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Work Facility Design of the Ergonomic Tempeh Plastic Wraps Punching Tool Reduces Musculoskeletal Complaints and Working Time

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Abstract. *Tempe Murni small unit is a tempeh processing business located in Ngoto, Bangunharjo, Sewon, Bantul, Yogyakarta. There was a work process which caused muscle fatigue on the process of making holes on the tempeh wraps using manual tool because it had not met the ergonomic standard. The work posture of the workers in doing the work was sitting on the floor, the left leg was folded inward and the right leg was stretched forward a little bit, thus, it might cause musculoskeletal complaints. Therefore, it required an ergonomic tempeh plastic wrap punching tool which could reduce the musculoskeletal complaints and the working time of the workers. The research object was the workers in the process of making holes on the tempeh plastic wraps. This research used ergonomic and anthropometric approaches to determine the dimensions of the workers' bodies. The Nordic Body Map (NBM) and the Visual Analogue Scale were used to determine the musculoskeletal complaints of workers. The results showed that the ergonomic design of the punching tool could reduce musculoskeletal complaints of pain sensation on the upper neck from the initial Visual Analog Scala (VAS) score of 65 into mild pain category with the scale score of 25. The initial back pain complaint with a moderate category with the scale score of 70 was reduced into mild pain category with the scale score of 16. The initial moderate pain on waist with the scale score of 70 was reduced into mild pain with the scale score of 18. The initial moderate pain on buttocks with the scale score of 70 was reduced into mild pain with the scale score of 26. The initial moderate pain on the lower part of the buttocks with a scale score of 69 was reduced into mild pain with a scale score of 29. The working time was reduced from 1.03 hours/unit into 0.52 hour/unit.*

Keywords: *Nordic Body Map (NBM), Visual Analogue Scale (VAS), Musculoskeletal Disorders, Working time*

I. INTRODUCTION

Industries in Indonesia are currently developing well and starting to rise up after the COVID-19 pandemic subsided. The industrial development is not only on medium or large industries, but also on small industries. Most of the small industries still use a lot of human labor in the production process to produce goods.

In the production activities of a small industry, it is often found some uncomfortable work facilities which can interfere with the workers' health. One of the health problems experienced by workers is caused by the work facility that is not suitable to the worker's body posture, thus, it can cause disorders of the musculoskeletal system. Receiving static loads repetitively in a long period of time can cause musculoskeletal complaints in the form of damage to joints, ligaments, and tendons. Those complaints and damages are usually called as musculoskeletal disorders (MSDs) or injuries to the musculoskeletal disorder system (Kroemer and Grandjean 2009; and Tarwaka, 2015).

HM Tempe Murni small industry is a tempeh processing business unit located in Ngoto, Bangunharjo, Sewon, Bantul, Yogyakarta. It had a work process that caused muscle fatigue, namely in the process of making holes on the plastic wraps of the tempeh. In the process, the worker worked with an awkward posture, in which, the worker sat on the floor with his left leg was folded inward and his right leg was extended forward to hold his right hand in swinging the plastic puncher. The tool used to make holes on the tempeh plastic wraps was still very simple and did not meet the ergonomic standards. The tool was

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in form of a nail with an iron handle wrapped in cloth.

The process started by placing the plastic on a thick wooden base which then stabbed using a hole puncher. The position of the worker's body was less ergonomic because he sat on the floor without using a pedestal. The posture was bending, and the nail was repetitively inserted into the plastic until the holes covered the size to wrap the tempeh. The bending body position which was monotonously and repetitively involving muscles stretching beyond the maximum motion range [Dul and Weerdmeester, 2008., Tarwaka. 2015] could cause the workers to experience musculoskeletal complaints [Budiyanto and Setiyoso, 2021.]. Musculoskeletal disorders are one of the ergonomic concerns that are often encountered in the workplace in relation to human energy and stamina [Adiyanto et.al, 2022, Farid et.al, 2020].

This business unit had an average capacity of 1 quintal of soybeans per day or approximately required 1,200 plastic wraps. Meanwhile, the consumer demand reached 2,150 plastic wraps. This condition was caused by the less ergonomic tool, thus, the time was wasted and the workers quickly experienced fatigue and pain on certain body parts. Work equipment that is not in accordance with the worker's posture creates an awkward or unergonomic work posture, thus, it can cause fatigue, uncomfortable feeling, and reduction on work efficiency [Kroemer and Grandjean, 2009]].

