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ANALYSIS OF THE DESIGN OF COCONUT SLEEP MACHINE OPRATOR CHAIR DEVELOPMENT WITH ERGONOMIC PRINCIPLES TO REDUCE THE RISK OF MSDS MUSCULOSCELETAL DISORDERS IN KELAMA TIGA PUTRA

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ABSTRACT

The production process in SME KelapaTiga Putra still uses human labor as well as the milling process which has not applied ergonomic principles. If the work posture is in a position that is less ergonomic, it can cause complaints in parts of the body such as the back, waist, neck, arms and it can lead to musculoskeletal risk. By paying attention to the situation at work, a tool will be made that if it can change a less ergonomic position into an ergonomic one. The design of this tool aims to simplify the coconut milling process using the anthropometric method. The object of this research focuses on the coconut milling process workers. There are three methods used, namely the NBM questionnaire to find out complaints, analysis of work postures using the REBA method, anthropometry used as a measure of aid. The results of the NBM questionnaire have complaints with a score of 65 with a very high level of risk. Classification of the level of risk of the musculoskeletal system based on the total score of individual workers having complaints with a score of 65 with a very high level of risk means that coconut mill workers need comprehensive action as soon as possible. Analysis of the initial work posture has a very high risk, while the analysis of the final work posture after using the tool has a very low risk. The anthropometric percentile used is the 50th percentile with the size of the tool. Chair back height 54.89 cm, chair back width 38.75 cm, seat seat width 32.32 cm, chair leg height 40.07 cm, seat seat length 39.88 cm

Keywords:*Ergonomics, anthropometry, work posture, Rapid Entire Body Assessment*

Introduction

Small and medium enterprises (SMEs) in the national economy have an important and strategic role, due to their relatively dominant existence, where SMEs are able to increase people's income [1]. As in the Gresik district, there are many different types of companies, ranging from large companies to small companies such as UKM (Small and Medium Enterprises). . This three-son coconut UKM sells various kinds of products such as coconut, oranges, crackers and various other products. In addition to the large demand for staple foods needed by restaurants, companies that need coconut shells and household needs, this business also has the potential to get big profits. Therefore, Small and Medium Industries (SMEs) are required to continuously improve and optimize production activities that will be able to meet consumer demand.

The main product of UKM Kelapa Tiga Putra is old coconut which is imported directly from Karangasem Regency, Bali Province to then be sold according to customer demand, ranging from peeled coconut, peeled coconut to ground coconut.the production process at Kelapa Tiga Putra UKM still uses human labor and millingprocesses that have not implemented ergonomic principles such as work postures that lack ergonomics.The effectiveness of a job can be analyzed based on work posture. Good results obtained by the operator because the operator's work posture is good and ergonomic. However, if the operator's work posture is not ergonomic, the operator will tire easily. It can trigger results that are not optimal because the operator is easily fatigued [2][3]. Unnatural work posture is an attitude or posture when working that causes body parts to move away from their natural position, such as a back that is too bent, a neck that is too up or down, and other positions that are not in accordance with its natural position[4]. The coconut milling process can be seen in Figure 1

Fig. 1 coconut milling process

As seen in Figure 1, the coconut milling process has not applied ergonomic principles. Ergonomics is a systematic branch of science to utilize information about human nature, abilities and limitations to design work systems so that humans can live and work in these systems properly. work effectively, safely and comfortably can be achieved through the application of good ergonomics[5][6].

