



## Implementation of Rapid Whole Body Assessment (REBA) to Reduce Musculoskeletal Disorders (MSDs) to Improve the Post-Harvest Work System of Oil Palm

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### Abstract

**Background.** Oil palm harvesting workers who work unergonomically often experience the risk of Musculoskeletal Disorders (MSDs) when using traditional harvesting tools, namely, egrek and angkong. Egrek is a tool for harvesting palm oil, and angkong is a tool for transporting oil palm from the plantation to a temporary shelter for palm oil. The unergonomic working position of palm oil workers during harvesting, combined with repetitive movements such as cutting leaves and picking palm oil, causes discomfort for the workers.

**Aims.** Researchers designed ergonomic harvesting tools (egrek) and transport tools (angkong) to improve efficiency in oil palm harvesting. Researchers evaluated harvesting and transportation activities using the Nordic Body Map (NBM) questionnaire and the Rapid Whole-Body Assessment (REBA) method.

**Result.** The analysis results showed that nearly all harvesting activities carry a high risk of MSDs. The respondents to this study were nine harvesters and 11 oil palm harvest workers who operated angkong.

**Conclusion.** The results showed that harvesters often experienced discomfort in the buttocks and abnormal posture, and repetitive movements required to cut leaves and oil palm bunches. The results of the REBA calculation for palm harvest showed that it was very high (Very High), with scores of 12 when lifting the angle and 11 when pushing the corner. Therefore, immediate improvement was needed, as this had an impact on the risk of MSDs.

**Implementation.** Also, the results of REBA's calculation for transporting oil palm bunches with angkong were 9. To reduce the REBA value by adding the angkong wheel so that the final REBA value is 7.

**Keywords:** Angkong, Egrek, Musculoskeletal disorders, Palm oil, NBM



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### INTRODUCTION

Currently, Indonesia is an agrarian country because most of its population still relies on the agricultural sector as its livelihood. Agriculture remains a significant contributor to job creation compared to other sectors in the Indonesian economy (Nadzirah, 2020). One of the significant contributors to job creation in Indonesia is the plantation sector. Several types of plants thrive in Indonesia, such as tea, rubber, and others.

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DOI 10.62885/improsci.v2i6.802

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Currently, oil palm plantations are a leading player in the plantation industry due to their significant benefits and the international demand for palm oil products (Limasento, 2021; Lina et al., 2023).

Currently, Indonesia is the world's largest producer of palm oil, which is expected to provide workers with approximately 16 million jobs (Limasento, 2021). Tools used to harvest oil palm are numerous, including *dodos*, *egrek*, *gancu*, axes, machetes, *angkong*, and *tojok*. However, farmers in Indonesia still use traditional tools to harvest oil palm. This research focuses on harvesting tools and transporting fresh fruit bunches of oil palms from gardens to temporary shelters. The results of the research on the design of *egrek* and *angkong* are significant for oil palm workers because they have a high target from the oil palm plantation manager. They hope that getting an ergonomic design and *angkong* will be beneficial for them in meeting their targets.

The Central Statistics Agency (2020) stated that the plantation sector is the most significant contributor to GDP compared to other agricultural sectors. Indonesia's oil palm plantations continue to expand, resulting in an increased demand for workers.

The researcher focuses on the process of cutting oil palm fronds and oil palm bunches using harvesting aids, namely, *egrek*. *Egrek* is a sharp, curved knife shaped like a scythe, or celurite, that is specifically used for oil palm harvesting.

Manual means of transport, commonly called *angkongs*, have one wheel at the front and are equipped with a container or body. *Angkong* is designed to transport large quantities of goods and is commonly used for agricultural products, construction materials, and other goods with substantial loads. *Angkong* is used mainly in the agricultural, construction, and industrial sectors to facilitate the transportation of goods. *Angkong* is needed to transport bunches of oil palm harvested from oil palm trees in a certain amount. Workers need more energy to push the *angkong*. If the load exceeds the limits of human strength, it can pose a risk of injury or pain to the worker's body parts, which can lead to MSDs (Monasari & Hadiguna, 2006).

MSDs are medical conditions caused by occupational factors, as they involve ergonomically unergonomic work (Halim et al., 2012; Grandjean, 1998). In 2015, MSDs accounted for 31% of total worker injury cases, which were 356,910 cases (U.S. Department of Labor, 2015). MSD disorders that occur, such as sprains or strains, are often caused by fatigue associated with lifting items.

Harvesting oil palm, such as cutting palm fronds and bunches, has a high risk of developing MSDs mainly affecting joints, muscles, bones, ligaments, tendons, and spine (Gill et al., 2023; Akbar et al., 2023; Anderson & Oakman, 2016). The leading cause of MSDs in oil palm harvesters is repetitive movements such as pulling the *egrek* many times in an unergonomic manner. With ergonomic tools, farmers will be more productive in harvesting oil palm. To measure the working position of oil palm harvesting, REBA (Tamala, 2022; Kok et al., 2019; Hignett & McAtammey, 2000) was used.

