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Implementation of rapid entire body assessment and anthropometry methods in conveyor design

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Abstract

The packaging station is one of the stations needed to produce the product. The workers in this station are still doing the process manually. The packaging station has several processes, namely the weighing process, the sewing process, and the moving process of the finished product by manually lofting the sack from the sewing machine to the pallet. The moving process has three activities holding, lifting, and moving. Workers who work manually often complain of pain felt while working, so they are at risk of experiencing musculoskeletal disorders. Accordingly, it is important to analyse the work posture to determine whether improvements must be made. The Rapid Entire Body Map (REBA) analyses the work position. Analysis of work posture is moving the product. The REBA method's posture assessment results are 8 for holding, 9 for lifting, and 10 for moving. From the results, it can be categorized as a high-risk level, and immediate improvements are needed. The improvements were made by designing a conveyor from the sewing machine to the pallet using the Anthropometric method with dimensions of 100cm, width of 65cm, and height of 113cm.

Keywords:
Musculoskeletal disorders, REBA, anthropometry, conveyor, packaging.

1 Introduction

Manufacturing companies must carry out production activities as effectively as possible without any obstacles. PT XYZ is a company engaged in manufacturing and producing animal feed. PT XYZ has marketed its products to various regions in Indonesia. PT XYZ wants to produce its products by prioritizing the best quality by reviewing every process. All processes of the stations in PT XYZ have been used with machines except the packaging station, which still needs workers. Workers in this station complained about the pain that they felt during work. Workers lifted the heavy loads and repeated it for 1 hour before taking turns with other workers. Workers work manually, so they are at risk of experiencing musculoskeletal disorders such as injuries to the nerves, bones, tendons, muscles, bone joints, and cartilage. The work postures of workers are not suitable. If muscles are given that so it will lead to gripe to workers from damage to tendons and joints are called musculoskeletal disorders (MSDs).

Musculoskeletal disorders can physically affect workers [1]. The perceived effect is a decrease in concentration at work which will automatically affect the result of the work. Then the working hours will be reduced due to the relaxation time and can trigger work accidents. If not getting further treatment, the pain workers feel, especially in the spine, will risk a spinal dislocation that causes pain and is potentially irreversible [2]. There are different factors affecting the occurrence of musculoskeletal disorders in the workplace. These factors can categorize into several groups, including physical, psychosocial, and personal determinants [3], [4]. Physical factors are an important group of effective factors. Herin et al. concluded that the factors of posture, heavy load, repetitive movement, vibration, and forceful effort can predict the chronic regional and multisite musculoskeletal pain in a working population [5]. Factors of human work and workplace, there is a potential that is quite dangerous so that a prevention effort is needed so that accidents do not occur and diseases or disorders due to work postures that are not suitable [6]. A work system requires good components and interactions between components to perform well. The components such as work methods, workers, and the work environment must be considered to provide the desired results [7].

An appropriate work posture is assessed by the movement of humans' body organs while working. The movements consist of: flexion, extension, abduction, adduction, rotation, pronation, and supination. Flexion is a movement in which the angle between two bones is decreased. Extension is a stretching motion where there is an increase in the angle between two bones. Abduction is a sideways movement away from the central axis (the median plane) of the body. Adduction is the movement towards the center axis of the body (the median plane). Pronation is the rotation of the middle (in) the limbs. Supination is rotation towards the side (out) of the limb [8].

Manual Material Handling (MMH) is an important study in industrial world. Humans' power plays a very important role in Manual Material Handling process. Manual Material Handling involves humans' physical power and muscles, which become the factors that can cause ergonomics danger. The determination of appropriate posture and movement, which is suitable with the ergonomics principles, can minimize the risk of Musculoskeletal Disorder (MSD), especially on the backbones. The study and simulation of Manual Material Handling is really necessary, in order to be able to identify and evaluate the work posture, especially for the work movements, such as lifting, carrying, and lowering [9].

In a company, humans still play an important role in production. Although most of the production processes already use machines and will automatically run the production process, some stations still use manual procedures. Of course, the company wants to produce products by prioritizing the best quality by reviewing every process. The packaging station is one of the stations needed to produce the product. At the station, workers are still doing the packaging process manually. Workers often complain of pain felt at work. Workers who work manually are at risk of experiencing musculoskeletal disorders. So it is necessary to analyze the work posture to determine whether improvements must be made. The method used to analyze the work posture at the packaging station is the Rapid Entire Body Map (REBA) method. Posture to find out whether improvements need to be made. The method used to analyze the work posture at the packaging station is the Rapid Entire Body Map (REBA) method.