At the time of the interview with the owner of the Tiga Putra coconut small business, the one-day grinding process can grind 200 to 300 coconuts and takes 2 hours to 3 hours if the working posture is in a less ergonomic position which can cause complaints in parts of the body such as the back, waist, neck, arm and it can lead to the risk of MSDS. musculoskeletal is a complaint that a person feels from very mild to very painful in the skeletal muscles. Pain in the joints, ligaments and tendons that a person feels is caused by the static load received by the muscles repeatedly and for a long time [7][8][9]. Workers experience complaints on the back, arms, waist and neck based on the results of interviews with coconut mill workers. Therefore, to find out the risk of complaints experienced by coconut mill workers, the Nordic body map questionnaire will later be used. The Nordic Body Map Questionnaire was obtained from the ergonomics checklist questionnaire. An assessment of pain complaints experienced by workers can be obtained and identified with the Nordic Body MapNordic Body Map, which is a measurement method to measure workers' muscle pain. The Nordic Body Map Questionnaire is a form of an ergonomic checklist questionnaire. By measuring using the Nordic Body Map instrument, an assessment of the pain that is complained of from a series of identifications can be carried out.Nordic body map is a measurement technique and assessment to identify and determine the level of complaints and injuries to the skeletal muscles for disorders of the musculoskeletal system [10][11][12].Based on the complaints felt by coconut mill workers and their work posture which lacks ergonomics, this problem requires an analysis of work posture using the REBA method. REBA functions to develop a posture analysis system that is sensitive to musculoskeletal risks in various jobs. By dividing the body into segments which are then given a special code based on the plane of motion. It then provides a scoring system for static, dynamic, rapidly changing or unstable induced muscle activity. with the need for a tool that has sensitivity to the unpredictable types of work postures found in the industry, the Rapid Entire Body Assessment (REBA) method was developed[13][14][15]. By paying attention to the situation when working, tools will be made that can change a position that is less ergonomic into one that is ergonomic. The design of this tool aims to simplify the coconut milling process using anthropometric methods. Anthropometry is used as a consideration in designing products that are adapted to work systems. These data are processed with the aim that the product design can be adapted to the general size of the workersTool design using anthropometric data is very important in determining the tool and how to operate it. The suitability between worker anthropometry and the tools used greatly influences work attitude, fatigue level, work ability and work productivity[16][17][18][19].

Research methodology

The research methodology contains the stages that will be carried out in the research. The stages are as follows

1. The first stage is in the form of
   a) Complaints felt by workers during the coconut milling process can be identified by distributing the Nordic Body Mapo questionnaire.
   b) Documentation of posture photos of coconut mill workers.
   c) collection of Indonesian anthropometric data
2. The second stage is in the form of
   a) After distributing the questionnaires in the first stage, the next step is in the form of summing up the total scores from the Nordic body map questionnaire.
   b) Display the angle on the image that has been taken by determining the angle of the group A section consisting of the back, neck, legs. Meanwhile, group B consists of the upper arms, forearms and wrists.
   c) anthropometric dimensions and anthropometric percentile width are used as design measurements for the tool to be made
3. the third stage viz
   a) after calculating the total score of the overall Nordic body map, the next step is to

categorize the risk level of the musculoskeletal system based on the individual's total value

b) After determining the angle of incidence in the second stage, the next step is the action level that measures the risk and action to improve work posture
c) After paying for the dimensions and percentiles The next step is to make tools that aim to reduce musculoskeletal risk

4. Ergonomic

In an effort to optimize health, well-being and performance, ergonomics includes the interaction between humans, technology and organizations. An unfavorable work environment can have a major impact on individuals, companies and society. Ergonomic work environment that is well managed also has a positive impact on improving quality and productivity for the company and the surrounding community. The International Ergonomics Association (IEA) states that ergonomics is a harmony between the characteristics of human anatomy, anthropometry, physiology and biomechanics, as well as the static and dynamic parameters of physical workers[20]. The term ergonomics actually comes from the Greek ergo which means work and nomos which means law. Therefore, ergonomics is understood as a scientific discipline that studies humans in relation to work. The discipline of ergonomics specifically examines the limits of human ability to deal with technology and its products[21]

5. Nordic body map

The Nordic Body Map Questionnaire is an ergonomic test questionnaire. With the Nordic Body Map, pain complaints can be identified and assessed. The Nordic Body Map Questionnaire as a questionnaire is too dominantly applied in a process of investigating complaints for workers because it is standardized and well managed[22]

Table 2nordic body map

	Skeletal Muscles	**Scoring**			
		1	**2**	**3**	**4**
0	Neck				
1	nape				
2	Left Shoulder				
3	Right Shoulder				
4	Left Upper Arm				
5	Back				
6	Right upper arm				
7	Waist				
8	Hips				
9	Butt				
10	Left Elbow				
11	Right Elbow				
12	Left forearm				
13	Right forearm				
14	Left wrist				
15	Right wrist				
16	Left hand				
17	Right hand				
18	Left Thigh				
19	Right Thigh				
20	Left Knee				
21	Right Knee				
22	Left Calf				
23	Right Calf				
24	Left ankle				
25	Right ankle				
26	Left Foot				
27	Right foot				
	Total score				

