PAPER NAME

Ergonomic Hazards for Work-Related Musculoskeletal Disorders among Workers of Traditional Manufactur

WORD COUNT

7676 Words

CHARACTER COUNT

39637 Characters

PAGE COUNT

20 Pages

FILE SIZE

1.7MB

SUBMISSION DATE

Nov 9, 2023 9:40 AM GMT+7

REPORT DATE

Nov 9, 2023 9:40 AM GMT+7

6% Overall Similarity

The combined total of all matches, including overlapping sources, for each database.

- 4% Publications database
- Crossref database
- Crossref Posted Content database
- 4% Submitted Works database

Excluded from Similarity Report

- Internet database
- Bibliographic material
- Quoted material
- Cited material
- Manually excluded sources

CERTIFICATE OF APPRECIATION

No: 036/04/ICHM/VII/2023

IS PRESENTED TO:

Dian Afif Arifah

as **Oral Presenter**

Title: ERGONOMIC HAZARDS FOR WORK-RELATED MUSCULOSKELETAL DISORDERS AMONG WORKERS OF TRADITIONAL MANUFACTURE INDUSTRIES

The 1st International Conference on Health and Medicine

Faculty of Medicine, Universitas Pattimura

"The Island Doctors-Overcoming Challenges for Improved Health"

Ambon, July 26-27, 2023

No SKP: 2456/PB/A.4/07/2023

Participant 12 SKP | Speaker 14 SKP | Moderator 6 SKP | Committee 3 SKP

Chairman of The Committee

dr. Parningotan Yosi Silalahi, Sp.S., FINA

Dean of Faculty of Medicine
Universitas Pattimura

Dr. dr. Bertha J. Que, Sp.S., M.Kes.

SURAT TUGAS
No. 84/UNIDA/FIKES-s/XII/1444

Dekan Fakultas Ilmu Kesehatan Universitas Darussalam Gontor menugaskan kepada :

No	Nama	NIY/ NIDN	Jabatan	Program Studi
1.	Dian Afif Arifah, S.ST., M.Kes	160587/ 0722039102	Dosen tetap	Keselamatan dan Kesehatan Kerja

Untuk menghadiri pertemuan Ilmiah **The 1st International Conference of Health and Medicine of Pattimura University (ICHM 2023),** sebagai peserta dan pemakalah pada:
Tanggal : 26-27 Juli 2023
Tempat : Hybrid from Hotel Santika Premiere Ambon (online)
Demikian surat tugas ini dibuat untuk yang bersangkutan agar dapat dilaksanakan dengan baik dan sebagaimana mestinya.

Ponorogo, 25 Juli 2023
Dekan Fakultas Ilmu Kesehatan

Apt. Amal Fadhollah, S.Si., M.Si.
NIP/ NIY. 150479

About ICHM 2023

The 1st International Conference on Health and Medicine (ICHM 2023): The Island Doctors-Overcoming Challenges for Improved Health is organized by the Faculty of Medicine, Pattimura University (FK UNPATTI) in Maluku Province, Indonesia. The conference is scheduled to take place on July 26 & 27, 2023.

The conference's primary focus is on the unique program of "island doctors" offered by FK UNPATTI. This program aims to prepare medical graduates to provide optimal health services to community members living in the archipelago, particularly in areas with limited access to medical facilities. Given Maluku Province's geographical characteristics, with more sea area than land, developing marine and island health is crucial for the safety and well-being of people residing on small islands, cruise ships, and participating in maritime activities.

As the only Faculty of Medicine in Maluku, FK UNPATTI plays a significant role in improving health services and medical care available to island communities. Graduates from FK UNPATTI are equipped with specialized knowledge, skills, and personality development necessary to address the challenges of providing medical services in remote and island regions. The competence of these island doctors is expected to contribute to the improvement of healthcare in Maluku and Indonesia.

The conference aims to address the demand for high-quality health services by promoting and showcasing scientific research in the field of island marine health. Given the rapid development of science and technology in medicine and health, research plays a crucial role in meeting the community's health needs. Therefore, the conference seeks to foster the exchange of knowledge and research findings related to island marine health, enabling attendees to learn from various studies conducted worldwide and adapt the findings to the local context in Maluku.

The conference will provide a platform for researchers, medical professionals, scholars, and students to share their latest research findings, innovative ideas, and experiences related to island marine health. Various topics may be covered, such as advancements in medical technology, public health strategies, preventive measures for island communities, and other relevant areas aimed at improving healthcare services in remote and island regions.

Publication is considered one of the most effective methods to disseminate research findings, and this conference may result in the publication of the presented research in scientific journals and other academic platforms. Additionally, the conference could also lead to the establishment of international collaborations and partnerships to further enhance research and healthcare initiatives in the field of island marine health.

The 1st International Conference on Health and Medicine: The Island Doctors-Overcoming Challenges for Improved Health is expected to be an important event that showcases the efforts and progress made by FK UNPATTI in addressing the unique healthcare challenges faced in the archipelagic province of Maluku, Indonesia.

Committee

Director
Dr. dr. Bertha Jean Que, Sp.S., M.Kes

Person in-charge
drg. Christiana Rialine Titaley, MIPH., Ph. D

Chairman
dr. Parningotan Yosi Silalahi, Sp. S

Secretary
dr. Filda Vionita Irene De Lima, M.Biomed

Treasury
Fitria Adam, A.Md

Programme co-ordinator
Yuniasih M. J. Taihuttu, S.Si., M.Sc

Programme Members
dr. Johan Bruiyf Bension, M.MedEd
George Sinay, SE.,M.Si
dr. Vina Z. Latuconsina, Sp. PK
dr. Rif'ah Z. Soumena, Sp. A., M.KedKlin
dr. Is Asma'ul Hac Hataul, Sp. PD
dr. Lidya B.E. Saptenno. M.Sc
Juen Carla Warella, S.Pd., M.Si
Rosdiana Mus, S.Si., M.Biomed
Grace Latuheru, S.Psi., M.Psi., Psikolog
Genevieva E Tanihatu, S.Psi., M.Psi., Psikolog
Presly G. Siahaya, S. Kep., Ns., M.Sc
Dinda Rehatta, S. Pd

Scientific committee co-ordinator
dr. Halidah Rahawarin, Sp. PA., M.Kes

Scientific committee Members
dr. Vebiyanti. Sp. P., M.Sc
dr. Nathalie E. Kailola, M. Kes
dr. Amanda G Manuputty, Sp. DV., M.Ked.Klin
dr. Samuel Maruanaya, Sp. OT
Eka Astuty, S.Si., M.Si
Elpira Asmin, S.KM., M.Kes
Melda Yunita, S.Si., M.Si
Mutmainnah Abbas,S.Si.,M.Sc
Dylan Tamalsir,S.Kep.,M.Biomed
Rachmawati Dwi Agustin, S.Si., M.Si., M.Sc
dr. Stazia Noija, MHPE
Alessandra F. Saija, S. Psi., M. Si
dr. Jerome C. Lekatompessy
dr. Jennifer Paath
Maxwell Malakauseya

Sponsorship co-ordinator
dr. Ony Wibriyono Angkejaya, Sp. An., M.Kes

Sponsorship Members
dr. Ritha Tahitu, M. Kes
dr. Sri Wahyuni Djoko, Sp. A
dr. Indrawanti Kusadniani, Sp.PD., M.Biomed
dr. Laura Bianca Sylvia Huwae, Sp.S., M.Kes
dr. Is Ikhsan Hataul, Sp.B
dr. Ivanmorl Ruspanah, Sp. BS
dr. Arlen Resnawaldi, Sp. OG

Public relations, information, and technology co-ordinator
Sean Semuel Istia, S.Kom., M. Kom

Public relations, information, and technology Members
Liyani Sartika Sara, Amd.Kep
Gloria Radjawane, S.T
Yudith Wakanno, S.H
Aldo E. Wijaya and Team

Equipment co-ordinator
Bariya Lakuy, SE

Equipment Members
General and Finance Department (Faculty of Medicine, Pattimura University, Ambon)

Secretariat co-ordinator
Martha D. Melmambessy, S.Sos., M.Si

Secretariat Members
Academic Staff (Faculty of Medicine, Pattimura University, Ambon)

Hospitality co-ordinator
Yanti Wali, S.E

Hospitality member
Fahera Payapo, S.Pd

Ergonomic Hazards for Work-Related Musculoskeletal Disorders among Workers of Traditional Manufacture Industries

Dian Afif Arifah [1,*], Ratih Andhika Akbar Rahma[1], Triana Harmini[2]

[1]Occupational Safety and Health Department, Faculty of Health Science, Universitas Darussalam Gontor
[2]Informatic Enginering Deparment, Faculty of Science and Technology, Universitas Darussalam Gontor

*Corresponding Author: dianafif@unida.gontor.ac.id

Abstract

Work-related musculoskeletal disorders (WMSDs) are most prevalent occupational health issues that could affect employees physically and socially. Ponorogo regency has several traditional manufacturing industries that support regional economic growth. The issues in this sector include the low adoption of current technology and the predominance of manual handling techniques, which raises the risk of WMSDs among employees.