2 Research Methods

The methods implemented in measuring the posture are Rapid Entire Body Assessment (REBA) and Rapid Upper Limb Assessment (RULA). REBA is a method developed in ergonomics field and it can be used to assess an operator's work posture rapidly [10], [11]. Meanwhile, RULA is a method developed in ergonomics field which aim to investigate and assess the work positions performed by the upper body [12]. Based on RULA and REBA analysis, it can be identified whether the posture of the employee needs any improvement to reduce any risk in working or not, and the improvements can be arranged when designing the work system [13].

This design uses REBA and Anthropometry methods. Rapid Entire Body Assessment is a method developed in ergonomics field and can assess the work position or posture of an operator's neck, back, arms, wrists, and feet quickly [11] .The following are the steps taken to analyze work posture using the REBA method:

1. Taking the posture of workers by using videos or photos.
2. Arrangement of the angles of the worker's body posture, divided into two parts, namely: a) Part A, which include the torso (back), neck, and legs; b) Part B, which include the upper arm, forearm, and wrist
3. Arrangement of the workload being lifted.
4. Calculation of the Rapid Entire Body Assessment (REBA) score

The following are the steps taken to obtain the conveyor design size that will be made using the Anthropometric method:

1. Perform data uniformity test calculations
2. Perform data adequacy test calculations
3. Perform percentile calculations

3 Result and Discussion

3.1 REBA method

The REBA method determines workers' work postures in the packaging section. REBA can identify work postures that do not suit the whole body. The packaging process has several processes, namely the weighing process, the sewing process, and the process of moving the finished product by manually lifting the sack. Moving the product involves three activities: holding, lifting, and moving. The initial stage is taking work posture data with photo/video documentation of workers when transferring finished goods to pallets in the packaging section. The work posture of 3 activities in transferring finished goods to pallets as shown in Fig. 1.

(a)

(b)

(c)

Fig. 1. Worker activities: (a) Holding, (b) Lifting, and (c) Moving

The next stage is to determine the angles of the workers' body parts in the photos taken, the weight of the object being lifted, the coupling, the risk of worker activities, and the REBA value. Determining the angle of the worker's body during holding activities as shown in Fig. 2

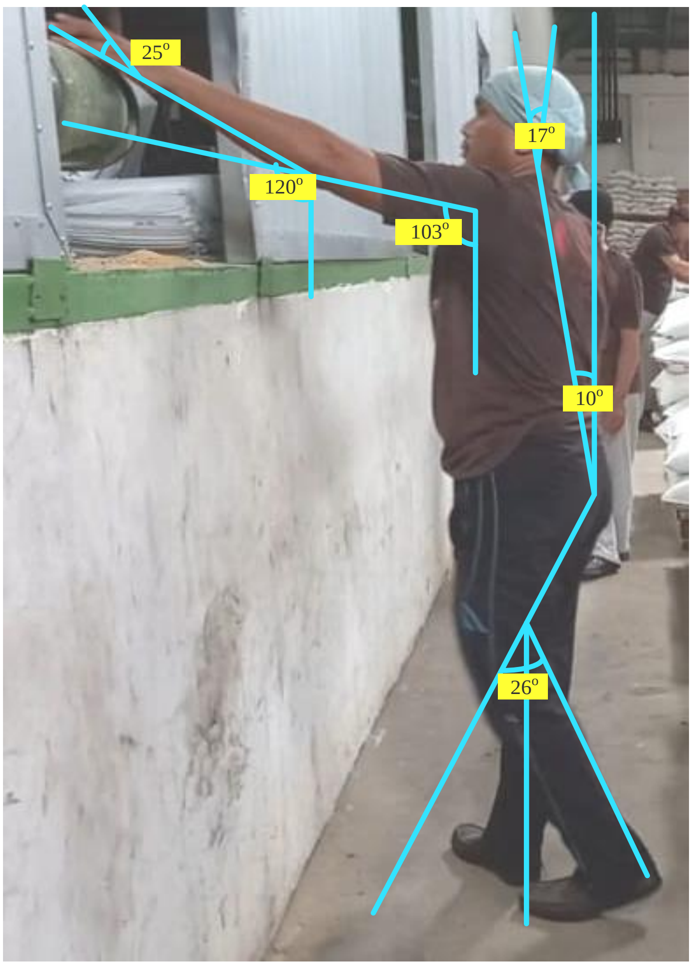

Fig. 2. Measuring the angle of holding activities

After determining the angle of the worker's body, it can determine the REBA score of the holding activity. The REBA assessment analysis is split into two parts: Group A, the neck, trunk, and legs, and Group B, the upper arms, lower arms, and wrists.

