International Journal of Occupational Safety and Health

ISSN: 2091-0878 (Online) ISSN: 2738-9707 (Print)

Original Article

Identification of Musculoskeletal Disorder among Eco-Brick Workers in Indonesia

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Date of submission: 21.04.2022
Date of acceptance: 02.08.2022
Date of publication: 01.01.2023

Conflicts of interest: None
Supporting agencies: UAD grant, PDD-301/SP3/LPPM-UAD/VI/2021
DOI: https://doi.org/10.3126/ijosh.v13i1.44575

ABSTRACT

Introduction: Plastic waste is considered one of the common vital waste problems in developing countries such as Indonesia. One proposed alternative way to reduce plastic waste is by reusing and recycling it into bricks. Eco-bricks are a form of recycled plastic waste that can be used as an alternative building construction material. Unfortunately, manufacturing workers do not ergonomically perform this work during their working hours. Therefore, it causes inappropriate body postures and leads to musculoskeletal disorders easily. This study intends to identify the posture of workers in the manufacture of eco-bricks in Indonesia

Methods: A cross-sectional study was done with purposively selected 32 eco-bricks workers from 10 waste bank communities in Central Java and Yogyakarta. Sampling was done by snowball method. This research was conducted by interviewing and collecting data on body complaints using a Nordic Body Map (NBM) questionnaire.

Results: All respondents (100%) experienced musculoskeletal disorder complaints while producing eco-bricks. Based on the results gained from the Nordic Body Map Questionnaire, the common complaints perceived by eco-bricks workers are upper neck, lower neck, back, waist, buttock, and bottom. In addition, workers also perceived complaints on the right side of the body, particularly the right shoulder, right upper arm, right elbow, right lower arm, right wrist, and right hand

Conclusion: Working postures that are not well-organized in terms of ergonomics during the production process of eco-bricks will provoke complaints on the limbs caused by the continuous load on the muscles on the right side of the body.

Keywords: Eco-brick, Nordic Body Map, MSDs, Plastic waste

Introduction

Waste management is identified as one of many severe environmental problems. Waste problems can surely disrupt the environment around the community, such as soil pollution. A polluted environment will also have an impact on public health. There are several causes for the increase in waste, specifically the increase in population, the level of community activity, the socio-economic level of the community, technological advances, and also the pattern of people's lives.[1] Technological boost also increases the amount of waste. It can be seen from the use of personal devices and frequently updating them to the latest ones.[2] The world population is rapidly increasing that it produces waste more and getting worrying. Various types of waste have been generated in various countries, and also numerous 3R programs (Reuse, Reduce, and Recycle) have been proposed to reduce waste that can affect the environment.[3]

Reduce, reuse, and recycle are now recognized as important waste management principles around

the world to avoid high tipping fees due to a scarcity of landfill sites. The significant increase in the amount of waste in developing countries has led to an increase in environmental impacts and health problems.[4] Waste reduction in the community can be controlled by the community setting into a useful product that has economic value.[1]

Plastic waste is identified as a prominent problem in developing countries such as Indonesia. In this instant era, plastic wrappers are easily found everywhere. Plastic packaging is widely used in everyday life because of its high-performance features and low production costs.[5] Besides, plastics are also made of chemical polymers that cannot be degraded naturally so that plastic will not decompose even if buried.[6] Combinations of synthetic polymers such as polyethylene, polyamide, polypropylene, polystyrene, polyethylene terephthalate, and polyvinyl chloride are often used as packaging materials.[7] Polymer waste such as post-consumption plastic is the main component of solid waste that creates a very large environmental burden because it is not easily degraded.[8] Plastic waste can pollute the environment caused by carbon bonds, both primary carbon and secondary carbon in plastic packaging.[9] Therefore, it is necessary to manage plastic waste into new and valuable products.