Based on SNI no. 9011:2021, the National Standardization Agency (BSN) establishes standards to evaluate possible ergonomic risks in the workplace. However, not every industry, particularly small ones, has a procedure for auditing these risks. This study aims to develop a model to evaluate WMSDs risks based on spesific work posture among traditional manufature industries. Using cross-sectional data collecting method, 250 workers participated in this observational study as respondents who were randomly selected using a stratified random sampling. Strata were determined by company scale. The model were designed by WMSDs as dependent variable and ergonomics hazard risks as determinants consisting of 10 indicators (arm movement, hand effort, awkward posture, direct pressure, vibration, environment, control of work rhythm, pushing/pulling, keyboard usage, and manual handling). Neural networks algorithm is used to determine the relationships path among variables.

The result finds that arm motions (2.5), uncomfortable postures (2.4), and rhythm control (2.3) had the largest risk weight for WMSDs. Neck (8.2), right shoulder (6.6) and calf (6.1) are the body parts that most exposed to the WMSDs risk due to work factor. The data modelling show that complaints on each body part are caused by specific work postures.

Keywords: *Posture risk, Work-related musculoskeletal disorders, Manufacture industries*

Ergonomic Hazards related to Muskuloskeletal Disorders among Workers of Traditional Manufacture Industries in Ponorogo Regency

Dian Afif Arifah
Occupational Safety and Health, Faculty of Health Science
Universitas Darussalam Gontor
First Author

Ratih Andhika Akbar
Occupational Safety and Health, Faculty of Health Science
Universitas Darussalam Gontor
Second Author

Triana Harmini
Informatic Enginering, Faculty of Science and Technology
Universitas Darussalam Gontor
Third Author

*Corresponding author:
Dian Afif Arifah
Occupational Safety and Health, Faculty of Health Science
Universitas Darussalam Gontor

Corresponding author:
E-mail:
dianafif@unida.gontor.ac.id

ABSTRACT

Ponorogo regency has several traditional manufacture industries that support regional economic growth. The common issues are low adoption of proper technology and most jobs are manually handled. The manufacturing sector usually involves various heavy labor-intensive activities which potentially causing strains on both the upper and lower body region which led to work-related musculoskeletal disorders (WMSDs) risk. This research aims to describe the ergonomic hazards and WMSDs compliants most exposed and develop a model to evaluate risks among traditional manufature industries.
Using cross-sectional method, 250 workers participated in this observational study and randomly selected through stratified random sampling. The neural network model were formulated by predicting WMSDs in the upper and lower body region based on its determinants. As determinants, ergonomic hazards divided into upper (8 variables) and lower (10 variables) body region.
The result shows that Manual handling (p-value=0.02) and neck bend or rotation (p-value =0.03) are factors associated with WMSDs in the upper body. While body bend or rotation (p-value =0.02) is the only determinat for WMSDs in the lower body region. Workers are frequently exposed to ergonomic risks to both the upper and lower body, but the upper body risks are more frequently associated to WMSD symptoms.

Keywords*: Ergonomic Hazards, Work-related musculoskeletal disorders, Manufacture industries*

1. INTRODUCTION

It is common in the developing countries that small-scale industries employ a large number of workers as a replacement for automation. As a culture center region in Indonesia, Ponorogo regency has several traditional manufacturing industries that support regional economic growth. In 2020, there were 3,807 traditional food and craft industries or 78% from total industries around Ponorogo. It has been absorb around 3,800 local workers or or 62% of the total workers in other formal industries [1].

Usually, small and traditional industries place less emphasis on the culture of health and safety for employees [2]. Additionally, most workplace in the local manufacturing industry has lack ergonomic design, which has led to ergonomic hazards among workers. Regardless of other work-related factors, ergonomic is one of the key elements that define the working environment in manufacturing industries [3]. There is less consideration on monitoring programs to evaluate workers health and safety due to the small-scale and informal most industries are.

The following studies prove that there is an issue that result in high levels of ergonomic problems among workers. Observational study by Dwijayanti [4] reported that more than 50% workers in the traditional food industries exposed to medium – high musculoskeletal com-plaints. Similar study among bakery industries by Arifah [5] find that 92% bakers exposed to medium – high risk ergonomic hazard due to the manual handling method.

The manufacturing sector usually involves heavy labor-intensive activities. In a traditional or small-scale setting, the issues are low adoption of modern technology and most of production process is manually handled [6]. In addition, repetitive movement, long-static or dinamic postures causing biomechanical overload, which may contribute to work-related musculoskeletal disorders (WMSDs) [7].

WMSDs are one of the most common occupational health problems which affect workers physically and socially [8] and result in financial losses for company due to decreased productivity [9]. According to WHO[10], WMSDs are known to be multifactorial responses and are influenced by work attitudes and positions. Use of machines or manual handling [6], [11], repetitive movements [12], monotonous work [13], lifting weights[14], awkward postures [11], [14], [15] and continuous and excessive use of force [11], [16] is a work factors that causes musculoskeletal system strain and increase the risk of WMSDs. Dominant work postures are most related to the types and parts of the body exposed to ergonomic hazards [14]. Professional computer users, for example, are more at risk of developing carpal tunnel syndrome because of their typing position [17], [18]. Workers in a standing position are at greater risk of experiencing low back pain [19], work with a lot of hand effort and manual handling has a greater risk of causing shoulder and neck complaints [20], etc.

Ergonomic hazards, posture, and WMSDs are interconnected issues that play a crucial role in the development and prevention of musculoskeletal injuries and discomfort among workers [21]. Ergonomic hazards refer to factors in the workplace environment that can lead to physical strain, discomfort, and potential injuries due to the incompability between the job demands and the capabilities of the workers [22]. These hazards include repetitive motions, forceful exertions, awkward postures, vibration, contact stress, and other un-ergonomic working postures that could led to WMSDs [23]. It increases as the physical requirements of a task exceed the body's ability to perform it out comfortably and safely. If it continues for a long working periods, workers will be forced to adopt unnatural body positions that led to musculoskeletal stress [24].

The most of study related to WMSD focuses on the particular working type associated to the percentage of WMSDs in a certain body area. It is become a fundamental question regarding which areas are more exposed based on the type of work or which part of the region that more exposed to WMSDs risk.

The Indonesian National Standardization Agency (BSN) establishes standards to evaluate possible ergonomic risks based on SNI 9011:2021 [23]. In these standard, ergonomic hazards are divided into upper and lower body region. This division can be used to determine the body are more at risk based on the worker's dominant working posture and identify the hazards that are common in particular working types.

It is typical that discomfort in a certain body parts is associated with an exposure to a single awkward work posture. However, some studies suggest that single postures that becomes an ergonomic hazards do not independently cause specific WMSDs. For example, carpal tunnel syndrome could caused by not only wrist strain stress but also manual handling jobs [25]. MSDs of the shoulder and neck were significantly linked with or brought on by occupational exposures to whole-body or hand-arm vibration[26]. Both upper and lower body region has a particular ergonomic hazards related to movements or exposure in the region.