Table 1. Assessment of group a workload elements of holding activities

	Group A				
	Angle	**Score**	**Adjustment**	**Total Score**	**Description**
Neck	17°	1	0	1	-
Trunk	10° flexion	2	0	2	-
Legs	Legs not supported	2	0	2	-

After getting group A score, determine the value in table A. Table 2 shows the value of table A.

Table 2. Determining the value of table a on the elements of holding activities

Table A		Neck											
		1				2				3			
	Legs	1	2	3	4	1	2	3	4	1	2	3	4
Trunk Position Score	1	1	2	3	4	1	2	2	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

So, the value of table A is 3. Then to get the value of score A, it is important to calculate the value of the load to the value of table A. Table 4 shows the assessment of the weight of the load [14].

Table 3. Load weight score

Load Weight	**Score**	**Score Changing**
Weight < 11 lbs (5 kg)	0	+1 If there is a sudden or rapid increase in load
Weight 11 – 22 lbs (5-10 kg)	1	
Weight > 22 lbs (10 kg)	2	

For holding activities, the weight of the load received is 0 kg. So the score of the weight of the load is 0. Then the total score of A is 3 + 0 = 3. After that, analyze group B. The assessment of group B's workload.

Table 4. Assessment of group B workload elements of holding activities

	Group B				
	Angle	**Score**	**Adjustment**	**Total**	**Description**
Upper Arm	103° flexion	4	0	4	-
Lower Arm	120° flexion	2	0	2	-
Wrist	25° extension	2	0	2	-

After getting a group B score, determine the value in table B. Table 5 shows the determination of the value of table B.

Table 5. Determination of the value of table B on the elements of holding activities

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	5	7	8	7	8	9
	6	7	8	8	8	9	9

After getting group B score, determine the value in table B. Table 6 shows the determination of the value of table B

Table 6. Coupling score

Coupling	**Score**
The handle is just right and not too strong	0 (*Good*)
The way of holding is acceptable but not good or the coupling is more suitable for use with other body parts	1 (*Fair*)
Hand holding is not acceptable even if possible	2 (*Poor*)
Forced, not safe grip, no grip, coupling not suitable for use by the body	3 (*Unacceptable*)

For holding activities, the type of coupling used is included in the Unacceptable category with a value of 3. So the total score of B is 6 + 3 = 9. Furthermore, after getting the A score and B score, the C score can be determined by Table C. Table 7 shows the determination of the table value C.

Table 7. Determining the value of Table C on holding activities

Score 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

So the value of table C is 7. Then to get the REBA value, it is necessary to add the activity value to table C. Table 8 shows the activity score assessment. [15]

Table 8. Activity score

Activity	Score
One or more body parts are still for more than 1 minute (static)	1
Repetitive activity (> 4x in 1 minute)	1
Activity causes fast and repetitive changes in posture or is unstable	1

For holding activities, including repetitive activities with a value of 1. The REBA value for holding activities is the value of table C added to the activity value, namely 7 + 1 = 8. Then the REBA value obtained for holding activities is 8. Table 9 shows there is a level of REBA risk. [15]

Table 9. REBA risk level

Action Level	REBA Score	Risk Level	Corrective Action
0	1	Can be ignored	No need
1	2-3	Low	May need
2	4-7	Currently	Need
3	8-10	High	Need urgently
4	11-15	Very high	Need it right now

Holding activities includes repetitive activities with a value of 1. The REBA value for holding activities is the value of table C added to the activity value, namely 7 + 1 = 8. Then the REBA value obtained for holding activities is 8. Table 9 shows there is a level of REBA risk. [15].

