that the value of p = 0.035 where p <0.05, so it is known that there is a relationship between age and complaints of WMSDs in the form of Low Back Troubles. The overall age frequency distribution results with WMSDs complaints in this study showed that workers with the adult category (26-45) experienced more WMSDs complaints in the form of HAVS on the fingers and hands, Shoulder Troubles, Hand / Wrist Troubles, and Low Back Troubles. This was also reinforced by research conducted by Dimi *et al*. (2014), which examined that the risk of developing WMSDs complaint disorders at ≥ 30 years of age was greater than those aged <30 years. According to this research, it was known that humans with middle age and above were more likely to have a decrease in the capacity of bodily functions experienced with age—the percentage impact of changes in human abilities by age group. The research also showed an increase in disabilities in body parts that occur rapidly at over 60 years.

Research shows that age had an impact due to variations in biodynamic responses or differences in sensitivity, experience, and health and fitness (Griffin and Jovanovich, 1990). These factors were important in work that exposed to vibration. Exposure to vibrations and variations in these factors could have a big influence, such as increased complaints of WMSDs in certain body parts in the subject of vibration measurement. Research from Griffin and Jovanovich (1990) showed the results of variables related to vibration discomfort in workers, including vibration magnitude and its combinations, vibration frequency and its combinations, vibration direction and its combinations, vibration input position and its combinations, as well as vibration duration and its combinations. The means that the relationship between age and complaints of WMSDs could occur due to work with exposure to vibration (Hand Arm Vibration). According to the research conducted on impact wrench and demolition hammer operators, it was known that the relationship between age and complaints of WMSDs in the form of Hand / Wrist Troubles and Low Back Troubles had a significant relationship.

The Relationship Between the Working Length and Worked Musculo Skeletal Disorders Complaints.

The results of cross-tabulation between the length of service and WMSDs complaints in the form of HAVS and shoulder troubles have the same data, which shows that 73.3% of new categories (1-2 years) of workers have complaints. In addition, 26.7% of workers in the old category (3-4 years) had complaints about HAVS. Based on the Fisher's Exact statistical test between the length of work and complaints of WMSDs in the form of HAVS, it was found that the value of $p = 0.662$ where $p > 0.05$ so that it can be said that there was no relationship between the length of work and complaints of WMSDs in the form of HAVS.

The result of cross-tabulation between the length of work and WMSDs complaints in the form of pain in the wrist or hand (hand/wrist troubles) was experienced by 68.8% of workers with the old category of new tenure (1-2 years). Meanwhile, 31.3% of workers with the old category (3-4 years) experienced complaints in the form of pain in the wrist or hand. Based on this, a Fisher's Exact statistical test was carried out. The results of this relationship test were found to have a value of $p = 0.350$ where $p > 0.05$, so it can be stated that there is no relationship between the length of work and complaints of WMSDs in the form of pain in the wrist or hand.

The cross-tabulation between the length of the work period and WMSDs complaints in the form of pain in the lower back (low back troubles) was experienced by 71.4% of workers with the new category (1-2 years). Meanwhile, 28.6% of workers with the old category (3-4 years) experienced similar complaints. Based on the results of the Fisher's Exact statistical test that has been carried out, it is found that the data value is $p = 0.648$ where $p > 0.05$ so that it can be stated that there is no relationship between the length of service and complaints of pain in the lower back (low back troubles).

The unrelated relationship between the length of work tenure and the level of WMSDs complaints could be due to the varying timing of complaints of WMSDs, where complaints occurred more frequently in adulthood. Based on the frequency distribution obtained, it was known that workers with a long working period of the new category (1-2 years) are more teenage workers. In contrast, workers with older categories are more adult workers. Based on this, it could be seen that in this study, workers with an impact wrench and demolition hammer between the length of service and complaints of WMSDs have no relationship or relationship.

Analysis of the Relationship Between HAV Intensity and Wmsds

The study results by cross-tabulating the intensity of hand-arm vibration with WMSDs complaints in the form of HAVS showed that 80% of workers had complaints with exposure to HAV above the threshold limit (TLV). In addition, only 20% of workers exposed to HAV below the TLV had experienced complaints of WMSDs. Giving findings that workers with exposure above TLV who experience complaints of WMSDs in the form of HAVS such as tingling, dullness, and numbness of the fingers in work with an impact wrench and demolition hammer in the concrete manufacturing industry amounted to $\geq 50\%$ of the total workers who were directly related to the vibrated tools. Based on statistical tests with Fisher's Exact, it was found that the value of $p = 0.014$; thus, it could be stated that there was a significant relationship between HAV and complaints of HAVS Complaints of WMSDs experienced by workers with exposure to HAV mostly resulted in an impact on the upper limb of the worker, thus affecting the nervous, muscle-skeletal, and peripheral vascular structure. This complaint was shown by the impact wrench and demolition hammer workers who were the study subjects, where 55.55% of workers experienced numbness, tingling, and/or dullness of the fingers.

It could be concluded that the relationship between HAV and shoulder pain was experienced by 66.7% of workers who were exposed to vibrations above TLV. These results were then performed statistical tests with Fisher's Exact stating that the value of p = 0.452, therefore it was stated that there was no relationship between shoulder pain and exposure to HAV. This study also conducted cross-tabulation between HAV and WMSDs complaints in the form of pain in the wrist or hand. The results showed that 68.8% of workers with exposure to HAV above TLV experience complaints in hand/wrist troubles. In addition, a cross-tabulation test was also carried out between exposure to HAV and pain in the lower back of the workers. The results illustrated that 57.1% of workers who experience exposure above TLV experience complaints of pain in the lower back (low back troubles). Based on statistical tests with Pearson Chi-Square, the value of p = 0.816 could be concluded that there was no significant relationship between WMSDs complaints in the form of pain in the lower back and exposure to HAV.

CONCLUSION

The spun pile manufacture process was carried out in several stages, including the product's setting, stressing, and demoulding using an impact wrench and a demolition hammer as vibration tools. The excessive hand-arm vibrations (HAV) from mechanical machines negatively impacted humans, such as the Work-Related Musculoskeletal Disorders (WMSDs) symptoms.

There was no relationship between the age of workers and WMSDs in the form of HAVS because all respondents were < 30 years old. It happened because the risk of developing WMSDs complaint disorders at ≥ 30 years of age was greater than those aged <30 years. The middle age and above were more likely to decrease the capacity of bodily functions experienced with age. There was no relationship between the length of work and complaints of WMSDs in the form of HAVS. The unrelated relationship between the length of work tenure and the level of WMSDs complaints could be due to the varying timing of WMSDs where complaints occurred more frequently in adulthood. There was a significant relationship between HAV and complaints of HAVS. It was happened because 66.7% of workers exposed to vibrations above TLV.

CONFLICT OF INTEREST

There is no conflict of interest. This work is supported by the Research Grant of DIPA Politeknik Perkapalan Negeri Surabaya 2021.

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