Workers in traditional manufacturing industries frequently engage in a variety of high-intensively working activity, which run the risks of causing strains on both the upper and lower body regions. This research aims to describe the ergonomic hazards and WMSDs compliants most exposed among workers in the traditional manufacturing industries in Ponorogo Regency. Predictive modeling is designed to identify specific hazards that most contribute to the WMSDs in the upper and lower body regions. The findings of this study can be used as a guide for determining the appropriate work station design or program to control ergonomic hazards among workers.

2. METHOD (10 PT)

2.1. Data collection and respondents

Using cross-sectional data collecting method, 250 workers in the traditional manufacturing industries in Ponorogo Regency participated in this observational study as respondents. They were randomly selected using a stratified random sampling. Strata is a scale or company levels were divided into small (workers<50), medium (workers 50-100) and large (workers >100). To be included as respondents, workers should been working as full-timer for at least 5 years of working period and had no injuries or chronic diseases in the last 10 years.

This study involved all traditional manufacturing industry workers which estimated 3,800 people were included as population. The minimum sample size following the sample size formula for finite population[27] given as :

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

Where :
n = minimum sample size
Z 1-α/2 = 1,96 (with α = 0,05)
P = workers proportion with WMSDs (assumed 80% = 0,8)
d = tolerable error rate in this study = 5 % = 0,05

So that the minimum sample size calculated as:

$$n = \frac{3.800\ x\ \ 1{,}96^2\ 0.8\ (1-0.8)}{(3.799)0.05^2 + 1{,}96^2\ 0.8\ (1-0.8)} = \frac{2335{,}69}{10{,}11} = \mathbf{230{,}9} \sim 231 \text{ respondents.}$$

In this study, 250 workers were chosen as respondents due missing in data gathering. They signed an informed consent after being informed of the study's goals and methods and voluntarily agreed to participate as respondents.

2.2. Variables and instruments

The region exposed to WMSDs and Ergonomic hazards in this research divided into upper and lower body regions. There are 17 ergonomic hazards determined by evaluate working posture as described in the Figure 1. There are 8 (eight) determinats in the upper body region and 10 (ten) determinats in the lower body region. Manual handling (Xc) were involved as WMSDs factor in both upper and lower body region.

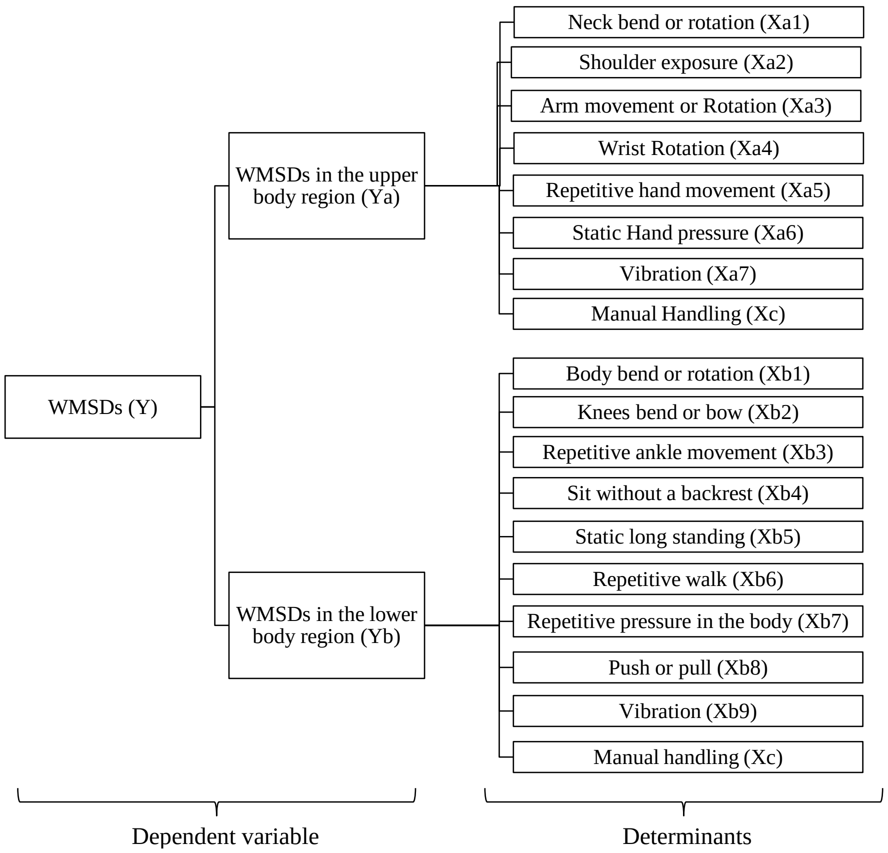


Figure 1. Determinants of WMSDs in the upper and lower body region

Measurement guide in this study based on SNI 9011:2021[23]. In the WMSDs complaints measurement, respondent reported discomfort, pain or burning in the 12 body limbs according to the assessment form and interpreted as binnary classification (Yes and No). Ergonomic hazards classified in the various rating scale based on the exposure level (0-3) which determined by accumulating severity and duration exposure.

2.3. Data analysis

Data modelling in this study build up by analyze WMSDs risks based on its determinats in the upper and lower body regions. There are two modelling steps with the diferent algorithm. Binary logistic regression is used to determine factor related to independent variable with significance level based on 95% confidence interval (CI). while Neural networks algorithm is used to determine the path correlation among variables.

3. RESULTS AND DISCUSSION (10 PT)

3.1. Descriptive result

Data were obtained from 251 workers of traditional manufacture industries in Ponorogo. Every work posture contributes to specific ergonomic hazards as described in Figure 2. Musculoskeletal disorders (MSDs) complaint among workers were evaluated based on 12 body parts as described in Figure 3.

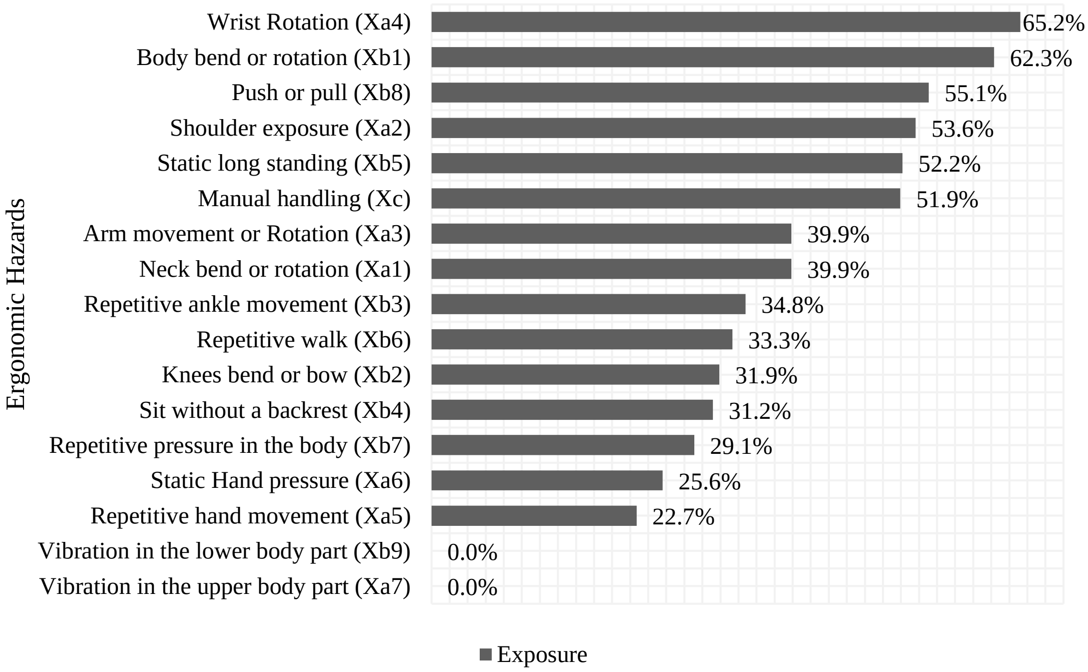


Figure 2. Ergonomic hazards based on posture exposure

Based on the descriptive result, Wrist rotation is the most common activity experienced by workers (65.2%), followed by body bend or rotetion (62.3%) and push or pull (55.1). There are no workers exposed to vibration in the both upper and lower body region.

