Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 8, No. 6, 4585-4598
2024
Publisher: Learning Gate
DOI: 10.55214/25768484.v8i6.2989

Redesign of stroller work tools at PT. Ika Bina Agro Wisesa

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Abstract: PT. Ika Bina Agro Wisesa (PT. IBAS) is one of the agro-industries that manages or produces palm oil with a production capacity of 30 tons / hour and a total of 420 tons / day. The raw material of Fresh Fruit Bunches (FFB) of this factory comes from the plantation land of the community around the factory. The activity of harvesting FFB in this oil palm plantation has many manual material handling activities, especially for workers who lift and push wheelbarrows (angkong). The angkong work tool used is relatively old and looks unergonomic which can be seen when pushing the angkong in a very bent position so it is assumed that there is a large amount of force expended by workers. This research begins with a survey of the company and the field, then distributing Nordic Body Map (NBM) questionnaires to workers, using the Rapid Entire Body Assessment (REBA) method used to determine the level of risk of work posture in workers before and after the design of the tool, for the redesign of the stroller, anthropometric measurements are taken then using the Biomechanics method to determine the amount of force generated when pushing. This stroller redesign was carried out using operator anthropometry with the 95th percentile. After using the proposed tool, the work posture assessment is categorized as moderate which means that action is needed. The final results of the redesign are the length of the cart 90 cm, the width of the cart 66 cm, the diameter of the tire 32 cm, the height of the cart from the ground 125 cm, the height of the handle 96 cm, the width of the handle 40 cm, and the diameter of the handle 3 cm and the final results of the biomechanical assessment after the design concluded that the operator was no longer dangerous when pushing.
Keywords: *Rapid entire body assessment (REBA), Redesign, Stroller, Work posture.*

1. Introduction

Oil palm plantations are one of Indonesia's strategic commodities that play an important role in the economy. However, behind its large contribution, there are a number of complex problems that may be faced by oil palm plantation workers as suppliers to processing plants. In work, especially in the industrial field, humans need various kinds of tools to help make their work easier. Humans have an important role in an industry, this is because the production process still requires a lot of direct human labor such as manual material handling activities, especially pushing activities. This can be the cause of various problems or diseases in the industrial world, such as work accidents, cardiovascular disease, and *musculoskeletal disorders* (MSDs).

PT Ika Bina Agro Wisesa (PT IBAS) is one of the agro-industries that manages and produces palm oil and has a plantation area of 6455.8 Ha. The raw material of Fresh Fruit Bunches (FFB) of this factory comes from the plantation land of the community around the factory. The activity of harvesting FFB in this oil palm plantation has many manual material handling activities, especially for workers who lift and push wheelbarrows (angkong) FFB to be processed into *Crude Palm Oil* (CPO) at the PT. Ika Bina Agro Wisesa (PT. IBAS) Factory. This creates a working position condition that is less ergonomic and has a high potential for musculoskeletal disorders (MSDs) in FFB harvester workers. Based on the results of the initial survey, many workers experienced musculoskeletal disorder (MSDs) complaints in several parts of the body such as the waist, back, hands, and feet caused by the

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position of the body pushing the stroller very bent and the load is so heavy.

Therefore, it is necessary to evaluate the work posture experienced by workers at PT Ika Bina Agro Wisesa (IBAS) so as not to cause occupational diseases, by designing work aids using the *Rapid Entire Body Assessment* (REBA) method and biomechanical methods.

2. Literature Review

2.1. Ergonomics

Ergonomics comes from the Greek words "ergo" which means work and "nomos" which means law. So, ergonomics can be interpreted as a science that studies humans in relation to their work [1]. The purpose of implementing ergonomics can also be made in a hierarchy with the lowest goal being a work system that is still acceptable (*tolerable*) within certain limits, provided that this system does nothave the potential to harm human health and life [2].

2.2. Work Posture

Work posture is an action taken by workers in doing work. A good work posture is a work posture or attitude that makes the implementation of work more effective, and less muscle effort. While poor work posture will result in muscle health problems [3]. How to overcome complaints due to body posture during work is to prevent forward inclination of the neck and head, prevent forward inclination of the body, prevent asymmetrical motion, joints in a range of one-third of the maximum movement and if using muscle power should be in a position with maximum strength [4].