Therefore, it is necessary to design a work facility which is based on the workers' anthropometric data. Anthropometric data is widely used by researchers to design tools or work facilities [Wibowo and Soni, 2014]. Anthropometry is a body measurement which covers body size, strength, shape, capacity, and volume for designing certain purposes [Taifa and Desai. 2017], [Shiru et.al. 2012]. , Dawal et.al 2012.), including the tempeh plastic wraps punching tool facility.

II. Research Method

This research was conducted by designing the work facility of tempeh plastic wraps punching tool at the HM Tempe Murni MSME located in Ngoto, Bangunharjo, Sewon, Bantul, Yogyakarta. The research was started by designing an ergonomic work facility for the tempeh plastic wraps punching tool using anthropometric data of the workers, to replace the old way of working which only used a nail-piercing tool. The anthropometric data was used to make the design so that it could be used by the workers, thus, the design of the work facility must be adjusted to the workers' bodies. Anthropometric data is influenced by factors such as age, race, region, and occupation (Abdurrahman et al, 2018 and Luximon at al 2013). The data testing covered the normality test, uniformity test, and adequacy test data. The work facility was designed after obtaining the anthropometric data that had fulfilled the tests. The designing of the work facility was done using the SolidWorks application by referring to the anthropometric data of the workers' bodies. The tool was made using used-materials to minimize costs and by applying the 3R principle (Reuse, Reduce, Recycle). Workers' complaints were determined using the Nordic Body Map-VAS. The production increase was measured based on the production time result. The Visual Analog Scala (VAS) has a recommended pain level, in which, no pain scales from 0-4 mm, mild pain scales from 5-44 mm, moderate pain scales from 45-74 mm, and severe pain scales from 75-100 mm [Hawker et. al, 2011 and Jensen et.al. 2003]. This research used an experimental treatment by subject design. The sample treatment was carried out by comparing the results before and after the application of the ergonomic work facility design of tempeh plastic wraps punching tool. The primary data were obtained directly through observation, questionnaires, documentation and interviews with informants at the location of making tempeh.

III. Results and Discussion

Anthropometric Data and Work Facility Design

Anthropometry is a scientific discipline related to the dimensions of certain body parts that are suitable to be applied in the design process [Joshi et al, 2021]. Anthropometric data was taken from the dimensions of the workers' bodies and used as a reference for redesigning [Wibisono and Soni, 2014] the work facility for the tempeh plastic wraps punching tool. Based on the dimensions of the workers' bodies, the design was expected to be able to contribute to the comfort and safety [Budiyanto at al, 2021] of the workers in the process of making holes on the tempeh plastic wraps.

The measurement results of the workers' anthropometric data that were used to design the work facility are shown in Table 1. A total of 30 data had met the adequacy test, uniformity test and normality test. Normality test was conducted using kolmogorov-smirnov method with the help of SPSS software.

Table 1. Workers anthropometric data

Measurement	Symbol	Percentile		
		5-th	50-th	95-th
Sitting Elbow Height	D11	34.69	34.72	34.76
Buttock-Popliteal Length	D14	35.29	35.32	35.36
Knee Height	D15	53.69	58.4	63.11
Popliteal Height	D16	42.93	45.6	48.27
Hip Breadth	D19	38.2	40	41.8
Upper Limb Length	D24	65.67	65.73	65.67
Hand Breadth	D29	13.89	13.92	13.94
Forward Grip Reach	D36	74.20	74.20	78.60
Hand Grip Diameter	Dgmin	2.54	3.89	5.64

The anthropometric data of workers presented in Table 1 was used as a basis for determining the dimensions of the design of the tempeh plastic wraps punching tool.