Most of the plastic waste in the community is only dumped in rivers and the sea. The study found around 10 million tons of plastic waste was dumped into the sea which ultimately had an impact on marine life.[10] High-Density Polyethylene (HDPE), Low-Density Polyethylene (LDPE) and Polyethylene (PET) are the most widely used materials for plastic packaging and plastic bottles. The process of recycling plastic waste is one way to reduce the amount of waste in the community. One form of recycling is to make a useful product from plastic waste. The products produced from inorganic waste processing include wallets, bags, plastic flowers, and other forms of crafts.[11]

In addition to crafts, plastic waste can also be used for various mixtures in the manufacture of asphalt, road construction, paving blocks, bricks, and eco-bricks.[12-17] Recycling is one of the technologies that can be adopted in waste management after the process of preventing, minimizing,g and reusing waste [18,19.] There are 3 types of low-cost construction developed in the construction sector, namely social-based low-cost construction consisting of 3 materials like wood plastic composite, tetra pack chip panels, and PET eco brick.

One environment-friendly alternative is to use PET plastic bottles to be used as bricks.[20]Plastics have properties that are durable and corrosion resistant. Besides, they are also energy efficient, economical, have long life spans, and are also lightweight. In short, the eco-brick concept might be used as an alternative building construction material. Those contemplate the reasons why eco-bricks might be utilized as a choice for building construction materials.[6,21-23] Furthermore, the reuse of PET plastic bottles as building materials will have a good effect on energy savings and also will reduce CO2 emissions.[20] The performance of eco-brick as a construction alternative depends on the material used and the power to fill the bottle. Construction materials using eco-bricks have been used by Rohingya refugees in Bangladesh to be adopted as houses. [22-24]

Waste management in Indonesia is mostly carried out by waste banks. The waste bank becomes of the activities to reduce waste by implementing community-based of 3Rs. The basic principle of waste banks in all provinces in Indonesia is collecting, storing, producing, changing behavior, and enjoying a clean environment. In the other concept of a waste bank, plastic waste can be reused for an economic transaction. In the waste banks, all PET bottles make some eco-bricks to reduce plastic waste to be disposed of in a landfill.

The eco-bricks have some advantages. Besides their strength and durability, eco-bricks are also long-lasting because of the original nature of the plastic which is water-resistant and does not decompose easily. However, it takes a long time to produce eco-bricks. Based on the observations addressed, it can be seen that the average time required to compact plastic pieces into 1 full bottle is approximately 27 minutes. Factors that affect its time-consuming compacting process are the location of the empty bottle holder and placing the filled bottle beyond the working range. The basin used for the small plastic piece container is only able to accommodate as many as 300 grams of plastic pieces so you have to repeatedly fill the material into the container and scatter tools.

In addition, during the plastic compacting process, most workers complained of pain, including back and neck pain due to a half-bent working position for a long and constant time. They also complained of leg cramps due to sitting on the floor with legs folded or cross-legged for a continued period.

Besides, the area around the palms of workers also experiences calluses (callus). This makes workers uncomfortable in carrying out activities. Poor work posture will cause disorders of the skeleton or disorders of musculoskeletal disorders. Musculoskeletal disorders (MSDs) are injuries to the muscles, nerves, tendons, ligaments, joints, cartilage, or spinal discs. Continuous work and improper posture will also increase the possibility of MSD risk factors for workers.[25]

Several former studies have assessed MSDs in various construction fields as well as in material handling. Galuh Sista, et al analyzed work posture and MSD complaints in batik workers. while Widyanti, et al also conducted an ergonomic analysis on mothering and child activities. In addition, Ijaz, et al conducted a quantitative and qualitative assessment of MSD disorders in the brick industry in Pakistan.[25,26,27] The method used in this study is the standard Nordic Body Map Questionnaire and RULA. The use of the Nordic Body Map Questionnaire method was also conducted by Okka, et al. [28] This study was carried out by analyzing the body posture of workers in SMEs. In addition, Ismayenti, et al also applied the Nordic Body Map to analyze fatigue and MSD complaints on garment sewing operators.[29]