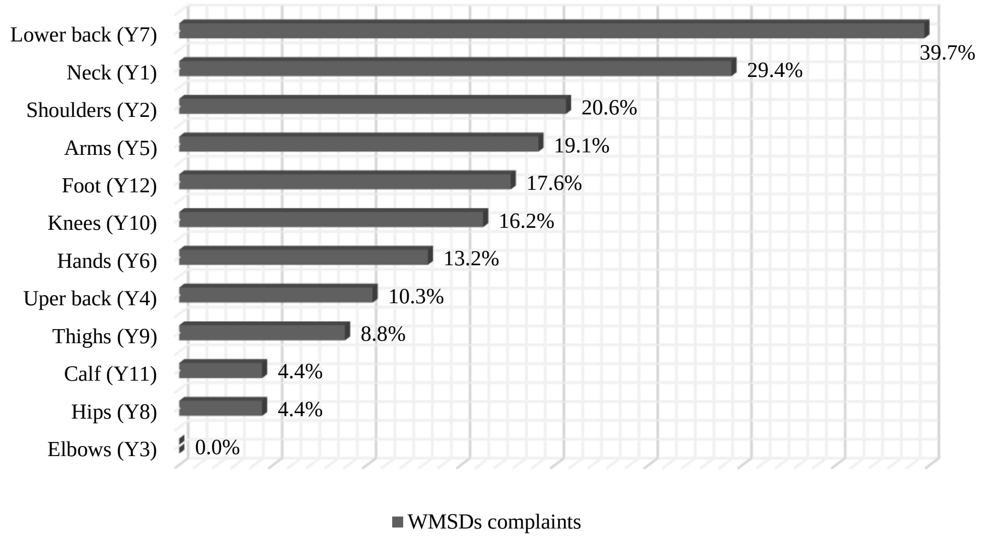


Figure 3. WMSDs complaints based on te body region exposed

The MSDs complaints were measured in 12 different body parts, as shown in Figure 3. The WMSDs exposure measured by accumulate severity and frequency score in the MSDs matrix in the SNI 9011:2021. Lower back (39.7%), neck (29.4%) and Shoulders (20.6%) are body segment most exposed to WMSDs. While there are no complaint in the elbows.

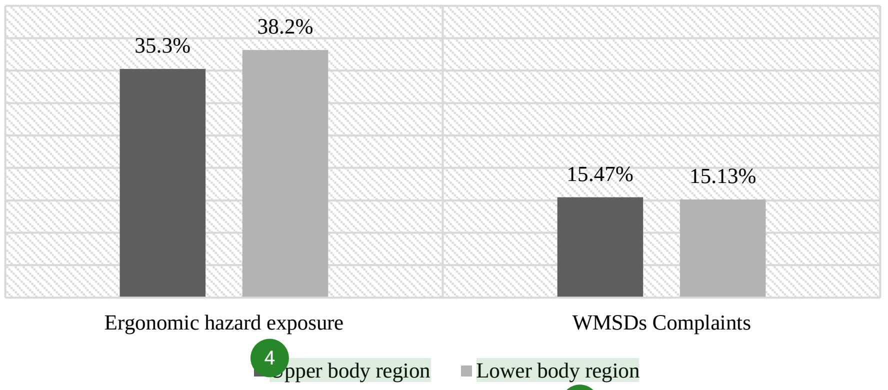


Figure 4. Ergonomic hazards and WMSDs complaints in the upper and lower body region

As explained in the method, the region exposed to WMSDs and Ergonomic hazards determined by work posture in this research divided into upper and lower body regions. The following figure shows a descriptive comparison of the hazard exposure and complaints rate among workers in both the upper and lower body regions.

Descriptively, workers are more likely to be exposed to ergonomic hazards in their lower body (38.2%) than than their upper body (35.3%). Meanwhile, WMSDs complaints on the upper body (15.47%) are higher compared to the lower part (15.13%). The difference, however tends to be insignificant.

3.2. Logistic regression model of WMSDs in the upper and lower body region

Upper body region including Neck, Shoulders, Upper back, Arms, and Hands. While lower body region including lower back, thighs, knees, calves and feet. WMSDs is determined by the complaints at least in the one region of the upper or lower body region. There are 15 ergonomic hazards divided into upper and lower body region. Manual handling (Xc) included as determinant in both the upper and lower body region.

Table 1. WMSDs model based on ergonomic hazards in the upper body region

Ergonomic Hazards	**Uper Body Region**										**WMSDs in the upper body**		**Lower Body Region**										**WMSDs in the lower body**	
	Neck		**Shoulders**		**Uper back**		**Arms**		**Hands**				**Lower back**		**Thighs**		**Knees**		**Calf**		**Foot**			
	B	***p-value***	***B***	***p-value***	***B***	***p-value***	***B***	***p-value***	***B***	***p-value***	***B***	***p-value***	***B***	***p-value***	***B***	***p-value***	***B***	***p-value***	***B***	***p-value***	***B***	***p-value***	***B***	***p-value***
Xa1	0.55	0.11	0.33	0.18	0.33	0.73	-0.57	0.21	0.20	0.62	0.83	0.03*	-	-	-	-	-	-	-	-	-	-	-	-
Xa2	0.69	0.05*	0.29	0.14	0.30	0.22	0.25	0.49	0.03	0.94	0.33	0.42	-	-	-	-	-	-	-	-	-	-	-	-
Xa3	0.18	0.95	1.41	0.77	-0.12	0.54	0.14	0.04*	-0.30	0.07	-0.29	0.32	-	-	-	-	-	-	-	-	-	-	-	-
Xa4	0.30	0.60	-0.26	0.95	0.06	0.51	-1.06	0.38	-0.14	0.79	-0.08	0.06	-	-	-	-	-	-	-	-	-	-	-	-
Xa5	-0.43	0.25	-0.27	0.04*	0.07	0.25	0.22	0.75	0.22	0.85	1.03	0.32	-	-	-	-	-	-	-	-	-	-	-	-
Xa6	0.53	0.18	0.22	0.02*	-0.27	0.12	-0.12	0.09	-0.09	0.11	-0.30	0.11	-	-	-	-	-	-	-	-	-	-	-	-
Xc	0.45	0.43	0.27	0.09	-0.06	0.62	0.09	0.05*	0.65	0.55	0.45	0.02*	-3.17	0.19	-3.31	0.22	-3.99	0.44	-6.92	0.28	0.36	0.04*	-1.98	0.26
Xb1	-	-	-	-	-	-	-	-	-	-	-	-	1.37	0.01*	0.40	0.89	-0.45	0.37	1.42	0.20	0.63	0.16	0.83	0.03*
Xb2	-	-	-	-	-	-	-	-	-	-	-	-	-0.01	0.95	-0.51	0.63	1.53	0.08	-0.57	0.44	-0.35	0.37	0.27	0.11
Xb3	-	-	-	-	-	-	-	-	-	-	-	-	0.48	0.14	0.25	0.66	0.84	0.09	0.32	0.64	-0.63	0.15	-0.05	0.87
Xb4	-	-	-	-	-	-	-	-	-	-	-	-	0.06	0.85	-0.56	0.20	0.49	0.33	0.05	0.94	0.01	0.97	-0.11	0.31
Xb5	-	-	-	-	-	-	-	-	-	-	-	-	1.22	0.05*	-0.18	0.06	1.16	0.17	0.98	0.48	0.84	0.25	1.91	0.55
Xb6	-	-	-	-	-	-	-	-	-	-	-	-	-0.76	0.45	0.10	0.48	-0.06	0.89	-0.08	0.91	-0.42	0.38	-0.22	0.74
Xb7	-	-	-	-	-	-	-	-	-	-	-	-	0.20	0.59	0.26	0.89	-1.06	0.06	0.38	0.63	0.10	0.62	0.11	0.68
Xb8	-	-	-	-	-	-	-	-	-	-	-	-	-0.07	0.58	0.19	0.33	0.07	0.66	0.26	0.46	-3.23	0.81	0.09	0.61