The seat width was determined by the hip Breadth (D19) which used the 95th percentile. The seat width was 41.8 cm. This seat width is in accordance with research of [Ansari et al, 2018], which is 42.15 cm with the 95th percentile. The 95th percentile is for the large size. The percentile was chosen so that all of the workers could use the tool, especially for those with large bodies. The seat length was determined by the Buttock-popliteal length (D14) using the 50th percentile. The seat length was 35.32 cm. The 50th percentile is for the average size. The percentile was chosen so that all of the operators could use the tool, both small and large bodies. The seat height was determined by the size of the popliteal height (D16) which used the 50th percentile with the average size of 45.6 cm. The height of the table is determined by the size of the popliteal height (D16) and elbow height (D11). The popliteal height (D16) used the 50th percentile with the average size of 45.6 cm and the elbow height (D11) used 50th percentile with the average size of 34.72 cm, which then subtracted by the height of the hole puncher which was 18 cm. The height of the work tool is obtained by adding D16 to D11 and then subtracted by the height of the punching tool which was 62.32 cm. The 50th percentile was used. The work tool height was determined by the popliteal height (D16) using 50th percentile with the average size of 45.6 cm and the elbow height (D11) using 50th percentile with the average size of 34.72 cm. Thus, the height of the work tool was 80.32 cm which was obtained by adding D16 to D11. The tool handle diameter was determined using the workers grip anthropometry so that when using it, the workers would feel comfortable and safe. The tool handle diameter was 1 inch or 2.54 cm using the 5th percentile so that the workers who had smaller hand grips could comfortably grip the handle and the workers with larger hand grips could still use it. The design of the tempeh plastic wraps punching tool facility based on the anthropometric data can be seen in Figure 1.

It is in accordance with research by [Budiyanto, 2019] which uses 5th percentile to determine the size of the diameter of the mold handle which is 3.01 and is rounded up to 3 cm. The use of the 5th percentile is in accordance with the diameter of the grip of the knife handle of the betel nut splitter using the 5th percentile which is 2.94 cm (Anwardi et al., 2013) and the diameter of the Tojok grip (Anizar, 2015) which is an oil palm mover tool using the 5th percentile data with a value of 2.77 cm.

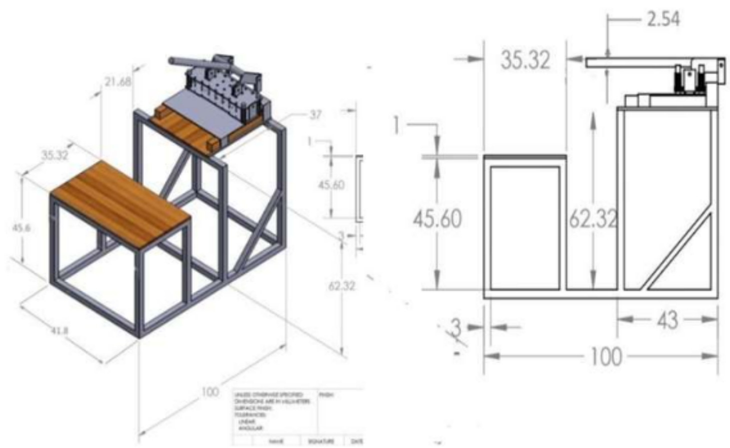

Figure 1. The Overall Design of The Tempeh Plastic Wraps Punching Tool

Work comfort level can be influenced by the relationship between work posture and the dimensions of work tool and workplace. The suitability of the workers' body posture with various workplace conditions can contribute to the completion of work [Budiyanto and Setioyoso, 2021, Dul and Weerdmeester, 2008]. In addition, it also affects on the level of work comfort.

Material Selection

The materials which were used in this work facility design were used-materials. The used-materials are shown in the Table 2.

Table 2. The Work Facility Materials Manufacture

Material	Amount
Iron Elbow	600 cm
Iron Plate	25 kgs
Iron Nail	26 pcs
Iron Bar Rails	4 pcs
Welding Wire	6 pcs
Handle Bolts	4 pcs
Paint	1 can
Used Woods	200 cm

Work Posture

In the initial condition, the worker who made holes on the tempeh plastic wraps worked using an awkward work posture. The worker sat on the floor with his left leg folded inward while his right leg formed an angle of 600 and his left hand held

Figure 2. The Work Posture before the Intervention of the Designed Work Facility

Figure 3. The Work Posture after the Intervention of the Designed Work Facility.

the plastic which would be holed. The right hand held the nail and the elbow pressed the right thigh to make a hole in the plastic. This work was done repetitively in a long period of time as shown in Figure 2.

The activity of making holes on the tempeh plastic wraps using an ergonomic work facility design showed that the worker's work posture was no longer sitting on the floor, the worker sat on a chair with both legs formed an angle of 900. The body position was upright and the right hand held the handle in a straight position on the direction of the handle using a small force to make holes on the tempeh plastic wraps. The activity is shown in Figure 3.