2.3. Anthropometry

Anthropometry is a collection of numerical data related to the characteristics of the human body, size, shape, and strength and the application of these data for handling design problems. Anthropometric measurements are a series of quantitative measurements of muscle, bone, and adipose tissue used to assess body composition. The core elements of anthropometry are height, weight, body mass index (BMI), body circumference (waist, hips, and limbs), and skinfold thickness [5].

2.4. Anthropometric Data Assessment

The shape and dimensions of the human body are generally different which are used in various product designs or work facilities. So, the limbs that need to be measured in this study can be seen as follows [6]:

1. Standing Elbow Height (TSB).
2. Shoulder Width (LB).
3. Standing Knuckle Height (TBJB).
4. Width of Gripping Hand (LTM).
5. Minimum Grip Diameter (DgMin).

2.5. Symptoms of Musculoskeletal Disorders (MsDs)

Nordic Body Map (NBM) is a questionnaire method used to assess the severity of the occurrence of disorders or injuries to the skeletal muscles. Through this questionnaire, it can be seen which part of the muscle is experiencing complaints with the level of complaints ranging from No Pain, Somewhat Pain, Pain and Very Pain. NBM results can estimate the type and level of complaints, fatigue, and pain in the muscles felt by workers [7].

2.6. Rapid Entire Body Assessment (REBA)

Rapid Entire Body Assessment (REBA) is a method in the field of ergonomics that is used quickly to assess the working position or posture of an operator's neck, back, wrist arms and legs. In addition, this method is also influenced by *coupling* factors, external loads supported by the body and operator activities. In REBA analysis, there are two types of postures that are assessed, namely types A and B. Type A covers the body, neck, and legs, while Type B covers the upper and lower arms and wrists for left and right movements. The REBA score is obtained by looking at the A and B values in table C to get the C value. Then it is added to the active value. While the level of risk in the workplace is taken from the REBA decision table [8].

2.7. Biomechanics

Biomechanics is the study of the movement of living things based on the principles of engineering mechanics using the concepts of physics and engineering to explain the movement of body parts and the forces acting on human body parts in daily activities. The biomechanics approach is useful for measuring the strength and physical endurance of humans to perform a certain operator, which aims to get a better way of working so that the biomechanics approach is useful for measuring the physical strength and endurance of humans.

The possibility of injury can be minimized. Generally, occurs due to excessive muscle contraction due to loads that are too heavy with a long duration of loading commonly experienced by the neck, shoulders, arms, fingers, back, hips, and lower muscles [9].

2.8. Stroller

A wheelbarrow is a device attached to wheels and can be controlled by the user to move luggage from one place to another which is usually used in industrial activities. Therefore, it is necessary to determine the characteristics of a good wheelbarrow that has considered the factors that most affect energy consumption and the possibility of injury. From the analysis of body posture position, it is known that the best body position during lifting is a straight body position with arms parallel to the spine [10].

Grip heights ranged from >103 cm, with 6% of pushes occurring below the knee height of the leg(<76 cm). Most (60%) pushing was performed between 76 cm (thigh height of the foot) and 114 cm (elbow height). Pushing forces are characterized by (i) an initial force required to initiate movement ofan object, (ii) a sustaining force - a lower force required to maintain movement and (iii) a stopping force required to stop movement of an object [11].

3. Methods

The research was conducted at PT Ika Bina Agro Wisesa (PT IBAS) Guha Uleue, Kuta Makmur sub- district, North Aceh district. The research time starts from April 2024 which begins with the preparation stage of preparing a research proposal to writing a research report until completion.
The stages carried out in data processing in this study are as follows:

3.1. NBM (Nordic Body Map) Analysis

The NBM questionnaire was given to respondents, namely workers, to determine the location of musculoskeletal complaints of tofu pressing workers.

3.2. Rapid Entire Body Assessment (REBA)

Identify work postures that lead to musculoskeletal disorders.

3.3. Anthropometric data determination

Determination of which body parts are measured in the stroller redesign.

3.5. Product Design

The new tool will be designed using *Auto* CAD *software* and will be the solution to the problems in this research.

3.4. Biomechanical Thrust Force Calculation

To determine the comparison of the magnitude of the thrust force of the thrust cart.