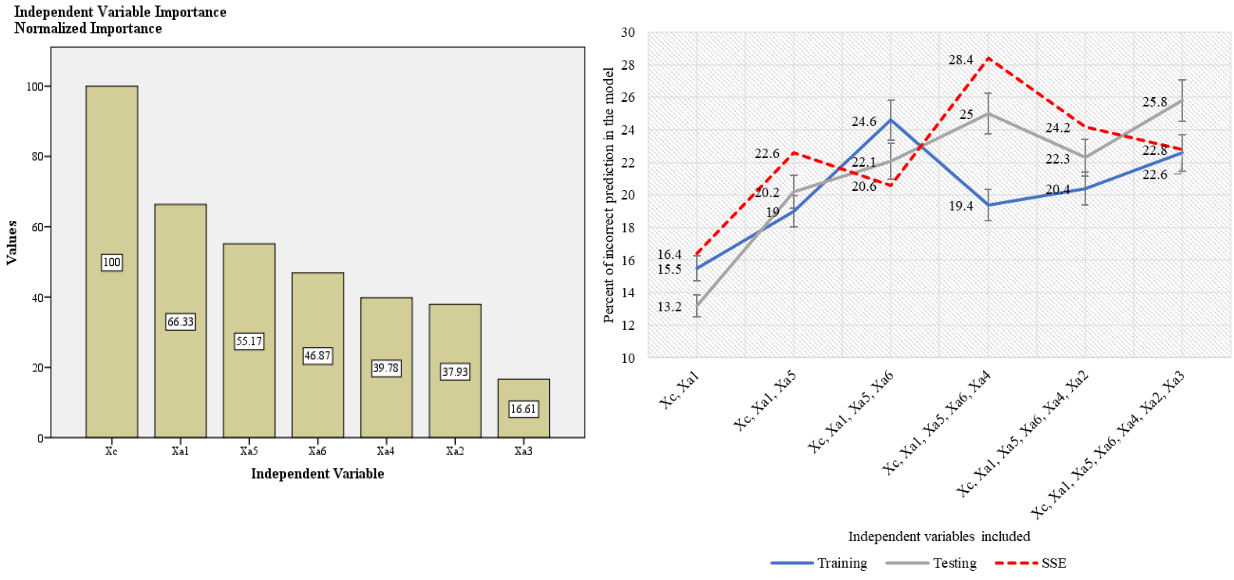
*) significant at *p*-value < 0.05

Based on the model in the table 1, WMSDs in the upper body region significantly related to Xa1/"neck bend or rotation" (p-value =0.03; β=0.83) and Xc/"manual handling" (p-value =0.02; β=0.45). Body limb affected by ergonomic hazards are neck that significantly affected by Xa2/"shoulder exposure" (p-value = 0.05; β = 0.69), shoulders that significantly affected by Xa5/"repetitive hand movement" (p-value = 0.04; β = -0.27) and Xa6/"static hand presure" (p-value = 0.05; β = 0.69), and arms that significantly affected by Xa3/"arm movement or rotation" (p-value = 0.04; β = 0.14) and Xc/"manual handling" (p-value = 0.05; β = 0.09) .

In the lower body, WMSDs are determined by the risk of ergonomic hazards consisting of 9 indicators, including: body bend or rotation (Xb1); knees bend or bow (Xb2); Repetitive ankle movement (Xb3); sit without backrest (Xb4); static/long standing (Xb5); repetitive walk (Xb6); repetitive pressure in the body (Xb7); push or pull (Xb8); and manual handling (Xc). The logsitic regression model is presented in table 5. Based on the logistic regression model, WMSDs in the lower body were significantly related to Xb1/"body bending or twisting" (p-value =0.02; β=0.43). The part of the lower body that is exposed to ergonomic hazards is the lower back which is significantly related to Xc/"manual handling" (p-value = 0.04; β = 0.36).

3.3. WMSDs Model in the upper body region

An importance analysis of the independent variables (ergonomic hazards) is performed in order to evaluate the degree of predictor's suitability (fitness) to dependent variable (WMSDs in the upper body). The analyses' findings are shown in figure 5.



(a) (b)

Figure 5. Factor's Importance of the WMSDs in the upper body region (a) and percent of incorrect prediction based on the independent variables included in the model (b)

As in logistic regression, the neural networks model shows that among the 7 ergonomic hazards, "manual handling (Xc) (NI:100%) and neck bending or twisting (Xa1) (NI:66.33%) are the 2 most important determinants in the model of WMSDs in the upper body. Based on the model summary and entropy error test, the model with two predictors (Xc and Xa1) has the lowest rate of percent incorrect prediction and sum of entropy error (SEE) both in the data training and data testing compared to the other models.

So that neural networks model of WMSDs in the upper body build up based on the "neck bending and twisting" (Xa1) and "manual handling" (Xc). In the modeling process, there are 100 data trainings and 100 data testings (present in the table 3 and figure 6) that carry out the learning process by calculating weights and reducing errors continuously.

Table 3. WMSDs parameter estimation based on synapsys weights in the input layer (Xa1 and Xc) and the hidden layer (H)

Predictor		Predicted			
		Hidden Layer 1		Output Layer	
		H(1:1)	H(1:2)	WMSDs : No	WMSDs : Yes
Input Layer	(Bias)	-0.207	-0.382		
	[Xa1=,00]	0.777	0.045		
	[Xa1=1,00]	-0.546	-0.214		
	[Xa1=2,00]	0.018	-0.411		
	[Xa1=3,00]	-0.180	-0.291		
	[Xc=,00]	0.508	0.052		
	[Xc=1,00]	1.067	0.670		
	[Xc=3,00]	-0.384	-0.194		
	[Xc=6,00]	-0.730	0.125		
Hidden Layer 1	(Bias)			0.131	0.443
	H(1:1)			0.884	-1.643
	H(1:2)			0.700	0.146

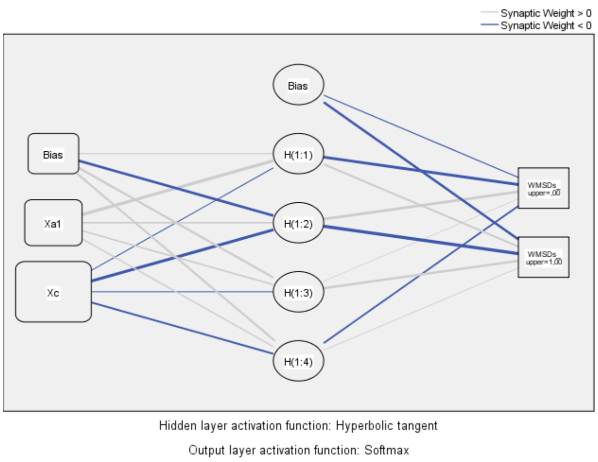


Figure 6. Network estimation of WMSDs Model in the upper body

The network model provides predictive information for the WMSDs possibility (Yes and No) based on all possible parameters in the predictors (Xa1 and Xc). Xa1 is a "neck bend or rotation" consisting of 3 levels, including : 0 = exposure level 0-25%; 1 = exposure level > 25-50%; 2 = exposure level > 50-75%; and 3 = exposure level > 75-100%. While exposure levels is the accumulation of position and duration of neck activity at work. Xc is “manual handling” activity consists of 4 risk levels (0,1,3 and 6). The risk level is determined based on the manual handling risk matrix which is an accumulation of the weight of the object being lifted, distance and duration or frequency of activity. Table 3 shows the synapse weights in each pathway that can be used as a prediction function.