Table 3. NBM Questionnare Before the Intervention of the Designed Work Facility

No	Location	Level of Complaint			
		1	2	3	4
0	Pain on the Upper Neck			√	
1	Pain on the Lower Neck	√			
2	Pain on the Left Shoulder	√			
3	Pain on the Right Shoulder	√			
4	Pain on the Upper Left Arm	√			
5	Pain on the Back			√	
6	Pain on the Upper Right Arm		√		
7	Pain on the Waist			√	
8	Pain on the Buttock			√	
9	Pain on the Bottom			√	
10	Pain on the Left Elbow	√			
11	Pain on the Right Elbow	√			
12	Pain on the Lower Left Arm		√		
13	Pain on the Lower Right Arm		√		
14	Pain on the Left Wrist	√			
15	Pain on the Right Wrist		√		
16	Pain on the Left Hand		√		
17	Pain on the Right Hand		√		
18	Pain on the Left Thigh	√			
19	Pain on the Right Thigh	√			
20	Pain on the Left Knee		√		
21	Pain on the Right Knee		√		
22	Pain on the Left Calf	√			
23	Pain on the Right Calf	√			
24	Pain on the Left Ankle	√			
25	Pain on the Right Ankle	√			
26	Pain on the Left Foot	√			
27	Pain on the Right Foot	√			

Information :
1 = no pain, 2 = moderate pain,
3 = pain 4 = very painful

Musculoskeletal disorders can be caused by factors such as the use of awkward body postures, excessive use of energy, static, high repetition, cold nature of work [Wardana, 2019].

Nordic Body Map Questionnaire

Nordic Body Map (NBM) is a questionnaire to find out the musculoskeletal complaints which are experienced by workers using level of complaints ranging from No Pain (1), Moderate Pain (2), Pain (3) and Very Painful (4) [Anggraini & Bati, 2016].

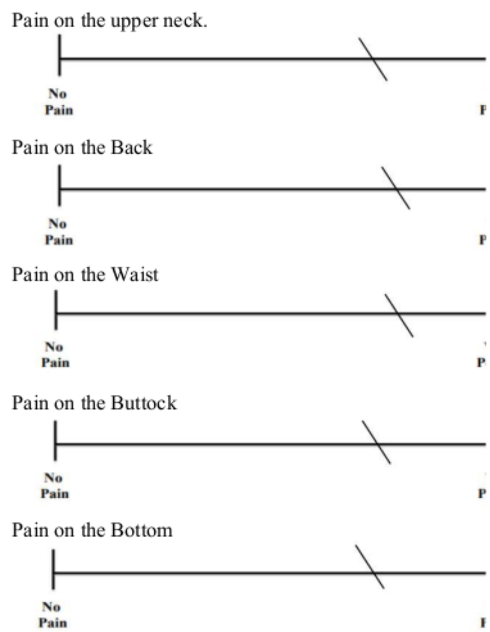

Figure 4. TheVAS based on Nordic Body Map Data Before the Intervention

Table 4. The VAS Pain Scale Before the Intervention of the Work Facility

Location	VAS Scale	Remarks
Upper Neck	65	Moderate
Back	70	Moderate
Waist	70	Moderate
Buttock	63	Moderate
Bottom	68	Moderate

Based on the Nordic Body Map questionnaire, there were several complaints of pain on the body parts of the workers in making holes on the plastic wraps in the initial condition. The complete pain complaints are shown in the Table 3. In this condition, the workers used unergonomic work posture and a makeshift facility. The use of work facilities that are not in accordance with the size of the worker's body posture can cause an awkward or unphysiological posture [Kroemer and Grandjen 2009] which is similar to the condition of workers in the process of making holes on the tempeh plastic wraps, which results in injuries if the work is carried out in a non-ergonomic way [Dianat et al. , 2015] and causes pain on certain body parts.

Table 5. NBM Questionnare after the Intervention of the Designed Work Facility

No	Location	Grade of Complaint			
		1	2	3	4
0	Pain on the Upper Neck		√		
1	Pain on the Lower Neck	√			
2	Pain on the Left Shoulder	√			
3	Pain on the Right Shoulder	√			
4	Pain on the Upper Left Arm	√			
5	Pain on the Back	√			
6	Pain on the Upper Right Arm	√			
7	Pain on the Waist	√			
8	Pain on the Buttock	√			
9	Pain on the Bottom	√			
10	Pain on the Left Elbow	√			
11	Pain on the Right Elbow	√			
12	Pain on the Lower Left Arm	√			
13	Pain on the Lower Right Arm	√			
14	Pain on the Left Wrist	√			
15	Pain on the Right Wrist	√			
16	Pain on the Left Hand	√			
17	Pain on the Right Hand	√			
18	Pain on the Left Thigh	√			
19	Pain on the Right Thigh	√			
20	Pain on the Left Knee	√			
21	Pain on the Right Knee	√			
22	Pain on the Left Calf	√			
23	Pain on the Right Calf	√			
24	Pain on the Left Ankle	√			
25	Pain on the Right Ankle	√			
26	Pain on the Left Foot	√			
27	Pain on the Right Foot	√			