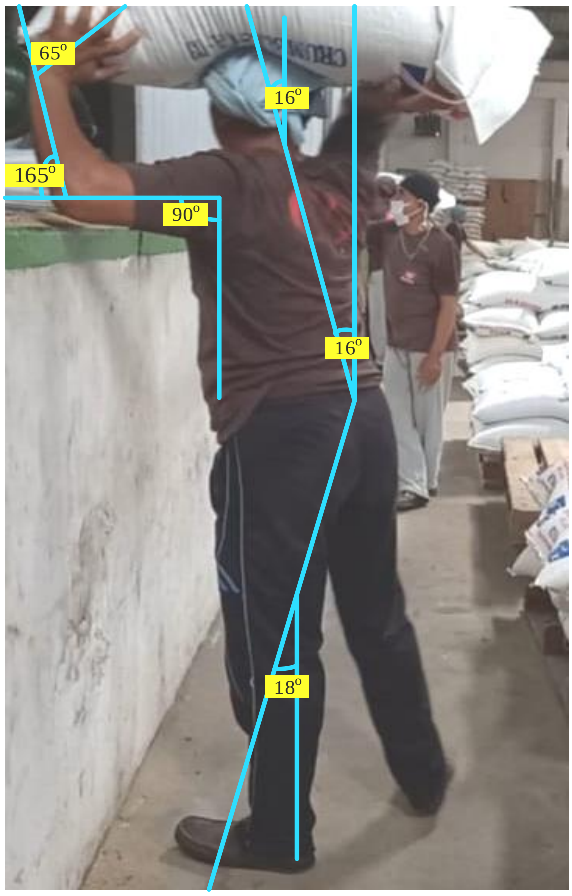

Fig. 3. Measurement of lifting activity angle

1. Table A

   The value in Table A is 2 and has a load of more than 10 kg, so 2+2=4.

2. Table B

   The obtained value in Table B is 5 and has no handle so 5+3=8.

3. Table C

   The obtained value in Table C is eight and has repeated lifting activities so that 9+1=9.

From the results of the REBA value that has been obtained from Fig. 3, it can be categorized into a high-risk level, and repairs are needed immediately.

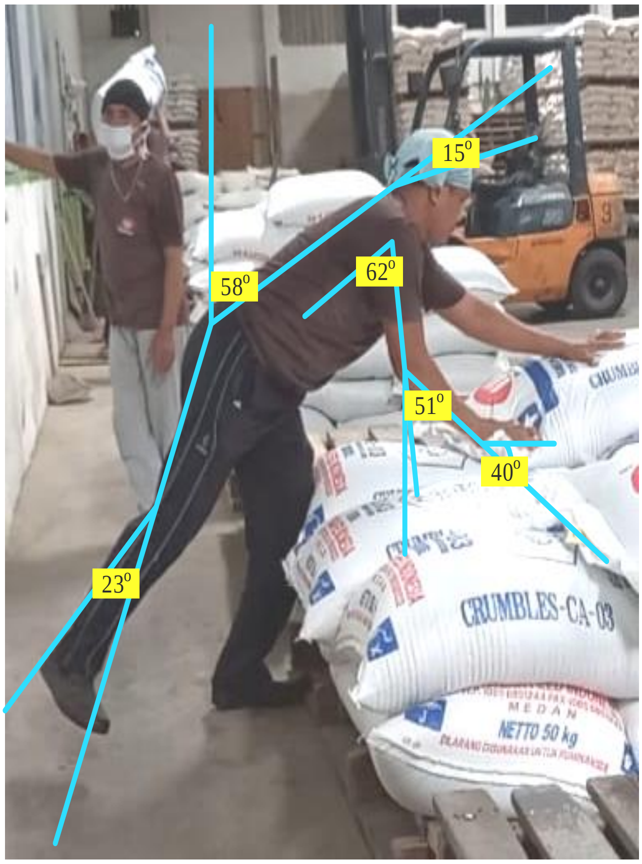

Fig. 4. Workers moving sacks of finished products

1. Table A

   The value in Table A is 4 and has a load of more than 10 kg so 4+2=6.

2. Table B

   The obtained value in Table B is 5 and has no handle so 5+3=8.

3. Table C

   The obtained value in Table C is nine and has repeated lifting activities so that 9+1=10.

From the results of the REBA value that has been obtained from Fig. 4, it can be categorized into a high-risk level, and repairs are needed immediately. The summary of the assessment results of the body posture assessment for holding, lifting, and moving activities can be seen in Table 10.