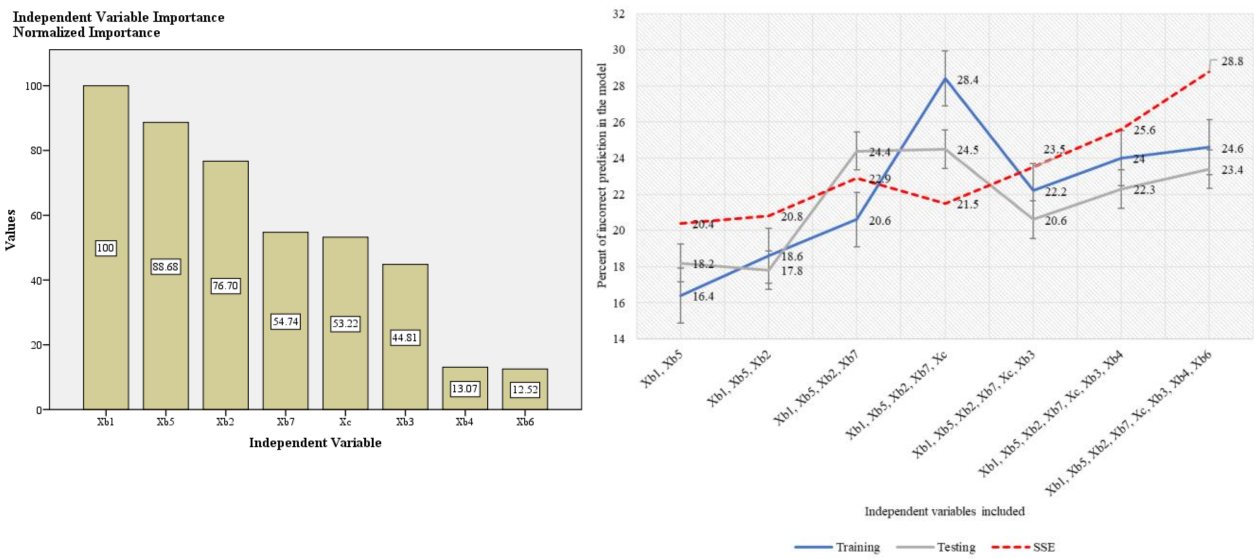
There are 1 hiden layer formed in the model. Bias weight in the model defined as the constant which is added to the product of features and weights. The activation function can be shifted in the model to the positive or negative side. The pathway estimation ilustrated in the Figure 5. Based on this function, the WMSDs predictions based on the Xa1 and Xc possibility is presented in table 4. The WMSDs in the upper body region predicted to be occurred in the grey marked cell in the matrix.

Table 4. Prediction model of WMSDs in the upper body region based on manual handling and neck or bend rotation

Neck or Bend Rotation (Xa1)	Manual Handling (Xc)			
	0	1	3	6
0	WMSDs : No	WMSDs : No	WMSDs : yes	WMSDs : yes
1	WMSDs : No	WMSDs : No	WMSDs : yes	WMSDs : yes
2	WMSDs : No	WMSDs : No	WMSDs : yes	WMSDs : yes
3	WMSDs : No	WMSDs : yes	WMSDs : yes	WMSDs : yes

3.4. WMSDs Model in the lower body region

As in the upper body, an Importance test of independent variables to WMSDs in the lower body region carried out as presented in Figure 7. It is shown that the "body bend or rotation" (Xb1) and "Static long standing" (Xb5) are predictors with ideal normalized importance values (NI > 85) to be used as WMSDs predictors in the lower body region. Based on the model summary in the section b, it is also known that model with two predictors (Xb1 and Xb5) have the smallest SSE (20.4) and sum of percent incorrect prediction.



(a) (b)

Figure 7. Factor’s Importance of the WMSDs in the lower body region (a) and percent of incorrect prediction based on the independent variables included in the model (b)

In table 5, the WMSDs model in the lower body region is constructed based on all possible rates in the "body bend or rotation" (Xb1) and "static long standing" (Xb5). There are 3 level of body bend or rotation exposure determined by awkward position and body angular degree, including: 0 = exposure level <25%; 1= exposure level 25 – 50%; and 2 = exposure level >50-100%. While in the static long standing exposure level determined by the static duration consist of level 0 = exposure level <50%; and 1= exposure level 50-100%.

Table 5. WMSDs parameter estimation based on synapsys weights in the input layer (Xb1 and Xb5) and the hidden layer (H)

Predictor		Predicted			
		Hidden Layer 1		Output Layer	
		H(1:1)	H(1:2)	[WMSDs : No]	[WMSDs : Yes]
Input Layer	(Bias)	-0.43	0.26		
	[Xb1=,00]	0.47	0.86		
	[Xb1=1,00]	0.67	-0.15		
	[Xb1=2,00]	-0.54	0.32		
	[Xb5=,00]	0.09	0.12		
	[Xb5=1,00]	-0.63	0.17		
Hidden Layer 1	(Bias)			0.12	-0.33
	H(1:1)			0.79	-0.29
	H(1:2)			0.24	0.05

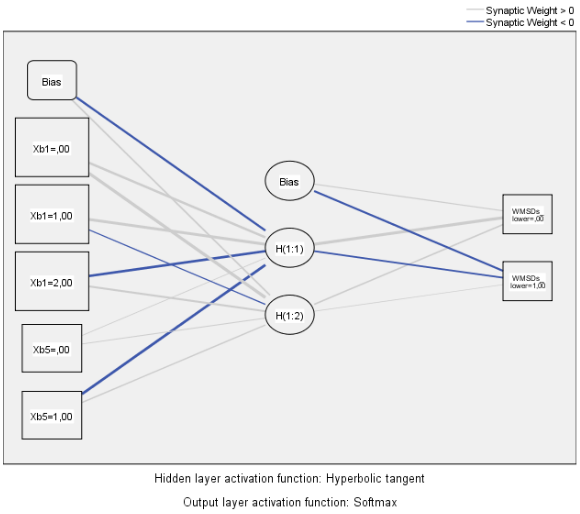


Figure 8. Estimasi jaringan neural pada pemodelan WMSDs pada tubuh bagian bawah

The model estimation consist of Xb1 and Xb5 as input layer with 1 hidden layer. Output layer is WMSDs in the lower body region which pedict as Yes or No. Neural network model ilustrated in the figure 6 simply described as WMSDs risk if all possible predictor variables are included. In the table 6, it is estimated a prediction results of WMSDs in the lower body based on the main predictors.

Table 6. Prediction model of WMSDs in the lower body region based on manual handling and neck or bend rotation

	Static long standing	
Body bend or rotation	0	1
0	WMSDs : No	WMSDs : No
1	WMSDs : No	WMSDs : yes
2	WMSDs : yes	WMSDs : yes

3.4. Discussion

Since MSDs are known to be multifactorial [10], observing WMSDs requires an accurate and specific diagnosis. This study minimizes all biases that result in the incorrect determination of WMDs. Our main method is to establish the criteria for respondents by excluding those who have an illness history or other health issues. Individual characteristics such as working period and work duration are controlled by set a specific requirements, so that every potential work posture can be observed as an ergonomic risks contribute to WMSDs in the upper and lower body areas, respectively.

First, the findings of this study led to a description of ergonomic hazards and WMSDs complaints among workers in the traditional manufacturing industries. In the figure 2, described work activities and ergonomic risks that traditional manufacturing industry workers most frequently experience, including wrist rotation, body bend or rotation, and push and pull activity. These activities raise ergonomic hazard score, which are reinforced by the substantial manual handling in work posture. Based on the descriptive result that 51.9% of workers were exposed to manual handling. It is common due to the fact that traditional manufacture industries tend to use less-contemporary technology and highly labour intensive that most of the tasks were performed manually with hand tools.

The manual handling determinant becomes an important aspect of this study because it is one of the key elements that has a significant impact on the risk of WMSDs theoritically. Based on Forwarda[28] manual handling plays a significant role in raising the risk of lower back pain and other occupational musculoskeletal illnesses among western australians. Rahman [29] also acquired that manual handling tasks involve with work-related lower back disorders. The most common cumulative trauma disorders (CTD) or WMSDs are injuries brought on by repetitive and load-handling activity manually [30]. However, the rate gives the study an advantage because it demonstrates a comparable distribution within work activites.

There is also an equal distribution in the upper and lower body activities. Although the results of the description indicate that ergonomic hazards in the lower body is higher compred to upper body exposure, the difference is unsignificant. It is indicates that working activities in the traditional manufacturing industries equally involve the upper and lower body, balancing the risk of WMSDs in both regions. Workers in traditional manufacturing industries tend to do physical activities that involve the whole body, especially during the production process. An active working position puts extra strain on the muscles, increasing the risk of musculoskeletal problems.