Information :
1 = no pain, 2 = moderate pain,
3 = pain 4 = very painful

Complaints on the body parts that feel pain can be measured using a scale, namely the Visual Analog Scala (VAS). The Visual Analog Scale (VAS) is intended to measure certain pain qualities such as intensity or discomfort [17].

Visual Analog Scala has four categories, namely the scale of 0-4 mm indicating no pain, the scale of 5-44 mm indicating mild pain, the scale of 45-74 mm indicating moderate pain, and the scale of 75-100 mm indicating severe pain [Jansen et. al, 2003]. Some initial complaints as shown in the Nodic Body Map questionnaire (Table 3) showed that there were 5 body parts in the category of pain, namely the upper neck, back, waist, buttocks and lower buttocks. The Complete body parts analysis including no pain and moderate pain can be seen in the Table 3.

The five body parts that experienced pain in form of the Visual Analogue Scale are shown in Figure 4. The tabulation of the VAS pain scale is shown in Table 4.

A questionnaire was also taken after the intervention of the designed work facility to compare the pain rating before and after the intervention. The questionnaire result after the intervention of the designed work facility is as follows.

The condition after the intervention of the work facility design in the form of a table with an attached tool and a work chair which was design based on the anthropometric data as the reference for the dimensions of the work facility design had resulted in a better work position. The working position is shown in Figure 3 and the questionnaire result after the improvement is shown in Table 5.

The five body parts which experienced pain are shown using Visual Analogue Scale (VAS) after the intervention. The VAS pain scale is shown in the Figure 5.

After the intervention of the ergonomic work facility design by utilizing workers anthropometric data, almost all pain complaints were reduced.

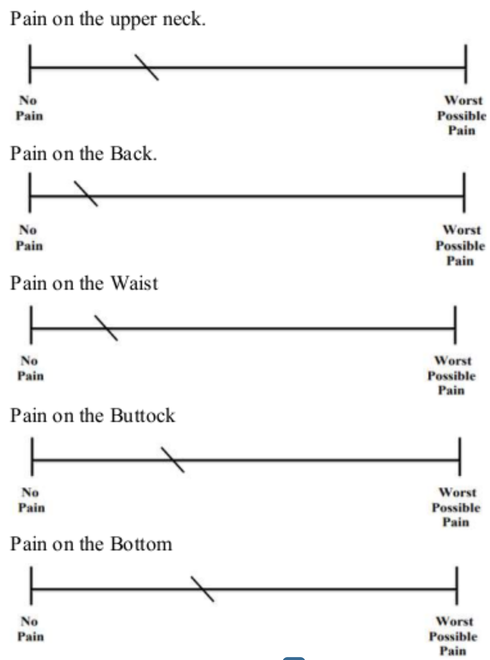

Figure 5. The VAS based on the Nordic Body Map Data after the Intervention

Table 6. The VAS Pain Scale After the Intervention

Location	VAS Scale	Remarks
Upper Neck	25	Mild Pain
Back	16	Mild Pain
Waist	18	Mild Pain
Buttock	26	Mild Pain
Bottom	29	Mild Pain

they became painless as shown in table 5. Complaints of musculoskeletal pain on the body parts which were initially moderate pain and pain became no pain by the intervention of ergonomic facility design (Budiyanto et al, 2022). Another research shows that initially, there are 6 body parts which experience pain and 9 body parts experience moderate pain, but after the intervention of ergonomic dough work facility, they become painless (Budi Yanto and Setiyoso, 2021). The work posture of sitting on the floor without work facility can be improved by an ergonomic design.

Normality Test for the Pain Scale Data

The normality test for the pain scale data was carried out to determine whether the obtained pain scale data was normally distributed or abnormal. The normality test for the pain scale data was conducted using the Kolmogorov-Smirnov method with the help of SPSS program. The result can be seen in Figure 6.