The Nordic Body Map questionnaire in its assessment uses a "4 Likert scale" with a scale of 1 to 4. Respondents are asked to provide an assessment of the part of their body that they feel sick during work activities according to a predetermined Likert scale.The 4 Likert scales on the Nordic Body Map questionnaire represent the indicators TS (Not sick), AS (Slightly sick), S (Painful), SS (Very sick)[23]

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6. work sheet REBA

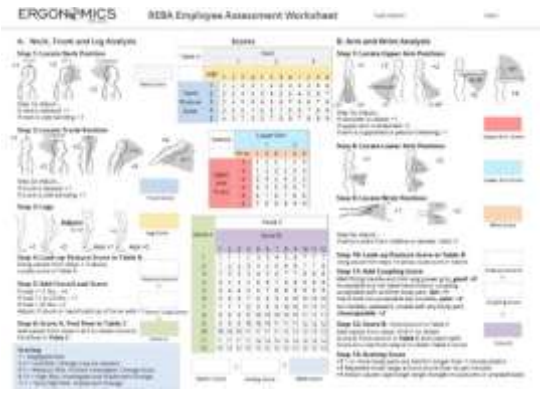

Fig 2 work sheet REBA

The steps for determining the REBA score are used to assess a worker's posture starting from the neck, back, arms, wrists, and legs of a worker. The steps for determining the REBA score are first calculating the score in table A which consists of the neck, trunk, and legs. The second step is calculating table B which consists of the upper arm, lower arm, and wrist. After obtaining the final scores of tables A and B, they are entered into table C which then determines the category of action[24]

7. percentileantropometry

In this percentile concept there are two concepts that need to be understood. First, anthropometric percentiles in individuals are based on only one body size, such as standing height or sitting height. Second, no one is called a 90th percentile person or a 5th percentile person. That is, a person who has the 50th percentile for sitting height may have the 40th percentile dimension for popliteal height or the 60th percentile for elbow sitting height[25]. Percentile values that are commonly applied in calculating anthropometric data can be seen in Table 2 below

table 2 percentile

Percentile	**Calculation**
1-st	X - 2,325sc
2,5-th	X -1,96sc
5-th	X -1,64sc
10-th	X -1,28sc
50-th	X
90-th	X +1,28sc
95-th	X +1,64sc
97-th	X +1,96sc
99-th	X + 2,325sc

Example: according to (Wignjosoebroto, 2006) the results of measurements of the Indonesian human body (adults, males, ages between 19 to 40 years) are obtained from normally distributed data with an average height of 169.5 cm and a standard deviation of 6.99 cm. what is the 95-th percentile measure?

Answer : 95-th size = $\bar{x}$ + 1.645. σ

= 169.5 + 1.645 (6.9)

= 180.85 cm

Results and Discussions

In table 3, the results of the Nordic Body Map questionnaire that have been distributed to coconut mill workers can be seen.

Table 3 NBM questionnaire recapitulation

No	location of worker complaints	complaint score
0	Top neck	3
1	Nape	2
2	Left shoulder	1
3	Right shoulder	4
4	Left upper arm	1
5	Back	4
6	Right upper arm	4
7	Waist	4
8	Buttocks	3
9	Buttocks / Bottoms	2
10	Left elbow	1
11	Right elbow	2
12	Left forearm	1
13	Right forearm	4
14	Left wrist	1
15	Right wrist	3
16	Left hand	1
17	Right hand	4
18	Left thigh	3
19	Right thigh	3
20	Left knee	2
21	Right knee	2
22	Left calf	3
23	Right calf	3
24	Left ankle	1
25	Right ankle	1
26	Left Foot	1
27	Right foot	1
Individual Score		65

In table 3 the NBM questionnaire. It can be seen from the complaints of coconut mill workers that the highest score is right shoulder score 4, back score 4, right upper arm score 4, waist score 4, right forearm score 4, hand score 4 and individual coconut mill workers score 65 which later scores This will

determine the risk level of the musculoskeletal system in table 4.

Table 4. Classification of the risk level of the musculoskeletal system based on the individual's total score

Likert scale	Total individual scores	Level of risk	Corrective action
1	0-20	Low	No corrective action has been found yet
2	21-41	Currently	It may not be needed in the future
3	42-62	High	Urgent action is required
4	63-84	Very high	Comprehensive action is required as soon as possible

In table 3 coconut mill workers have a score of 65 with a very high risk level, meaning that coconut mill workers need comprehensive action as soon as possible.