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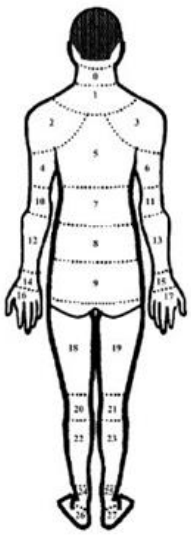
However, there has been no former study evaluating the body posture in eco-bricks manufacturers. Therefore, this study aims to analyze the body posture of workers in the manufacture of eco-bricks as many complaints felt by operators of eco-bricks.

Methods

This research was conducted in Yogyakarta and Central Java. There were 32 respondents from 10 waste bank communities in Central Java and Yogyakarta incorporated in this study. This study purposively selects 32 respondents by using the Slovin method with an acceptable error of 10 percent. Sampling in this study by snowball sampling. The type of research used in this study is observational with a cross-sectional study approach. This research was conducted by interviewing and collecting data on body complaints using a Nordic Body Map (NBM) questionnaire. The NBM questionnaire is used for the identification of musculoskeletal disorders, the detailed questionnaire used can be observed in Figure 1.



No	Location	Grade of complaints			
0	Pain/stiff in the upper neck	A	B	C	D
1	Pain in the lower neck				
2	Pain in the left shoulder				
3	Pain in the right shoulder				
4	Pain in the left upper arm				
5	Pain in the back				
6	Pain in the right upper arm				
7	Pain in the waist				
8	Pain in the buttock				
9	Pain in the bottom				
10	Pain in the left elbow				
11	Pain in the right elbow				
12	Pain in the left lower arm				
13	Pain in the right lower arm				
14	Pain in the left wrist				
15	Pain in the right wrist				
16	Pain in the left hand				
17	Pain in the right hand				
18	Pain in the left thigh				
19	Pain in the right thigh				
20	Pain in the left knee				
21	Pain in the right knee				
22	Pain in the left calf				
23	Pain in the right calf				
24	Pain in the left ankle				
25	Pain in the right ankle				
26	Pain in the left foot				
27	Pain in the right foot				

Figure 1: Nordic Body Map Questionnaire (Source: https://pei.or.id/)

The respondents filled in personal data before doing the questionnaire such as name, age, height, weight, years of service, and average working hours per day. In addition, the researchers explained the implementation of the research. Then the respondents were asked to fill out an agreement to take part in the study. Furthermore, respondents were asked to fill out a Nordic Body Map (NBM) questionnaire containing 28 extremities that experienced musculoskeletal complaints by placing a checkmark on one of the MSD complaints options, namely no pain, mild pain, pain, and very painful. Measurement of Body Mass Index (BMI) is done by calculating height and weight. According to WHO

BMI was categorized into severely underweight (BMI < 18.5), normal (BMI 18.5-24.9), overweight (BMI 25-29.9), and obese (BMI 30).[32,33] To calculate Body Mass Index (BMI), respondents were required to measure their height and weight. BMI is computed as body weight in kilograms divided by the square of height in meters (kg/m2) and is categorized into four groups according to WHO. The division of BMI according to WHO is determined as underweight (BMI < 18.5), normal (BMI 18.5-24.9), overweight (BMI 25-29.9), and obese (BMI 30).

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Results

The respondents of this research are 32 eco-brick craftsmen in Central Java and Yogyakarta. The respondent's character data were analyzed based on age, weight, height, working years, operational time, and also BMI.

Subject character data was summarized in mean and standard deviation. The measurement of age is based on the date of birth written on their national ID card, gender is a phenotypic feature that can be seen. Detailed data on the characteristics of the respondent might be observed in Table 1. While the age and gender data are displayed in Table 2.