This study found that low back pain is the most prevalent issue, affecting 39.7% of workers. According to Fatoye [31], symptoms on the lower back are frequent as a result of physical exercise that involves a lot of movement, repetition, and body bending. Due to the lack of technology used, production operations in the manufacturing sector tend to be physically taxing, repetitive, and high force manual procedures. According to the result, long periods of static body standing and/or bending are signifficantly associated with low back discomfort. At a body bend position, the joints, muscles, and skeleton at the waist extends, putting more strain on the spinal muscles [32]. Due to its location around the waist, the lower back is susceptible to significant pressure. Meanwhile, static long standing should theoretically put strain on the feet and lower body due to the center of the weights in human body builds on the feet [33]. In this study, the static long standing position may be followed by certain awkward postures such as bending over, causing low back pain.

The neck is the second part of the body which most exposed to WMSDs, reported by 29.4% of respondents. Based on Arvidsson[34], neck complaints in workers occur due to repetitive head movement or static long neck bend or rotation in the neck joint. But in this study, neck complaints were significantly caused by exposure to ergonomic hazards on the shoulders. Shoulder exposure indicates by the position of lifting objects without support on the elbow position [23]. It increases by arms strain due to the heavier object or the effort made [11]. Since the shoulder joints are close to the cervical vertebrae joints, it might causing discomfort area spread to the neck.

In the result we know that there are diference ergonomic hazards that significantly associated with WMSDs in the particular body region. Most of ergonomic hazards in the upper body contribute in MSD complaints in particular part of the body. The only hazard that not significantly related to any MSD symptoms is wrist rotation. In the lower body, only body bend or rotation and static long standing significantly caused WMSDs in the lower body. These results may indicate that the proportion of ergonomic hazards in the upper body causes more risk of WMSDs than in the lower body, which may also be related to the dominant working position in the manufacturing industry. Workers are frequently exposed to ergonomic risks to both the upper and lower bodies, but the upper body risks are more frequently linked to WMSD symptoms.

According to Huysamen [35], work activities in the upper body are mostly related to hand and arm effort and lifting objects with using non-foot-centered supports. If this activity is carried out continuously, it will raising load in the upper body which physiologically are not designed to be weight fulcrum. The upper body is more likely less intense as a center of support compared to the lower body such as the hips, calves and feet [36]. This may explain how work activities in the upper body parts are more likely to be at higher risk for WMSDs.

Indeed, all of ergonomic hazards in the SNI 9011:2021 are defined as measurement standard and confirmed to be WMSDs risks. However, it is hard to do an overall assesment by measuring 43 indicators, epecially for a small-scaled or traditional industries. The main objectives in this study is to determine which WMSDs caused by particular ergonomic hazars based on the upper and lower body region assesment. The findings in this study could be used as a fundamental reference in evaluating certain work posutre and the risk in the manufacture occupation.

In the end, The methods and instruments used in this research have not been compared with other measuring tools, such as RULA, ROSA, etc. However, it is defined as national standard tool which has been validated. Although it is generally acknowledged that a balanced body posture is crucial for the appropriate operation of musculoskeletal structures, postural assessment is a complicated and challenging measurement. There have been only few studies that show how various musculoskeletal ailments or dysfunction can alter body posture. In order to further the development of control proram that is based on evidence, it is crucial to construct trustworthy and reliable procedures that are intended to quantify variables that aid in postural assessment.

4. CONCLUSION

Based on the result of the study, it can be concluded that most workers in the traditional manuacturing industries in Ponorogo Regency exposed to ergonomic hazards caused by wrist rotation, followed by body bend or rotation and push or pull activity. While the body parts most vulnerable to WMSDs include the lower back, neck, and shoulders.

Workers are frequently exposed to ergonomic risks to both the upper and lower body region, but the upper body risks are more frequently associated to WMSD symptoms. WMSDs in the upper body region determined by the neck bend or rotation and manual handling, while in the lower body region, body bend or rotation is the only ergonomic hazard that has a significant correlation.

REFERENCES

[1] K. dan U. M. Dinas Perdagangan, "Data Statistik Sektoral Kabupaten Ponorogo," 2020. [Online]. Available: https://data.ponorogo.go.id/instansi/Dinas Perdakum.

[2] S. Vinberg, "Occupational safety and health challenges in small-scale enterprises," *Ind. Health*, vol. 58, no. 4, pp. 303–305, 2020.

[3] Y. Ayub and Z. A. Shah, "Assessment of work related musculoskeletal disorders in manufacturing industry," *J Ergon.*, vol. 8, no. 3, pp. 1–5, 2018.

[4] Y. DWIJAYANTI, "PENILAIAN POSTUR KERJA0DENGAN METODE RAPID ENTIRE BODY ASSESSMENT (REBA) DI INDUSTRI JENANG TEGUH RAHARDJO, PONOROGO, JAWA TIMUR," Universitas Gadjah Mada, 2020.

[5] D. Afif Arifah, "Stretching exercise to reduce musculoskeletal pain among x bakery's workers," *Stretching Exerc. to reduce Musculoskelet. pain among x Bak. Work.*, vol. 10, no. 3, pp. 544–550, 2021.

[6] D. F. R. Dwi Feby Ramadanu, "Analisis Postur Kerja pada Pekerja Manual Handling di Perusahaan: Sebuah Tinjauan Sistematis," 2020.

[7] G. Ahn, S. Hur, and M.-C. Jung, "Bayesian network model to diagnose WMSDs with working characteristics," *Int. J. Occup. Saf. Ergon.*, vol. 26, no. 2, pp. 336–347, 2020.

[8] M. Z. Alnaser, "Effect of Work-Related Musculoskeletal Disorders on Psychosocial Health and Well-Being," *J. Allied Health*, vol. 50, no. 4, pp. 299–306, 2021.

[9] H. Daneshmandi, A. R. Choobineh, H. Ghaem, M. Alhamd, and A. Fakherpour, "The effect of musculoskeletal problems on fatigue and productivity of office personnel: a cross-sectional study," *J. Prev. Med. Hyg.*, vol. 58, no. 3, p. E252, 2017.

[10] WHO, "Musculoskeletal health," *Newsroom*, 2022.

[11] Y.-W. Chan, T.-H. Huang, Y.-T. Tsan, W.-C. Chan, C.-H. Chang, and Y.-T. Tsai, "The risk classification of ergonomic musculoskeletal disorders in work-related repetitive manual handling operations with deep learning approaches," in *2020 International Conference on Pervasive Artificial Intelligence (ICPAI)*, 2020, pp. 268–271.

[12] O. Korhan and A. A. Memon, "Introductory chapter: work-related musculoskeletal disorders," in *Work-related musculoskeletal disorders*, IntechOpen, 2019.

[13] M. L. C. Comper, J. T. Dennerlein, G. dos Santos Evangelista, P. R. da Silva, and R. S. Padula, "Effectiveness of job rotation for preventing work-related musculoskeletal diseases: a cluster randomised controlled trial," *Occup. Environ. Med.*, vol. 74, no. 8, pp. 543–544, 2017.

[14] Center for Disease Control and Prevention (CDC), "Work-Related Musculoskeletal Disorders & Ergonomics," *Workplace Health Strategies*, 2020. https://www.cdc.gov/workplacehealthpromotion/health-strategies/musculoskeletal-disorders/index.html#print.

[15] J. Theurel and K. Desbrosses, "Occupational exoskeletons: overview of their benefits and limitations in preventing work-related musculoskeletal disorders," *IISE Trans. Occup. Ergon. Hum. Factors*, vol. 7, no. 3–4, pp. 264–280, 2019.

[16] G. Wang, Y. Zhang, X. Ye, and X. Mou, "Artificial neural networks," in *Machine Learning for Tomographic Imaging*, IOP Publishing, 2019.

[17] K. K. Toosi, N. S. Hogaboom, M. L. Oyster, and M. L. Boninger, "Computer keyboarding biomechanics and acute changes in median nerve indicative of carpal tunnel syndrome," *Clin. Biomech.*, vol. 30, no. 6, pp. 546–550, 2015.