The SPSS of pain scale data showed that the pain scale data before and after the intervention of the work facility were normally distributed.

Working Time

One of the objectives of this work facility design was to reduce the working time, therefore the working time was measured. The result of the working time for making holes on one unit of tempeh plastic wraps can be seen in Table 7. The working time data after the intervention of the work facility can be seen in Table 8.

Normality Test for the Working Time Data

The normality test for the working time data was carried out to determine whether the obtained anthropometic data was normally distributed or abnormal. The normality test for the working time data was conducted using the

One-Sample Kolmogorov-Smirnov Test

		atasleher	atasleher2	punggung	punggung2	pinggang	pinggang2	pantat	pantat2	bawahpantat	bawahpantat2
N		30	30	30	30	30	30	30	30	30	30
Normal Parameters[a,b]	Mean	6.5600	2.2633	6.6933	1.7333	6.8033	1.7900	6.6433	2.1467	6.5133	2.2867
	Std. Deviation	.29781	.26193	.37226	.24542	.40470	.27336	.42725	.38483	.35597	.44546
Most Extreme Differences	Absolute	.087	.143	.144	.140	.128	.115	.131	.145	.141	.129
	Positive	.080	.143	.098	.140	.113	.095	.131	.106	.091	.129
	Negative	-.087	-.122	-.144	-.128	-.128	-.115	-.126	-.145	-.141	-.117
Kolmogorov-Smirnov Z		.476	.781	.788	.766	.700	.628	.720	.793	.773	.709
Asymp. Sig. (2-tailed)		.977	.575	.563	.600	.712	.826	.679	.555	.588	.697

a. Test distribution is Normal.

b. Calculated from data.

Figure 6. The SPSS Result of Kolmogorov-smirnov Test.

Table 7. The Working Time Before the Intervention of the Work Facility

Time (s/unit)	Time (s/unit)	Time (s/unit)	Time (s/unit)	Time (s/unit)
50	43	49	40	50
40	35	41	41	42
42	36	49	44	36
45	44	36	38	45
38	46	38	49	39
37	41	40	37	35

Table 8. The Working Time After the Intervention of the Work Facility

Time (s/unit)	Time (s/unit)	Time (s/unit)	Time (s/unit)	Time (s/unit)
30	23	27	26	23
28	25	30	27	25
27	27	25	28	23
25	27	23	25	25
23	30	25	27	23
22	28	26	25	21
				∑ 769

One-Sample Kolmogorov-Smirnov Test

		before	after
N		30	30
Normal Parameters[a,b]	Mean	40.8667	25.6333
	Std. Deviation	4.75419	2.38506
Most Extreme Differences	Absolute	.127	.138
	Positive	.127	.138
	Negative	-.109	-.129
Kolmogorov-Smirnov Z		.694	.756
Asymp. Sig. (2-tailed)		.721	.617

a. Test distribution is Normal.

b. Calculated from data.

Figure 7. Result of Kolmogorov-smirnov test.

kolmogorov-smirnov method with the help of SPSS program. The result can be seen in Figure 7.

The SPSS of working time data showed that the working time data before and after the intervention of the work facility were normally distributed.

Standard Time Calculation

The standard time calculation was carried out on the working time data before and after the intervention of the work facility to compare the working time in making holes on the tempeh plastic wraps. To determine the standard time, the cycle time and normal time were previously calculated. The performance rating and allowance were first determined by the value of 1.06 and 1.28 respectively. The calculation of the standard time is as follows.

1. Cycle Time before the intervention of the Work Facility

   $\underline{x} = \frac{\sum_{i=1}^{n} x}{N} = \frac{1226}{30} = 40.8667$ min/unit

2. Normal Time before the intervention of the Work Facility

   $T_n = T_c \times P_r$

   $= 40.8667 \times 1.06 = 43.31$ min/unit

3. Standard Time before the intervention of the Work Facility

   $ST = T_n \times \frac{100\%}{100\% - \%Allowance}$

   $= 43.31 \times 1.43$

   $= 61.933$ min

   $= 1.03$ hrs/unit

4. Cycle Time before the intervention of the Work Facility

   $\underline{x} = \frac{\sum_{i=1}^{n} x}{N} = \frac{703}{30} = 23.43$ min/unit

5. Normal Time before the intervention of the Work Facility

   $T_n = T_c \times P_r$

   $= 23.43 \times 1.06 = 24.83$ min/unit

6. Standard Time before the intervention of the Work Facility

   $ST = T_n \times \frac{100\%}{100\% - \%Allowance}$

   $= 24.83 \times 1.28$

   $= 31.79$ min

   $= 0.52$ hrs/unit

Data Comparison

The comparison of the data was carried out using the Paired Sample T-test to prove that the results were significant. Before and after the intervention of the ergonomic work facility design, the results showed that the pain scale and the working time were significantly reduced. The results of the Paired Sample T-test on the pain scale data and the working time data are shown in Figures 8 and 9.