Table 1: The characteristics data of the respondents

Description	Average (n=32)	StdDev (n=32)
Age	44.4	7.8
Height (cm)	162.0	4.0
Weight (kg)	67.4	12.8
experience (year)	3.4	1.0
Working hours/day	3.1	0.7
BMI	25.7	5.1

Table 2: The age and genders of the respondents

Variable	Characterization	Frequency	Percentage (%)
Age	20-30	1	3%
	31-40	9	28%
	41-50	16	50%
	51-60	6	19%
Gender	Male	6	19%
	Female	26	81%

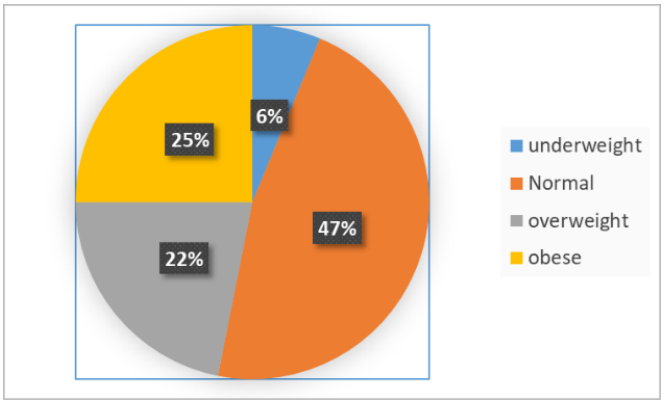

Figure 2: Distribution of Body Mass Index of respondents according to WHO

The results of the BMI distribution show that 6% of respondents are underweight, 47% of respondents are in the normal category, the overweight category of respondents has a value of 22%, and 25% of

respondents are in the obese category Figure . The BMI of each population has a different value, this depends on environmental factors, such as the amount of physical activity and diet. A high percentage of BMI reflects a higher risk of disease.[34] The Body Mass Index of eco-bricks makers ranges from 17.15 to 36.51.

Furthermore, the results of the grouping of all respondents might be observed in Table 3. Table 3 presents the complaints experienced by respondents. Most of those who belong to the category of underweight, normal, overweight, and obese had complaints in 3 parts of the body. They are the neck, shoulders, and back. Meanwhile, most workers who belong to the normal category have complaints about the right shoulder.

Table 3: Classification of complaints experienced by the respondent

BMI	Neck		Shoulder		Back
	Upper	Lower	Left	Right	
Underweight (n = 2)	2	2	0	2	2
Normal (n = 15)	4	15	0	15	15
Overweight (n = 7)	7	7	0	7	7
Obese (n = 8)	8	8	0	8	8

Based on the results of the Nordic Body Map questionnaire filled up by the respondents, it was also found that there are several complaints about the members of the workers' bodies can be seen in Table 4. The detailed prescribed complaints might be seen and analyzed in Figure 3.

Table 4: Distribution of complaints by respondents

No	Part of body	Complaints									
		Not Pain		Moderate pain		Pain		Very Painful		Total	
		N	%	N	%	N	%	N	%	N	%
1.	Upper neck	0	0	6	19	26	81	0	0	32	100
2.	Lower neck	0	0	1	3	31	97	0	0	32	100
3.	Right Shoulder	0	0	2	6	30	94	0	0	32	100
4.	Back	0	0	1	3	31	97	0	0	32	100
5.	Right Lower arm	1	3	3	9	28	88	0	0	32	100
6.	Waist	0	0	1	3	31	97	0	0	32	100
7.	Buttock	0	0	2	6	31	97	0	0	32	100
8.	Bottom	0	0	2	6	30	94	0	0	32	100
9.	Right Elbow	1	3	28	88	3	9	0	0	32	100
10.	Right Upper arm	2	6	1	3	29	91	0	0	32	100
11.	Right wrist	1	3	3	9	28	88	0	0	32	100
12.	Right hand	0	0	1	3	31	97	0	0	32	100