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 8, No. 6: 4585-4598, 2024
DOI: 10.55214/25768484.v8i6.2989

4. Results and Discussion
4.1. Data Collection Results

4.1.1. NBM Questionnaire Recapitulation Results

The results of the NBM questionnaire recapitulation on workers in the transportation of FFB can beseen in Table 1 as follows:

Table 1.
Recapitulation of NBM questionnaire results.

No. body segment	Occupational complaint score		
	TS US	S	SS
0 Pain/stiffness in the upper neck	1	2	
1 Pain/stiffness in the lower neck	1	2	
2 Pain in the left shoulder	1	2	
3 Right shoulder pain	2	2	
4 Pain in the left upper arm	1	1	1
5 Pain in the right upper arm		1	2
6 Back pain	1	2	
7 Back pain			3
8 *Buttock* pain			1
9 Pain in the buttocks (*Bottom*)			
10 Pain in the left elbow	3		
11 Pain in the right elbow	3		
12 Pain in the left forearm	1	2	
13 Pain in the right forearm	1	2	
14 Pain in the left wrist	1	2	
15 Pain in the right wrist	1	2	
16 Pain in the left hand		3	

Table 1.
Recapitulation of NBM questionnaire results (Continued).

No. Body segment	Occupational complaint score	
	TS US	S SS
17 Pain in the right hand	1	2
18 Pain in the left thigh	2	1
19 Pain in the right thigh	1	2
20 Pain in the left knee	2	
21 Right knee pains	1	2
22 Pain in the left calf	1	2
23 Pain in the right calf	1	2
24 Pain in the left ankle	1	2
25 Pain in the right ankle	1	2
26 Pain in the left leg	1	2
27 Pain in the right leg	1	2

Description: TS: No pain, AS: Somewhat Sick, S: Pain, and SS: Very Sick

4.1.2. Worker Position Condition

The condition of the operator's position working in the transportation of FFB can be seen as follows:

Figure 1.
Operator's working position 1.

Figure 2.
Working position of operator 2.

Figure 3.
Working position of operator 3.
Source: PT IBAS Palm Plantation.

The condition of the operator's position in the transportation of fresh fruit bunches (FFB) is often in a state of bending when lifting the load carried, moreover environmental factors such as uneven roads make it difficult for operators to turn the wheelbarrow and balance the position of the body with the load it carries.

4.1.3. Stroller (Angkong)

The wheelbarrow work tool used by the operator to transport FFB can be seen in Figure 4. as follows:

Figure 4.
Wheelbarrow (Angkong).
Source: PT IBAS Palm Plantation.

The initial wheelbarrow specification data can be seen in Table 2. as follows:

Table 2.
Initial wheelbarrow specification data.

No.	Component name	Dimension (Cm)
1	Front height	55
2	Rear height	51
3	Support height	31
4	Support width	37
5	Skeleton length	138
6	Tub length	80
7	Tub width	64
8	Distance between handles	67
9	Axle mount height	5
10	Axle length	15
11	Axle diameter	2
12	Tire diameter	20

4.1.4. Operator Anthropometry Data

The data measured in the redesign of this work tool are Standing Elbow Height (TSB), Shoulder Width (LB), Standing Knuckle Height (TBJB), Grasping Hand Width (LTM), Minimum Grip Diameter (DgMin). The recapitulation of anthropometric data of workers can be seen in Table 3.as follows:

Table 3.
Recapitulation of operator anthropometric data.

Operator	TSB (Cm)	LB (cm)	TBJB (cm)	LTM (cm)	DgMin (cm)
1	101	47	70	10	2.6
2	100	49	77	10	2.7
3	113	45	84	10	2.7
Total	314	141	231	30	8
Average	100	47	77	10	2.6

4.2. Data Processing

4.2.1. Measurement of Work Posture Angles and REBA Calculation of Fresh Fruit Bunch (FFB) Transportation Operators

This REBA assessment is carried out to determine whether the operator's posture is in a naturalor awkward position. The REBA calculation of this operator uses *ergofellow software* which can be seen in the following figure::

Figure 5.
Working Position and REBA results of operator 1.