The results of the paired Sample T-test for the pain scale data and the working time data showed a significant result with the score of 0.000

Paired Samples Test

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pair 1 Upper neck – upper neck2	4.29667	.37919	.06923	4.15508	4.43826	62.064	29	.000
Pair 2 back - back2	4.96000	.39966	.07297	4.81077	5.10923	67.976	29	.000
Pair 3 waist - waist2	5.01333	.46811	.08546	4.83854	5.18813	58.660	29	.000
Pair 4 buttock - buttock2	4.49667	.61615	.11249	4.26659	4.72674	39.973	29	.000
Pair 5 bottom - bottom2	4.22667	.54198	.09895	4.02429	4.42905	42.714	29	.000

Figure 8. Result of the Paired Sample T-test for the Pain Scale Data.

Paired Samples Test

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pair 1 before - after	15.23333	4.53099	.82724	13.54143	16.92523	18.415	29	.000

Figure 9. Result of the Paired Sample T-test for the Working Time Data.

(less then 0.05), it meant that the pain scale and the working time after the intervention of the work facility was significantly reduced compared to the pain scale and the working time before the intervention.

IV. Conclusion

The work facility of the tempeh plastic wraps punching tool which was designed using an ergonomic approach by referring to the anthropometric data of the workers was proven to significantly reduce the pain scale of some body parts after the intervention of the work facility. The maximum pain scale of some body parts before the intervention of the work facility was on the moderate pain level, while the maximum pain scale of some body parts after the intervention was on the mild pain. The designed work facility also reduced the working time from 1.03 hrs/unit into 0.52 hrs/unit.

References

Abdurrahman I. R., Tahid A., Fathurachman. (2018). Foot Anthropometric Profile of High School Students in Bandung. *Althea Medical Journal, 5*(2), 93-97 doi: http://dx.doi.org/10.15850/amj.v5n2.1418

Adiyanto O. ,Effendi M.,Jaafar R.,Razak J. A., Faishal M.,Mulaicin M, and Mohamad N. A. (2022). "Integrated Self-Report and Observational Risk Assessment for Work-Related Musculoskeletal Disorder in Small and Medium Enterprises." *Engineering and Applied Science Research. 49*(1), 73–80.

Anggraini, D. A., Bati, N. C. (2016). Analisa Postur Kerja Dengan Nordic Body Map dan REBA Pada Teknisi Painting Di PT. Jakarta Teknologi Utama Motor Pekanbaru. *Phonton: Jurnal Sains dan Kesehatan, 7* (1), 87-79.

Anizar. 2015. Analisis Desain Tojok Sebagai Alat Sortasi Tbs Kelapa Sawit Di Loading Ramp. *Jurnal Teknik Industri, 10* (3), pp. 149-154.

Ansari S, Nikpay A and Varmazyar S. 2018. Design and Development of an Ergonomic Chair for Students in Educational Settings. *Health Scope. 7* (4). pp 1-9. doi: 10.5812/jhealthscope.60531.

Anwardi, Saleh F. MH. dan Sahria. 2013. Re-Disain Alat Pembelah Buah Pinang Berbasis Ergonomi Makro Melalui Pendekatan 'Ship' (Studi Kasus di Kecamatan Keritang – Inhil). *Jurnal Teknik Industri, 2*(1), pp. 37-48.

Budiyanto T, 2019. *Redesain Berbasis Ergonomi pada Stasiun Kerja Cetak Wajan Meningkatkan Kesehatan Dan Produktivitas Pekerja Pada Industri Cor Aluminium Di Kampung Nitikan Yogyakarta.* Dissertation. Denpasar. Post Graduate Program Udayana University.Hal. 156.