REBA*Rapid Entire Body Assessment*

At the NBM questionnaire stage it was known that workers had a very high risk, which then from this risk would be followed by an analysis of work postures that affected the complaints felt by coconut mill workers. The analysis of work posture is explained as follows

Fig 3. determining the angle of REBA degrees

In figure 3 is the determination of the angle of degrees of the reba method which consists of group A of the back, neck, legs and group B which includes the upper arms, forearms and wrists. The explanation for determining the angle and REBA score is as follows

Group A

1. The back has 34 degrees of movement and scores 3+1 sideways tilt. So the final back movement score is 4.
2. The neck has a movement of 34 degrees and scores 2+1 rotated/tilted to the side. So the final neck movement score is 3.
3. Legs have supported leg movements, weight is spread evenly or posture is unstable, a score of 2 + 1, knees form 47 degrees, so a leg movement score is 3

After knowing the movement of the angle and score in group A, the next step is to enter the score into the group A table which includes the back of the trunk, neck, legs. The explanation of the scores in the group A table is as follows.

Table 5 group A

Table A		*Neck*											
		1				2				3			
	Legs	1	2	3	4	1	2	3	4	1	2	3	4
Trunk	1	1	2	3	4	1	2	3	4	3	3	5	6
	2	2	3	4	5	3	4	5	6	4	5	6	7
	3	2	4	5	6	4	5	6	7	5	6	7	8
	4	3	5	6	7	5	6	7	8	6	7	8	9
	5	4	6	7	8	6	7	8	9	7	8	9	9

Table 5 of group A above shows the score in table A for coconut mill workers who get a score of 8 without adding a score because the load is less than 5 kg.

Group B

1. The upper arm has 46 degrees of movement and scores 3
2. The forearm has a 95 degree movement and has a score of 1
3. The wrist has a movement of 15 degrees and has a score of 1+1, the wrist deviates so the wrist score is 2

After knowing the movement of the angle and score in group B, the next step is to enter the score into the group B table which includes the upper arm, lower arm, and wrist. The explanation for the score in the group B table is as follows.

Table 6 group B

Table B	Lower Arm						
		1			2		
	Wrist	1	2	3	1	2	3
	1	1	2	2	1	2	3
	2	1	2	3	2	3	4

Upper Arm Score	3	3	4	5	4	5	5
	4	4	5	5	5	6	7
	5	6	7	8	7	8	8
	6	7	8	8	8	9	9

Table 6, group B can be seen the score in table B coconut mill workers get a score of 4. And there is no additional score because the handle is good.
Determination of the total score for the movement of the coconut milling process is carried out by combining the grub A score and the grub B score using table C.
A score = 8
Score B = 4
In the score column A, enter code 8 and drag the line to the right. Then in the score line B enter code 4 and drag it down until it meets the codes for scores A and B so that the score for table C is known.

Table 7 score table C

Table A	Table C: Score B											
	1	2	3	4	5	6	7	8	9	10	11	12
1	1	1	1	2	3	3	4	5	6	7	7	7
2	1	2	2	3	4	4	5	6	6	7	7	8
3	2	3	3	3	4	5	6	7	7	8	8	8
4	3	4	4	4	5	6	7	8	8	9	9	9
5	4	4	4	5	6	7	8	8	9	9	9	9
6	6	6	6	7	8	8	9	9	10	10	10	10
7	7	7	7	8	9	9	9	10	10	11	11	11
8	8	8	8	9	10	10	10	10	10	11	11	11
9	9	9	9	10	10	10	11	11	11	12	12	12
10	10	10	10	11	11	11	11	12	12	12	12	12
11	11	11	11	11	12	12	12	12	12	12	12	12
12	12	12	12	12	12	12	12	12	12	12	12	12

In table 7 above there is a +1 change in score due to a significant change in body posture or unstable posture during work.

REBA score = C score + activity score
= 9 + 1
= 10
After obtaining the REBA score, from this score it is known the level of risk and the actions of posture/body position while working. The explanation is as follows

Table 8 action level

Levels	REBA score	Risk Levels	Corrective action
0	1	Can be ignored	Not required
1	2-3	low	May be Required
2	4-7	Currently	Required
3	8-10	high	Immediately Required
4	11-15	very high	Is indispensable

In table 8, namely the risk level acton REBA method. Coconut mill workers have a score of 10 which is high, which means coconut mill workers need to improve their position at work because they carry musculoskeletal risks. Therefore this study will provide suggestions for improving work positions by making chair aids whose sizes are adjusted to the size of the human body using anthropometric methods.