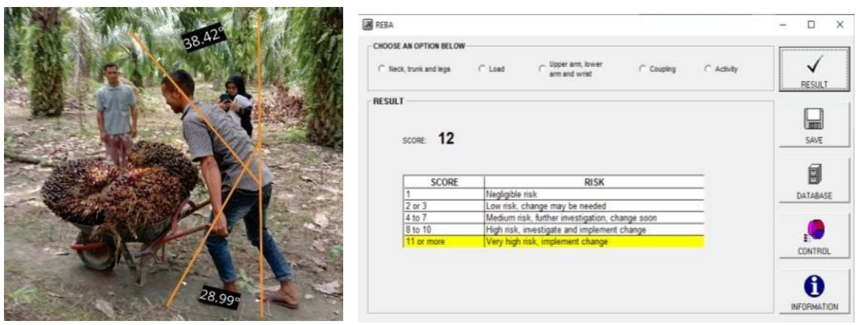

Figure 6.
Working Position and REBA results of operator 2.

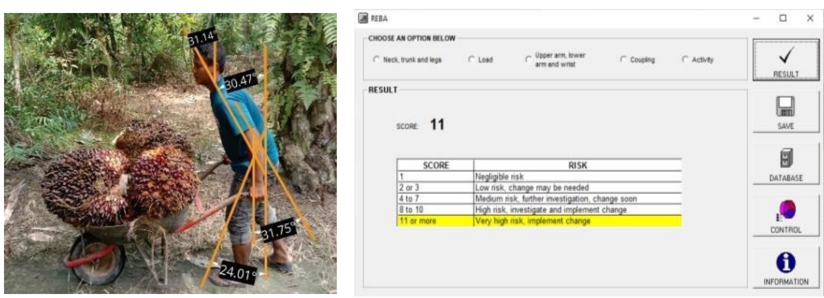

Figure 7.
Working Position and REBA results of operator 3.

The measurement results using *Ergo Fellow Software* show a REBA score of 11-12, which is included in the very high category, which means that posture improvements are needed for operators working in oil palm plantations. With such a score, the work posture in oil palm plantations can lead to musculoskeletal problems in the operators who work. During interviews with operators, complaints were found that the wheels of the wheelbarrow (angkong) were difficult to control, making the operators often bump into and lose their balance. This is an input for the author in redesigning wheelbarrow work aids that can help the operator's work.

4.2.2. Biomechanical Calculations

This biomechanical calculation is made to find out how much force is generated when pushing withthe initial position and after being designed and to find out the maximum weight of a worker who is allowed to push goods / loads in accordance with the standards of *the National Institute of Occupational*

Safety and Health. The biomechanical calculations can be seen as follows:

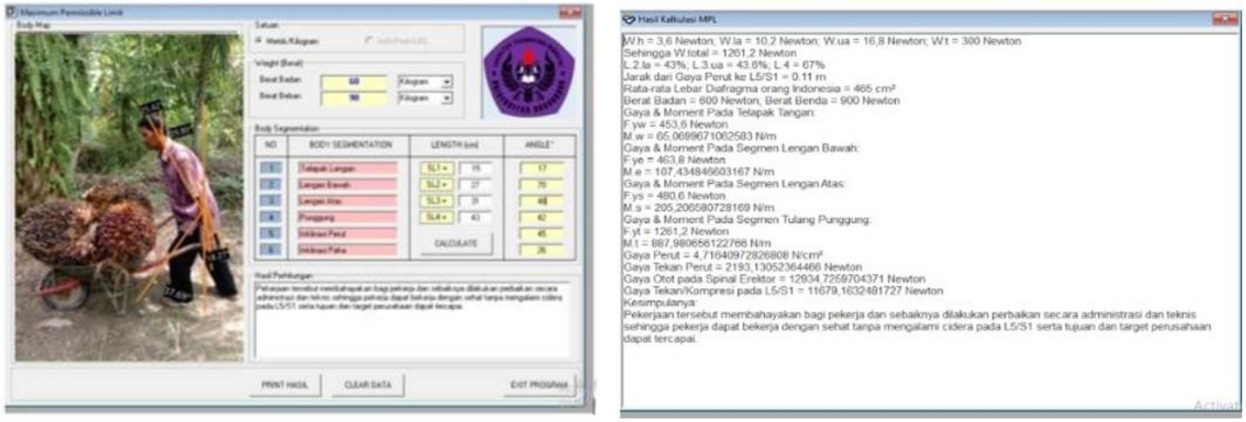

Figure 8.
Biomechanics calculation results of operator 1.