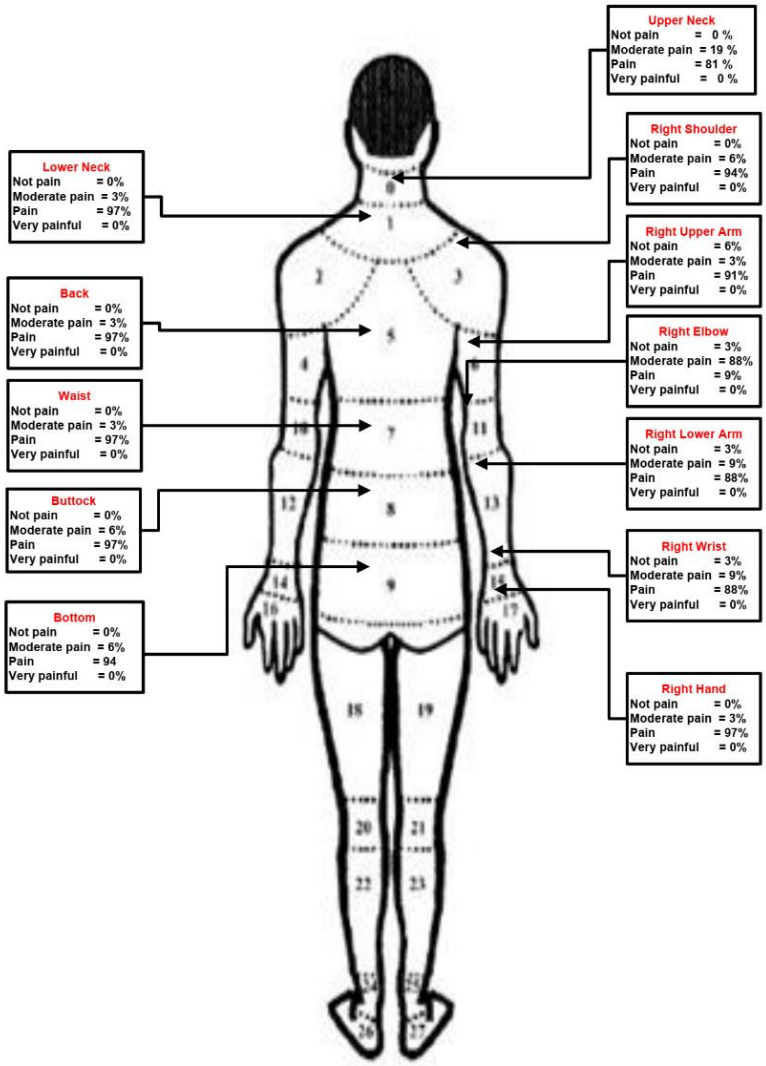

Figure 3: Nordic Body Map questionnaire results

Statistical analysis was assessed using the chi-square test. The statistical analysis was done using SPSS produced p value >0.05, which means that there is no relationship between gender with body parts grievance. It is also possible that it is the result of a habit of working with a workload that exceeds the limit of muscle strength. Also, their work posture is unusual, and their body part moves away from their natural position on a continuous and long-term basis because the space for movement is limited and the equipment used is still traditional.

The p-value > 0.05 means that there is no relationship between gender with body parts grievance. It is also possible that it is the result of a habit of working with a workload that exceeds the limit of muscle strength. Also, their work posture is unusual, and their body parts move away from their natural position on a continuous and long-term basis because the space for movement is limited and the equipment used is still traditional.

The p-value is more than 0.05 which indicates that the BMI is not as significant with body parts grievance. But in the back, waist, and right-hand p-value is less than 0.05 which means BMI was significant with pain in the back, waist, and right hand. Eco-brick workers have several complaints Around the palms. Workers also experience calluses that cause discomfort in carrying out activities Figure 4. The body position of the ecobrick maker can be seen in Figure 5.