Antropometri

At this stage it will be explained about the size of the chair aids whose data is taken from Indonesian anthropometric data. The anthropometric data and dimensions to be used are as follows.

Table 9 anthropometric dimensions and sizes

Dimensions	Information	5th	50th	95th	SD
D10	Shoulder height in a sitting position	37.75	54.89	72.03	10.42
D17	Shoulder width	26.35	38.75	51.16	7.54
D19	Hip width	21.65	32.32	43	6.49
D16	Popliteal height	31.03	40.07	49.1	5.49
D14	Popliteal length	30.1	39.88	49.65	5.94

In the table, the 8th percentile that will be used in making chairs is the 50th percentile, which will be used as the chair size to be made.

Information

1. The shoulder height of the sitting position is used as the backrest height of 54.89 cm
2. The width of the shoulder side is used as the width of the backrest measuring 38.75 cm
3. The width of the hips is used as the seat width of the seat mat measuring 32.32 cm
4. The popliteal height used as the chair leg height is 40.07 cm

5. The length of the popliteal is used as the length of the seat cushion measuring 39.88 cm

Chair design

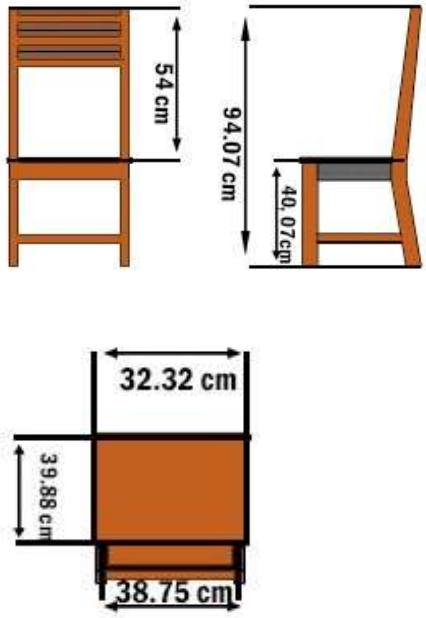

Fig 4. of the chair design

Size description

1. Chair back height 54.89 cm
2. The width of the back of the chair is 38.75 cm
3. The width of the seat holder is 32.32 cm
4. Chair leg height 40.07 cm
5. The length of the seat holder is 39.88 cm

The materials used for the manufacture of chairs are Hollo stainless steel.

Fig 5. coconut mill chair aids

By paying attention to the results of the work posture analysis of the Reba method. Workers have a fairly high risk of musculoskeletal disorders. the initial position when working was standing bent over and after using a chair the position when working was sitting with an upright back. The hope is that in the future, having an assistive chair can reduce the occurrence of musculoskeletal risks.

REBA final work posture analysis

This stage will explain the final work posture analysis using the REBA method after using an assistive device in the form of a chair to find out whether the working posture still contains musculoskeletal risks or the working posture after using assistive devices does not contain musculoskeletal risks. The explanation is as follows.

Fig 5. analysis of REBA final work posture

In figure 5 is the analysis of the final working posture and the determination of the angle of degrees of the reba method which consists of group A of the back, neck, legs and group B which includes the upper arms, forearms andwrists. The explanation for determining the angle and REBA score is as follows

Group A

1. The back has a natural upright movement and according to the REBA worksheet it has a score of 1.
2. The neck has a movement of 16 degrees and according to the REBA worksheet has a score of 1.
3. Legs have supported leg movements, weight is evenly distributed or posture is unstable score 1.

After knowing the movement of the angle and score in group A, the next step is to enter the score into the group A table which includes the back of the trunk, neck, legs. The explanation of the scores in the group A table is as follows.

Table 10 REBA score table A

Table A		*Neck*											
		1				2				3			
	Legs	1	2	3	4	1	2	3	4	1	2	3	4
Trunk	1	1	2	3	4	1	2	3	4	3	3	5	6
	2	2	3	4	5	3	4	5	6	4	5	6	7
	3	2	4	5	6	4	5	6	7	5	6	7	8
	4	3	5	6	7	5	6	7	8	6	7	8	9
	5	4	6	7	8	6	7	8	9	7	8	9	9

Table 10 group A above can be seen the score in table A for coconut mill workers who get a score of 1,

there is no additional score because the load is less than 5 kg.

Group B
a. The upper arm has 72 degrees of movement and scores 3
b. The forearm has 126 degrees of movement and has a score of 2
c. The wrist has movement of 2 degrees and has a score of 1.