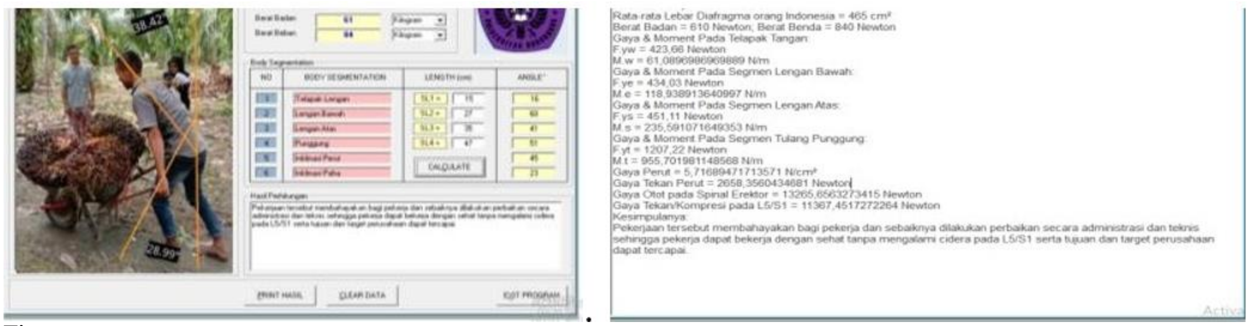

Figure 9.
Biomechanics calculation results of operator 2.

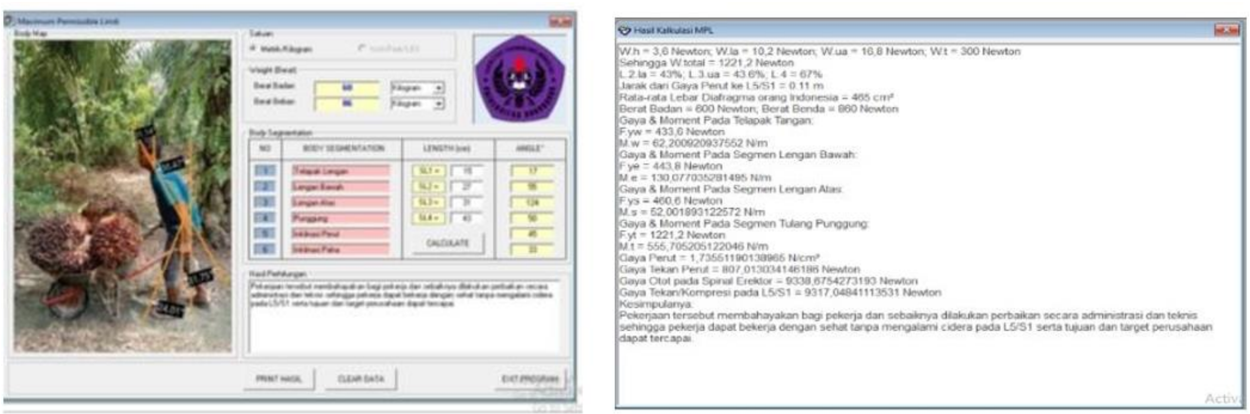

Figure 10.
Biomechanics calculation results of operator 3.

From the results of the biomechanical calculations above, it shows the conclusion that the operator works in a dangerous category because he has an injury to the L5 / S1 spine, therefore the need for immediate improvement regarding the position or posture of the workers. Therefore, the author will design a tool to improve the work posture of the workers in the transportation of FFB.

4.2.3. Anthropometric Calculation

The results of the anthropometric recapitulation of workers can be seen in Table 4. as follows:

Table 4.
Recapitulation of anthropometric calculations.

No.	Anthropometric data	Average	Standard deviation	BKA	BKB
1	TSB	100	1	102	98
2	LB	49	2	53	45
3	TBJB	64	2	68	60
4	LTM	10	0	10	10
5	DgMin	3	0	3	2

In this study, the percentile used is the 95th percentile-th because of the development of further research.The results of the percentile calculation can be seen in Table 5. as follows:

Table 5.
Recapitulation of anthropometric data.