Table 10. Results of the recap of the work posture assessment of the process of moving animal feed sacks with the REBA method

Activity	Score	Description
Hold	8	Risk level is high and repair is needed urgently
Lift	9	Risk level is high and repair is needed urgently
Move	10	Risk level is high and repair is needed urgently

3.2 Anthropometric Method

In determining the conveyor design as a proposed improvement due to inappropriate work postures, anthropometry is needed to determine the conveyor height size to be used. As for the length of the conveyor, data is used for the distance from the sewing machine station to the pallet. For the width, the data for the width of the finished product sack and the height of the side of the sewing machine are used.

Table 11. Conveyor design size data

No.	Dimensions	Size
1.	Long	100 cm
2.	Wide	65 cm
3.	Top side height (sewing machine side)	150 cm

Anthropometric data were obtained from 18 workers in the packaging process section. Anthropometric data required is Elbow Height Standing. The following is the data on the standing elbow height of the packaging worker.

Table 12. Data on standing elbow height of packaging workers

No.	Worker	Standing Elbow Height (TSB) (cm)
1.	Worker 1	100
2.	Worker 2	103
3.	Worker 3	108
4.	Worker 4	116
5.	Worker 5	102
6.	Worker 6	108
7.	Worker 7	99
8.	Worker 8	95
9.	Worker 9	96
10.	Worker 10	104
11.	Worker 11	101
12.	Worker 12	107
13.	Worker 13	108
14.	Worker 14	110,5
15.	Worker 15	109
16.	Worker 16	96,5
17.	Worker 17	106
18.	Worker 18	98

Researchers need additional data on body dimensions to meet the data adequacy test. As many as 30 samples were taken from the Ergonomics and Industrial Engineering Work System Design Laboratory at the University of North Sumatra.

Table 13. Data on standing elbow height, Ergonomics Laboratory and Design of Industrial Engineering Work Systems, University of North Sumatra

No.	Standing Elbow Height (TSB) (cm)
1.	103
2.	106
3.	103
4.	108
5.	91,3
6.	107
7.	102,3
8.	126,6
9.	101,5
10.	96,5
11.	111,2
12.	102,1
13.	101
14.	102
15.	102,6
16.	103,4
17.	98,3
18.	110,6
19.	97,3
20.	112,7
21.	107,5
22.	101,1
23.	105,7
24.	96,1
25.	98,2
26.	89,6
27.	96,2
28.	105,2
29.	107,5
30.	92

The data used are 48, sufficient after the data adequacy test. The data that has been obtained will be tested for the data uniformity to find out whether there is data that is not uniform. The data uniformity test’s calculation is as follows.

1. Average Score

Average value's calculation (mean) as in Eq. (1)

$$\bar{x} = \frac{\Sigma xi}{n} \quad (1)$$

where:

N = Number of observations

Σxi = Number of nth observations

$\bar{x}$ = X average

$$\bar{X} = \frac{100+103+\ldots+92}{48} = \frac{4937{,}9}{48} = 102{,}87$$

The calculation results obtained an average value of 102.87

2. Standard Deviation

Calculation of Standard Deviation as in Eq. (2)

$$\sigma = \sqrt{\frac{\Sigma (xi-x)^2}{(n-1)}} \quad (2)$$

$$\sigma = \sqrt{\frac{(100-102{,}87)^2+(103-102{,}87)^2+\ldots+(92-102{,}87)^2}{48-1}} = 5{,}90$$

The calculation results obtained a standard deviation of 5.90.

3. BKA and BKB

Calculation of BKA and BKB

$$BKA = \bar{X} + 3\,\sigma X = 102{,}87 + 3\,(5{,}90) = 120{,}58$$

$$BKB = \bar{X} - 3\,\sigma X = 102{,}87 - 3\,(5{,}90) = 85{,}16$$

The calculation results are that the Upper-Class Limit (BKA) is 120.58 cm, and the Lower Class Limit (BKB) is 85.16 cm. The calculation results shown in Fig. 5.