After knowing the movement of the angle and score in group B, the next step is to enter the score into the group B table which includes the upper arm, lower arm, and wrist. The explanation for the score in the group B table is as follows.

Table 11 REBA score table B

Table B		Lower Arm					
		1			2		
	Wrist	1	2	3	1	2	3
Upper Arm Score	1	1	2	2	1	2	3
	2	1	2	3	2	3	4
	3	3	4	5	4	5	5
	4	4	5	5	5	6	7
	5	6	7	8	7	8	8
	6	7	8	8	8	9	9

Table 11 for group B shows the score in table B for the coconut mill workers who get a score of 4. And there is no additional score because the handle is good.

After determining the scores in table A and table B, the next step is to determine the total score for the movement of the coconut milling process by combining the grub scores A and grub B scores using table C.
A score = 1
Score B = 4
In the score column A, enter code 8 and drag the line to the right. Then in the score line B enter code 4 and drag it down until it meets the codes for scores A and B so that the score for table C is known.

Table 12 REBA score table C

Table A	Table C											
	Score B											
	1	2	3	4	5	6	7	8	9	10	11	12
1	1	1	1	2	3	3	4	5	6	7	7	7
2	1	2	2	3	4	4	5	6	6	7	7	8
3	2	3	3	3	4	5	6	7	7	8	8	8
4	3	4	4	4	5	6	7	8	8	9	9	9
5	4	4	4	5	6	7	8	8	9	9	9	9
6	6	6	6	7	8	8	9	9	10	10	10	10
7	7	7	7	8	9	9	9	10	10	11	11	11
8	8	8	8	9	10	10	10	10	10	11	11	11
9	9	9	9	10	10	10	11	11	11	12	12	12
10	10	10	10	11	11	11	11	12	12	12	12	12
11	11	11	11	11	12	12	12	12	12	12	12	12
12	12	12	12	12	12	12	12	12	12	12	12	12

In table 11 above there is a change in score +1 If 1 or more body parts are static, held for more than 1 minute
REBA score = C score + activity score
= 2 + 1
= 3
After obtaining the REBA score, from this score it is known the level of risk and the actions of posture/body position while working. The explanation is as follows

Table 13 action level

Levels	REBA score	Risk Levels	Corrective action
0	1	Can be ignored	Not required
1	2-3	low	May be Required
2	4-7	Currently	Required
3	8-10	high	Immediately Required
4	11-15	very high	Is indispensable

From the action level table above, it proves that the working posture after using the designed tool has a low risk. so that it can be said that the tool is ergonomic and does not need position correction when working.

Table 14 Comparison of initial working position and final working position

initial working posture	
Picture	Activity
	Milling coconuts in a standing position and bending the neck of the population

	gets a score of 10 which is very high
final working posture	
Picture	Activity
	Milling coconut in a sitting position in a chair using tools that are adjusted to the size of the body. Like a straight back has a score of 3 which is relatively low

in the comparison table workers have an initial posture that is less ergonomic causing a risk of musculoskeletal occurrence because they have not used ergonomic tools or applied ergonomic principles. Meanwhile, the final working position of workers who use chair aids is able to change the position that was originally standing, bending the neck down and changing to sitting in a chair with an upright back and can reduce the risk of musculoskeletal events. Therefore coconut mill workers no longer have musculoskeletal risks

Conclusion

The classification of the risk level of the musculoskeletal system based on the total score of individual workers has complaints with a score of 65 with a very high level of risk, meaning that coconut mill workers need comprehensive action as soon as possible.

Based on the posture analysis of coconut mill workers using the REBA method, a score of 10 is relatively high, which means that coconut mill workers need to improve their position at work because they carry musculoskeletal risks. While the final working position using the REBA method is known from the results of the REBA action level method that the working posture after using the chair aid has a low risk, meaning that there is no longer a need for position correction during the working position.

Based on the determination of anthropometric dimensions and sizes. The percentile that will be used in making chairs is the 50th percentile which will later be used as the size of the chair to be made. Shoulder height for sitting position was used as the height of the back of the chair 54.89 cm, Width of the shoulder side was used as the width of the backrest 38.75 cm, Width of the hips was used as the width of the chair base seat size of 32.32 cm, Popliteal height was used as the height of the chair legs 40.07 cm, Popliteal length used as the length of the seat cushion measuring 39.88 cm

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