No.	Anthropometric data	95th percentile-th
1	Standing elbow height (TSB)	102
2	Shoulder width (LB)	52
3	Standing knuckle height (TBJB)	67
4	Grasping hand width (LTM)	10
5	Minimum grip diameter (DgMin)	3

4.2.4. Tool Redesign

The results of the product size specifications to be designed according to anthropometric calculations andthe results of direct research surveys at PT IBAS plantations can be seen in Table 6 as follows:

Table 6.
Product specifications.

No.	Component	Size	Description
1	Cart length	90 cm	Customization
2	Cart width	66 cm	Customization
3	Tire diameter	32 cm	Customization
4	Cart height from the ground	125 cm	Anthropometry
5	Height (*Handle*) of handle	96 cm	Anthropometry
6	Width (*Handle*) of handle	40 cm	Anthropometry
7	Diameter (*Handle*) of handle	3 cm	Anthropometry

The results of the drawings of the stroller and spatula work aids that have been designed with the sizeaccording to the table above can be seen in Table 7 below:

ISSN: 2576-8484
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DOI: 10.55214/25768484.v8i6.2989

Table 7.
Results of the redesign of wheelbarrow work aids.

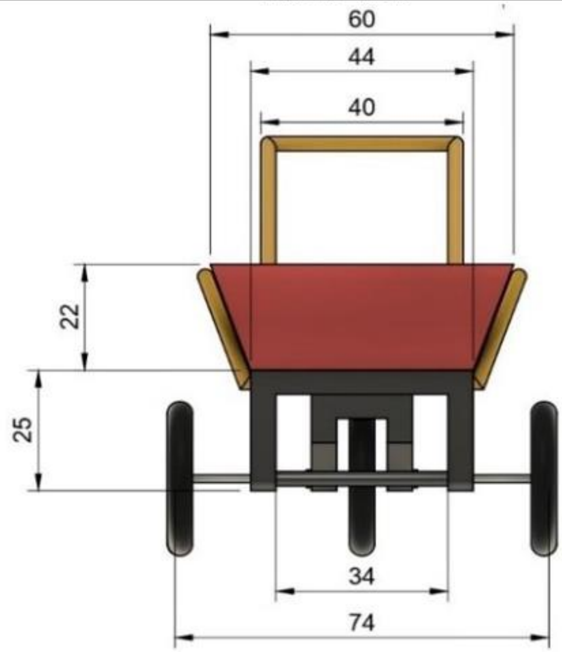
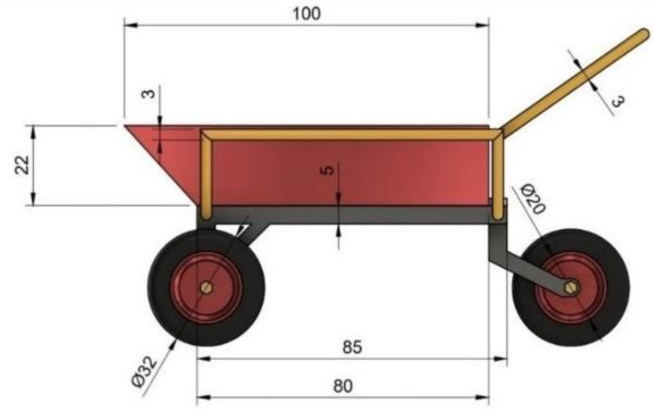
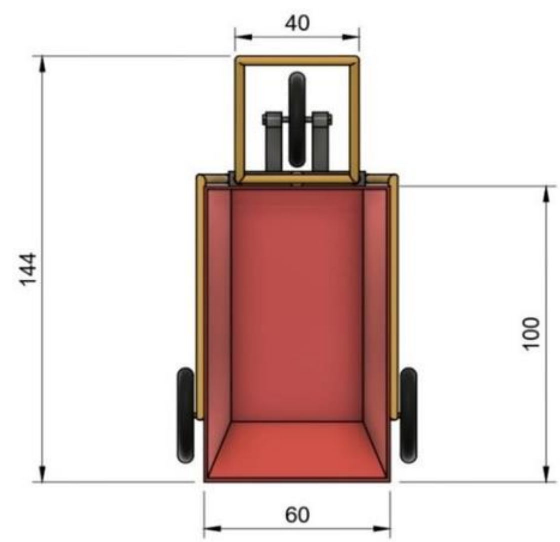
Front View


Table 7.
Results of the redesign of wheelbarrow work aids (Continued).