[18] A. M. Mesia, L. P. Ruliati, and A. Setyobudi, "The Relationship of Long Work When Using Laptop With Carpal Tunnel Syndrome (CTS) in College Students," *J. Heal. Behav. Sci.*, vol. 4, no. 2, pp. 215–223, 2022.

[19] R. de Cássia Pereira Fernandes, S. M. da Silva Pataro, R. B. De Carvalho, and A. Burdorf, "The concurrence of musculoskeletal pain and associated work-related factors: a cross sectional study," *BMC Public Health*, vol. 16, no. 1, pp. 1–9, 2016.

[20] J. Wang, D. Chen, M. Zhu, and Y. Sun, "Risk assessment for musculoskeletal disorders based on the characteristics of work posture," *Autom. Constr.*, vol. 131, p. 103921, 2021.

[21] G.-W. J. Andreas and E. Johanssons, "Observational methods for assessing ergonomic risks for work-related musculoskeletal disorders. A scoping review," *Rev. Ciencias la Salud*, vol. 16, no. SPE, pp. 8–38, 2018.

[22] M. Ramaganesh, R. Jayasuriyan, T. Rajpradeesh, S. Bathrinath, and R. Manikandan, "Ergonomics hazard analysis techniques-A technical review," *Mater. Today Proc.*, vol. 46, pp. 7789–7797, 2021.

[23] B. S. N. (BSN), "SNI 9011:2021 tentang Pengukuran dan Evaluasi potensi Bahaya Ergonomi di Tempat Kerja." 2021.

[24] L. M. Schleifer, R. Ley, and T. W. Spalding, "A hyperventilation theory of job stress and musculoskeletal disorders," *Am. J. Ind. Med.*, vol. 41, no. 5, pp. 420–432, 2002.

[25] F. S. Violante *et al.*, “Carpal tunnel syndrome and manual work: the OCTOPUS cohort, results of a ten-year longitudinal study,” *Scand. J. Work. Environ. \& Heal.*, pp. 280–290, 2016.

[26] L. E. Charles, C. C. Ma, C. M. Burchfiel, and R. G. Dong, “Vibration and ergonomic exposures associated with musculoskeletal disorders of the shoulder and neck,” *Saf. Health Work*, vol. 9, no. 2, pp. 125–132, 2018.

[27] S. K. Lwanga, S. Lemeshow, W. H. Organization, and others, *Sample size determination in health studies: a practical manual*. World Health Organization, 1991.

[28] R. Forwarda and J. Mangharama, “Influencing nationally recognised training programmes for the purpose of applying evidence based manual task training across Australia.,” in *Proceedings 19th Triennial Congress of the IEA*, 2015, vol. 9, p. 14.

[29] M. N. A. Rahman and M. F. A. Zuhaidi, “Musculoskeletal symptoms and ergonomic hazards among material handlers in grocery retail industries,” in *IOP Conference Series: Materials Science and Engineering*, 2017, vol. 226, no. 1, p. 12027.

[30] B. Singh and P. Singhal, “Work related musculoskeletal disorders (wmsds) risk assessment for different welding positions and processes,” in *14th International Conference on Humanizing Work and Work Environment HWWE*, 2016, pp. 264–267.

[31] F. Fatoye, T. Gebrye, and I. Odeyemi, “Real-world incidence and prevalence of low back pain using routinely collected data,” *Rheumatol. Int.*, vol. 39, pp. 619–626, 2019.

[32] J. Chen, J. Qiu, and C. Ahn, “Construction worker’s awkward posture recognition through supervised motion tensor decomposition,” *Autom. Constr.*, vol. 77, pp. 67–81, 2017.

[33] T. Bosch, J. van Eck, K. Knitel, and M. de Looze, “The effects of a passive exoskeleton on muscle activity, discomfort and endurance time in forward bending work,” *Appl. Ergon.*, vol. 54, pp. 212–217, 2016.

[34] I. Arvidsson, C. Dahlqvist, H. Enquist, and C. Nordander, “Action levels for the prevention of work-related musculoskeletal disorders in the neck and upper extremities: a proposal,” *Ann. Work Expo. Heal.*, vol. 65, no. 7, pp. 741–747, 2021.

[35] K. Huysamen, T. Bosch, M. de Looze, K. S. Stadler, E. Graf, and L. W. O’Sullivan, “Evaluation of a passive exoskeleton for static upper limb activities,” *Appl. Ergon.*, vol. 70, pp. 148–155, 2018.

[36] K. F. Allison *et al.*, “Musculoskeletal, biomechanical, and physiological gender differences in the US military.,” *US Army Med. Dep. J.*, 2015.

6% Overall Similarity

Top sources found in the following databases:

- 4% Publications database
- Crossref database
- Crossref Posted Content database
- 4% Submitted Works database

TOP SOURCES

The sources with the highest number of matches within the submission. Overlapping sources will not be displayed.

1	**Ratih Andhika Akbar Rahma, Fahri Cahyo Satria, Aisy Rahmania, Rinda...** Crossref	<1%
2	**Nueva Ecija University of Science and Technology on 2023-05-20** Submitted works	<1%
3	**Universitas Airlangga on 2023-10-10** Submitted works	<1%
4	**International Islamic University Malaysia on 2015-10-26** Submitted works	<1%
5	**"Industrial Engineering and Applications", IOS Press, 2023** Crossref	<1%
6	**The University of Texas at Arlington on 2023-08-15** Submitted works	<1%
7	**"Proceedings of the 20th Congress of the International Ergonomics As...** Crossref	<1%
8	**Ton Duc Thang University** Publication	<1%
9	**D. Kriebel, H. Checkoway, N. Pearce. "Exposure and dose modelling in ...** Crossref	<1%

10	Higher Education Commission Pakistan on 2016-08-17 Submitted works	<1%
11	Universiti Putra Malaysia on 2015-07-27 Submitted works	<1%
12	University of Edinburgh on 2019-08-22 Submitted works	<1%
13	Ganaswaran Segar, Mohd Nasrull Abdol Rahman. "Musculoskeletal sy... Crossref	<1%
14	"Recent Trends in Manufacturing and Materials Towards Industry 4.0", ... Crossref	<1%
15	Middlesex University on 2019-10-04 Submitted works	<1%
16	Merry Siska, Reski Mai Candra, Eki Saputra, Masud Zein, Alex Wenda, ... Crossref	<1%
17	M.F. Antwi-Afari, H. Li, D.J. Edwards, E.A. Pärn, J. Seo, A.Y.L. Wong. "Bi... Crossref	<1%
18	Udayana University on 2023-04-30 Submitted works	<1%
19	Universitas Diponegoro on 2022-06-27 Submitted works	<1%
20	Abrar Arbhiwa Tanguirsyaf Siregar, Shalita Dastamuar, Theodorus The... Crossref	<1%
21	Junqi Zhao, Esther Obonyo. "E-health of Construction Works: A Proacti... Crossref	<1%

22	Rochester Institute of Technology on 2020-05-28 Submitted works	<1%
23	School of Business & Computer Science Limited on 2023-04-25 Submitted works	<1%
24	Coventry University on 2017-08-21 Submitted works	<1%
25	Faisal Reza Pradhana, Taufiqurrahman, Inqi Azhar Aziz Basyaruddin. "... Crossref	<1%
26	Sunshin Kim, Kuck-Hyeun Woo, Seong-Yong Yoon, Hyun-Sul Lim et al. "... Crossref	<1%
27	"Human-Centered Technology for a Better Tomorrow", Springer Scienc... Crossref	<1%
28	Habluetzel, A.. "Impact of the botanical insecticide Neem Azal^(R) on s... Crossref	<1%

Excluded from Similarity Report

- Internet database
- Quoted material
- Manually excluded sources
- Bibliographic material
- Cited material

EXCLUDED SOURCES

"NAASO Oral Presentations", Obesity Research, 1995. Crossref	1%
R P Findlay. "FDTD calculations of specific energy absorption rate in a seated ... Crossref	<1%
Universitas Negeri Jakarta on 2022-01-11 Submitted works	<1%
The University of Texas at Arlington on 2023-08-15 Submitted works	<1%
Universitas Diponegoro on 2019-07-29 Submitted works	<1%