Table 5: The association between Gender and pain in body parts

Variables	Gender	Body grievances				p-values
		Yes		No		
		N	%		%	
Upper neck	Male	5	16	1	3	0.885
	Female	25	78	1	3	
Lower neck	Male	6	19	0	0	0.625
	Female	25	78	1	3	
Right Shoulder	Male	6	19	0	0	0.483
	Female	24	75	2	6	
Back	Male	6	19	0	0	0.625
	Female	25	78	1	3	
Right Lower arm	Male	6	19	0	0	0.304
	Female	22	69	4	13	
Waist	Male	6	19	0	0	0.625
	Female	25	78	1	3	
Buttock	Male	6	19	0	0	0.625
	Female	25	78	1	3	
Bottom	Male	6	19	0	0	0.483
	Female	24	75	2	6	
Right Elbow	Male	1	3	5	16	0.497
	Female	2	6	24	75	
Right Upper arm	Male	6	19	0	0	0.382
	Female	23	72	3	9	
Right wrist	Male	5	16	1	3	0.732
	Female	23	72	3	9,4	
Right hand	Male	6	19	0	0,0	0.625
	Female	25	78	1	3,1	

Table 6: The association between the BMI and pain in body parts

Variables	Body grievances		BMI				p-values
			underweight	Normal	Overweight	Obese	
Upper neck	Yes	N	2	11	5	8	0.338
		%	6	34	16	25	
	No	N	0	4	2	0	
		%	0	13	6	0	
Lower neck	Yes	N	2	14	7	8	0.760
		%	6	44	22	25	
	No	N	0	1	0	0	
		%	0	3	0	0	
Right Shoulder	Yes	N	1	14	7	8	0.057
		%	3	44	22	25	
	No	N	1	1	0	0	
		%	3	3	0	0	
Back	Yes	N	1	15	7	8	0.001

		%	3	47	22	25	
	No	N	1	0	0	0	
		%	3	0	0	0	
Right Lower arm	Yes	N	1	12	7	8	0.139
		%	3	38	22	25	
	No	N	1	3	0	0	
		%	3	9	0	0	
Waist	Yes	N	1	15	7	8	0.001
		%	3	47	22	25	
	No	N	1	0	0	0	
		%	0	0	0	0	
Buttock	Yes	N	2	15	7	7	0.377
		%	6	47	22	22	
	No	N	0	0	0	1	
		%	0	0	0	3	
Bottom	Yes	N	2	14	7	7	0.768
		%	6	44	22	22	
	No	N	0	1	0	1	
		%	0	3	0	3	
Right Elbow	Yes	N	0	1	0	2	0.339
		%	0	3	0	6	
	No	N	2	14	7	6	
		%	6	44	22	19	
Right Upper arm	Yes	N	1	14	7	7	0.185
		%	3	44	22	22	
	No	N	1	1	0	1	
		%	3	3	0	3	
Right wrist	Yes	N	1	14	7	6	0.159
		%	3	44	22	19	
	No	N	1	1	0	2	
		%	3	3	0	6	
Right hand	Yes	N	1	15	7	8	0.001
		%	3	47	22	25	
	No	N	1	0	0	0	
		%	3	0	0	0	