Side View

Top View


Parts of a Wheelbarrow (Angkong)

Parts List			
Item	Qty	Part Number	Material
1	1	Frame	Steel
2	1	Front Axle	Steel
3	1	Shock	Steel
4	1	Axle	Steel
5	3	Velg	Steel
6	3	Rev Tire	Steel
7	4	Bolt	Steel
8	1	Rear Axle	Steel
9	1	Large Bolt	Steel
10	1	Reverse Gear Case	Steel
11	2	Support	Steel
12	1	Handle	Steel

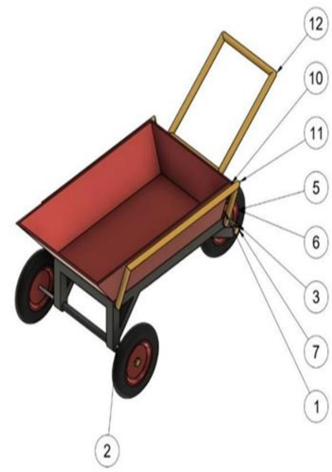
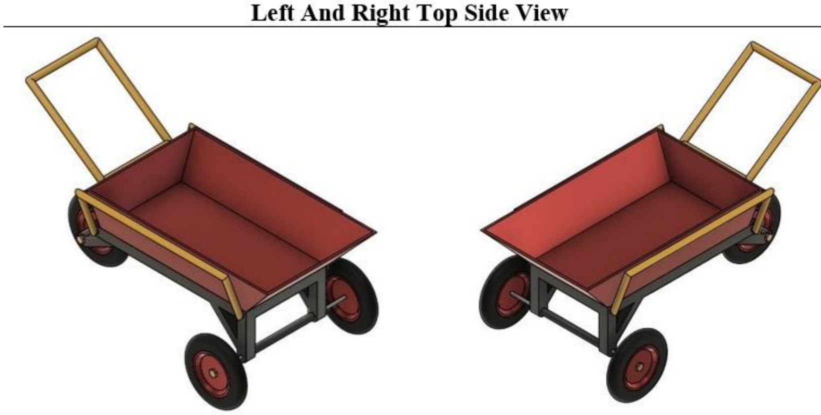


Table 7.
Results of the redesign of wheelbarrow work aids (Continued).

Left And Right Top Side View



Source: 3-Dimensional design.

5. Analysis of Results

5.1. REBA Analysis After Redesign

The purpose of this REBA recalculation is to determine the results of the comparison between the initial work posture before being designed and after being designed. REBA calculations after this design were carried out using *Ergo Fellow software*. The operator's work posture after designing the work aid along with the angle that has been determined can be seen in Figure 11 below:

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Vol. 8, No. 6: 4585-4598, 2024
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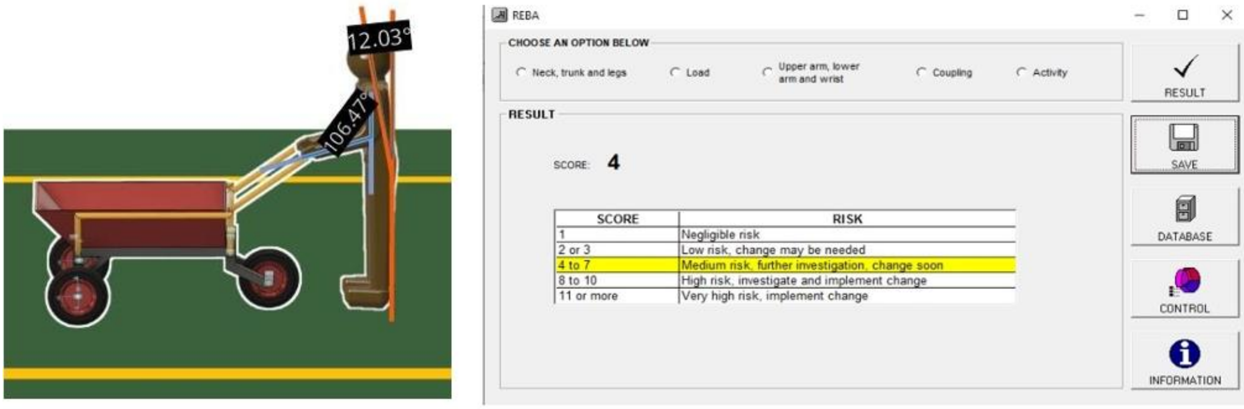