Budiyanto T dan Setiyoso F.K. 2021. Designing An Ergonomic-Based Work Facility Of Dough Stirrer For Kerupuk Cipir Using Rapid Entire Body Assesment (Reba) Analysis To Reduce Muskuloskeletal Complaints And Increase Productivity. *Journal LOGIC. 29*(2), pp. 87-92. p-ISSN : 1412-114X. e-ISSN : 2580-5649

Budiyanto T., Asih H. M., Adiyanto O., Kristanto I. (2021), Designing Of Work Facility For Ecobrick Material Using Ergonomic Intervention To Reduce Muscoloskeletal Disorder. *Journal of Engineering Design and Technology (LOGIC). 21*(3), 323-239.

Dawal S. Z, Zadry H. R, Azmi S.N, Rohim S.R, Sartika S.J. 2012. Anthropometric database for the learning environment of high school and university students. *Int J Occup Saf Ergon. 18* (4). pp. 461–472. doi: 10.1080/10803548.2012.11076953.

Dianat, I., Nedaei, M.. and Nezami, M.A.M. 2015. The effects of tool handle shape on hand performance, usability and discomfort using masons' trowels. *International Journal of Industrial Ergonomics. 45* (2015) 13-20

Dul, J., Weerdmeester, B. 2008. *Ergonomics for Beginners : A Quick reference Guide*. Third Edition. Boca Raton: Taylor & Francis Group. p. 1 and 69–78.

Farid M, Adiyanto O., and Triesnaningrum H. F. (2020). "Analisa Biomekanika Pada Aktivitas Penyetrikaan Studi Kasus Nafiri Laundry Yogyakarta." *Jurnal Ergonomi dan K3, 5*(1), 11–19.

Hawker G. A., Mian S, Kendzerska T., and French M. 2011. Measures of Adult Pain: Visual Analog Scale for Pain (VAS Pain), Numeric Rating Scale for Pain (NRS Pain), McGill Pain Questionnaire (MPQ), Short-Form McGill Pain Questionnaire (SF-MPQ), Chronic Pain Grade Scale (CPGS), Short Form 36 Bodily Pain Scale (SF-36 BPS), and Measure of Intermittent and Constant Osteoarthritis Pain (ICOAP). *Journal Arthritis Care & Research, 63* (S11), pp S240–S252.

Jensen M. P., Chen C, Brugger A. M. 2003. Interpretation of visual analog scale ratings and change scores: a reanalysis of two clinical trials of postoperative pain. *J Pain. 4*:407–414.

Joshi, Mangesh, and Deshpande V.(2021) International Journal of Industrial Ergonomics Identification of Indifferent Posture Zones in RULA by Sensitivity Analysis. *International Journal of Industrial Ergonomics, 83*, pp. 103-123.

Kroemer, K. H. E., & Grandjean, E. (2009). *Fitting The Task To The Human, Fifth Editione A Textbook Of Occupational Ergonomics*. London: CRC Press.

Luximon A, Luximon Y, Chao H. A (2013) Human Surface Prediction Model Based on Linear Anthropometry. *Int. J. Adv. Intell. Sys. 6*(3), 213–22.

Shiru J.J, Abubakar S. 2012. in engineering design (a case study of cassava grating machines installed in Doko and Kutigi metropolis of Lavun local government areas of Niger state). *Niger Acad Forum, 22*.(1), pp. 132–139.

Taifa I. W, Desai D. A. 2017. Anthropometric measurements for ergonomic design of students' furniture in India. *Eng SciTech Int Journal, 20*(1), pp. 232–329. doi: 10.1016/j.jestch.2016.08.004

Tarwaka. 2015. *Ergonomi Industri. Dasar-dasar Pengetahuan Ergonomi dan Aplikasi di Tempat Kerja*. Edisi II dengan Revisi, Cetakan ke 2. Surakarta : Harapan Press.

Wardana, Marcelly Widya, Sulastri, and Siti Hasanah. 2019. "Penerapan Metode Failure Mode and Effect Analysis (FMEA) Dalam Mengidentifikasi Masalah Keruskaan Produk Pakan Ayam Pada PT. Japfa Comfeed Indonesia, TBK Unit Lampung." *Spektrum Industri 17*(1):1–91.

Wibowoa R. K. K , Soni P (2014). *Anthropometry and Agricultural Hand Tool Design for Javanese and Madurese Farmers in East Java, Indonesia*. APCBEE Procedia.. 8, 119 – 124.

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