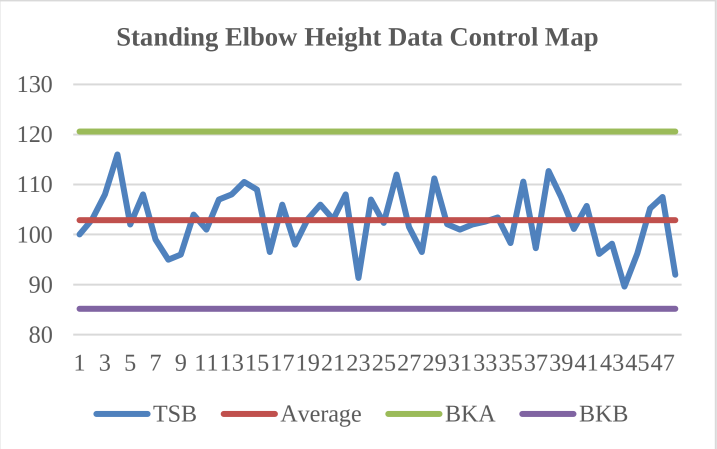

Fig. 5. Data control map of standing elbow height

All data are uniformly based on the results uniformity test's calculation of standing elbow height data. It can be seen on the control chart that all the data are within the control limits. There is no data that crosses the upper-class limit and the lower-class limit. The data that has been uniform will be tested again to determine whether the data is sufficient to be used. The calculation of the data adequacy test is as in Eq. (3) [15].

$$N' = \left(\frac{40\sqrt{N.\ \Sigma x_j^2 - (\Sigma x_j)^2}}{\Sigma x_j} \right)^2 \quad (3)$$

$$N' = \left(\frac{40\sqrt{48.\ (100^2+103^2+\ldots+92^2)-(100+103+92)^2}}{100+103+\ldots+92} \right)^2$$

$$N' = \left(\frac{40\sqrt{48 \text{ x } 509614{,}3 - 24382856{,}4}}{4937{,}9} \right)^2 = 5{,}16 = 5$$

The observation data taken is sufficient because it meets the requirements of N'<N, namely 5 <48.

For standing elbow height, use the 90th percentile. The percentile calculation is as follows.

$P_k = \bar{X} \pm k_i.s$

$P_{95} = 102{,}87 + 1{,}645\ (5{,}90)$

$P_{95} = 112{,}58 = 113$ cm

Based on the calculation of the percentile data for standing elbow height, it is found that the conveyor height used is 113 cm. The material used is steel and specifically for conveyor belts using rubber. Based on the data that has been obtained, the results of the conveyor design can be seen in the Fig. 6.

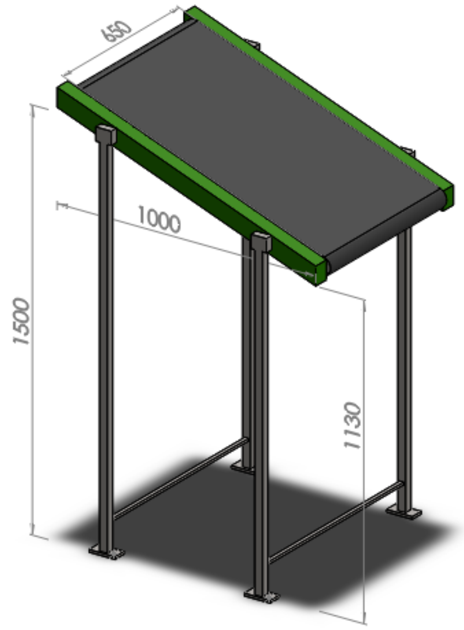

Fig. 6. Proposed conveyor design

4 Conclusions

REBA is affected by coupling, the load being lifted, and the worker's activities. This method only requires a short time to complete and perform a general assessment of the identified activities needed to reduce the risk due to the work posture of the workers. In determining the conveyor design as a proposed improvement due to inappropriate work postures, anthropometry is needed to determine the conveyor height size to be used. As for the length of the conveyor, the data is used for the distance from the sewing machine station to the pallet. For the width, the data for the width of the finished product sack and the height of the side of the sewing machine are used. Regarding ergonomics, the percentile value of several anthropometric data measurements is often used. The percentile calculations can be done with statistics. Simple calculations can be done by sorting the data from the smallest to the largest. Then the percentile value calculated statistically can be done using the formula. Percentile calculation using anthropometric data on standing elbow height with 95th percentile. Based on calculations, the conveyor height measurement is 113 cm. The design of the conveyor should add a barrier on the edge of the conveyor frame so that the product that passes does not fall easily. The design of the conveyor should be added with pallet supports so that the conveyor and pallet are interconnected so that the product will not fall outside the pallet.

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