Figure 11.
Working position and REBA results after redesign.

5.2. Biomechanical Analysis After Redesign

The purpose of biomechanical calculations after this design is to determine the results of the comparison between the results before being designed and after being designed. The results of biomechanical calculations after design can be seen in Figure 12 as follows:

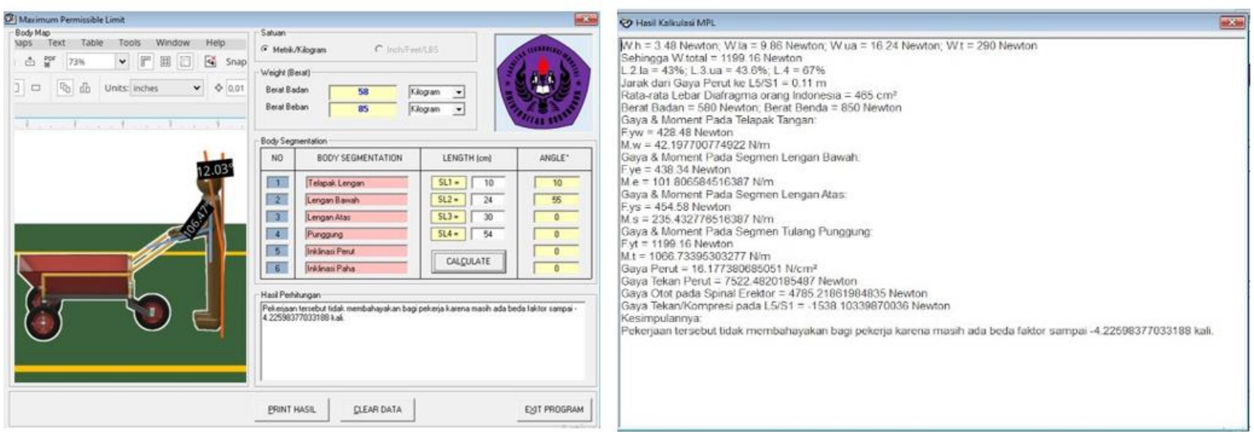

Figure 12.
Biomechanics value results after redesign.

From the analysis of biomechanical calculations after the design also shows the conclusion that the operator is not dangerous for the operator. By using the proposed stroller, the operator's posture when pushing is no longer very bent.

6. Conclusion

From the results of data processing that has been carried out in the previous chapter on researchers,the authors can draw the following conclusions:

- Based on the REBA calculation, it shows that the risk of work posture in the operator of the transportation of FFB who is hunched is high, especially in the back, waist, hands, and feet caused by pushing with a load of > 80 kg with a hunched pushing position. After analyzing the body's workload using REBA, the REBA value is obtained with a range of values, namely 11-12 where the value is classified as high, which means that the value is very high, it is necessary to take action now, where the value shows that pushing and lifting the angkong in a hunched position causes keletal pain in several parts of the body as mentioned above. After the design is carried out, the

ISSN: 2576-8484
Vol. 8, No. 6: 4585-4598, 2024
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final value of the REBA calculation for the stroller operator is 4 where the value is classified as moderate need for action. So it can be concluded that there is an influence in the design of work aids carried out.

- The results of the *redesign of* the tools that have been designed show a change in the value in the REBA method from a value of 11 to a value of 4, which means that the *redesign* that has been designed can reduce keletal pain in several parts of the body because the handle height is changed from 67 cm to 96 cm so that the worker's posture when pushing is not very bent which makes the worker comfortable in carrying out the activities of pushing the stroller.

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