Figure 2: Callus in the hand worker

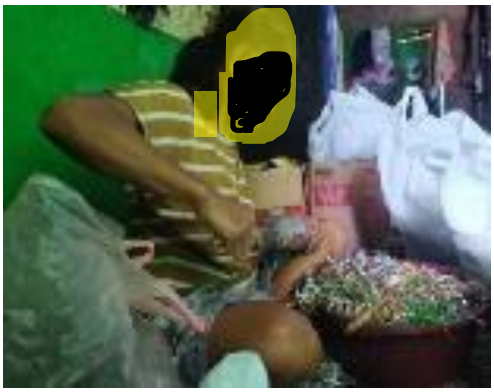

Figure 3: Body Position of eco-brick worker

Discussion

The findings from the Nordic body map survey revealed that there is no relationship between gender and body parts grievances. But the relationship between BMI and body parts grievances was statistically significant with pain in the back, waist, and right hand. Being overweight and obese are some of the common health problems that greatly affect medical conditions. Elevated BMI conditions have been identified as an independent risk factor that can lead to musculoskeletal disorders (MSDs).[35] Research from Viester, et al illustrates that BMI conditions affect several body parts, including the neck, shoulders, and back.[36] In this study, the complaints of respondents who answered moderate pain, pain, and very painful were grouped as complaints of having overall musculoskeletal symptoms, while those who answered not pain were classified as having no musculoskeletal symptoms. It is well known that people with a higher body mass index (BMI) have more musculoskeletal pain than people with a lower BMI. BMI is an independent risk factor for the development of MSDs, as well as an increase in MSD prevalence over 12 months.[37]

When the body moves, it uses ATP (adenosine triphosphate) and calcium energy to contract muscles. When muscles use ATP for contraction, it is directed by anaerobic metabolism, or fuel metabolism without oxygen, which causes fuel damage and the formation of lactic acid. Muscle pain is caused by an accumulation of lactic acid. Muscle complaints occur when the muscles continue to contract without the possibility of relaxation.[38]

Several studies on MSDs complaints experienced by workers showed its impact on the back and shoulder muscles. This complaint is often experienced by workers who carry out constant movements without taking a rest for several hours. In this study, out of 32 respondents from waste bank workers, it was found that 100% of the respondents experienced MSDs complaints. This questionnaire was filled out by asking for complaints for 1 year doing the same job.

Musculoskeletal disorders (MSDs) are a major health problem in the working community, with low back pain (LBP) being one of the most common MSDs. MSDs have a high impact on individual workers, due to problems such as pain and limitations in daily activities. This MSDs' complaint is the result of repetitive movements that are carried out continuously.[30]

Based on Figure 3, the most common complaints felt by eco-brick workers are on the upper neck, lower neck, back, waist, buttock, and bottom. In addition, workers also feel complaints on the right side of the body, particularly the right shoulder, right upper arm, right elbow, right lower arm, right wrist, and right hand. The complaint on the right is due to the rest on the right side of the body while working on the waste banks.[39,40] Besides, the back is one of the body parts that are vulnerable because of the mechanism of the human body, the tissues, structures of the vulnerable spine, and bring in the weight-bearing muscle aspect. Work postures that are not ergonomic will drive workers to do a coercive attitude during their work. The working position of eco-brick workers is less ergonomic and there is a continuous load on the muscles on the right side of the body. This will result in trauma and a form of injury that is manifested by pain or tingling, swelling, and muscle weakness.[37,41] There is a possibility that waste bank workers experience MSDs due to the habit of doing work with a workload that exceeds the limit of muscle strength. This study can be used as a surveillance program for risk implications for eco-brick workers. However, the prevention of MSDs can be performed by attending ergonomic training programs and doing starching breaks in the muscles so that workers get more comfort in their workplace.

Conclusions

The results of the analysis showed that all eco-brick workers experienced MSDs complaints. Besides, based on the results of the Nordic Body Map Questionnaire, the common complaints felt by eco-brick workers are on the upper neck, lower neck, back, waist, buttock, and bottom. In addition,

workers also feel complaints on the right side of the body, particularly the right shoulder, right upper arm, right elbow, right lower arm, right wrist, and right hand. in addition, the BMI analysis showed the complaints experienced by 32 respondents can be categorized into 4 BMI categories, namely underweight, normal, overweight, and obese. Eco-brick workers who are included in the normal category have complaints in the form of a right shoulder. In short, workers categorized as underweight, normal, overweight, and obese have neck, shoulder, and back complaints. Further detailed research is warranted for this area of study using detailed ergonomic assessments.

Acknowledgments

This research is fully supported by UAD grant, PDD-301/SP3/LPPM-UAD/VI/2021. The authors fully acknowledged Universitas Ahmad Dahlan and Universiti Teknikal Malaysia Melaka for the approved fund which makes this important research viable and effective.

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