Currently, the transportation of oil palm bunches from the plantation to the shelter is done while the oil palm is still using *angkong*. Transportation with *angkong* has a heavy load because the wheel is only one piece. Researchers designed a more ergonomic *angkong* that is able to improve the health of the workers' body and minimize the occurrence of complaints of MSDs (Wiskens et al., 2004; Wijaya, 2019; Wahyudiniarti et al., 2022; Indonesian Anthropometry, 2013).

**Table 1** Sukma NBM Harvester Questionnaire

Nordic Body Map <i>Questionnaire</i>					
Name: Sukma			Weight: 57 kg		
Age: 34			Height: 170		
Gender: Male			Working Time: 1.5 Years		
Job Position: Harvester			Working Time: 7 hours/day		
TS: It doesn't hurt	US: Slightly painful		Q: Pain		SS: Very sick
Yes	Types of Complaints	Complaint Rate			
		TS	AXLE	S	SS
0	Pain/stiffness in the upper neck			v	
1	Pain/stiffness in the lower neck				v
2	Pain in the left shoulder			v	
3	Pain in the right shoulder			v	
4	Pain in the left upper arm			v	
5	Pain in the back		v		
6	Pain in the right upper arm			v	
7	Pain in the waist			v	
8	Pain in the buttocks				v
9	Pain below the waist			v	
10	Pain in the left elbow			v	
11	Pain in the right elbow		v		

Table 1 shows that the average harvester experiences pain in several parts of his body such as in the neck, shoulders, upper arms, waist, buttocks, knees, and calves. The results of the interview with the harvester revealed complaints of pain due to the repetitive and unexpected movements carried out (Gill et al., 2023; Atmojo, 2020).

**METHODS**

A preliminary study was conducted on oil palm farmers at PT Perkebunan Kelapa Sawit X in Sukabumi Regency. The next stage involves identifying problems with the literature study of the article, followed by observation and measurement in the field, specifically among oil palm farmers. The results of REBA and Nordic Body Map measurements were processed to determine the level of risk associated with MSDs experienced by farmers (Hignett & Mc Atammey, 2000; Ghasemi & Mahdavi, 2020). The analysis process was conducted to assess the risk of injury associated with posture using the REBA [18]. If the results

of REBA state that improvements are needed, the next stage is ergonomic intervention to get an ergonomic working position. From the results of the ergonomics intervention using the SolidWorks application, a more ergonomic ejection and angkong design was produced.

**DISCUSSION**

**Research Location**

The research was conducted at PT Perkebunan Nusantara VIII Parakansalak, Sukabumi. The research location shows the activities of workers in oil palm harvesting. The activity began with cutting using egrapples, scraping with angkong using tongk, and moving Fresh Fruit Bunches (FFB) to the Yield Collection Site (YCS) using angkong tools. This study examined the load of FFB carried by workers to the TPH, which led to poor posture that compromised the comfort of workers. The activity was conducted for approximately 7 hours, and each worker had a target to cover an area of 2.5 to 3 hectares.

**Improved Angkong Aid Design**



Figure 1 Position of the Worker When Operating the Angkong

Figure 1 is the position of the worker when operating the angkong. In the picture, you can see that the body is bent when lifting weights. Other workers will run positions to collect further data. Data collected using the *Nordic Body Map* (NBM) by filling out a questionnaire and being filled out by 11 workers who operate angkong. The results of the NBM recapitulation are in Table 2.

Table 2. *Nordic Body Map* (NBM) Recapitulation

Name	Total Individual Score	Average Nordic Body Map
Jamaludin	72	69,54
Gambling (1)	73	
Hendi (1)	63	
Warya	72	
Hendi (2)	70	

Ajid	72
Squirrel	71
Anto	68
O'neill	70
Misto	66
Gambling (2)	68

Table 2 is a recapitulation of the *Nordic Body Map* (NBM). The average result obtained was 69.54, indicating a moderate level of risk if classified. Therefore, based on the predetermined classification, improvements may be necessary. When viewed from this level of risk, the results do not show a high urgency for immediate remediation. However, several other factors make this research urgent. Workers have daily goals to achieve, so they have to work long hours every day to meet those targets. This relatively long duration of work can have a destructive impact if not addressed immediately. Additionally, if a problem is identified, it's better to address it promptly than to wait until the issue worsens. Wrong posture can also be harmful to future workers. After the study employs the Nordic Body Map (NBM) method, further evaluation can be conducted before and after the improvement proposal is implemented. The posture identification method can be used using Rapid Whole Body Assessment (REBA). The second method, Rapid Whole Body Assessment (REBA), is an ergonomic risk assessment method for evaluating the risk of musculoskeletal injuries that may arise from an unergonomic working position. This method is used to help identify the potential risk of work-related injuries involving repetitive movements of the human body. This study utilizes full-body and dynamic movements, making this method suitable for assessing posture when workers operate angkongs.

After obtaining the data, calculations were carried out using the NBM and REBA methods. The NBM method was used for nine harvesters on the plantation. The questionnaire had four levels of complaints: not sick, somewhat sick, sick, and very sick. In the questionnaire, the harvester must fill in personal data, such as age, height, weight, gender, and working time, to process the data. Harvesters fill out a questionnaire by giving a checklist for each part of their body. There are a total of 28 parts of the body that can be measured in pain.

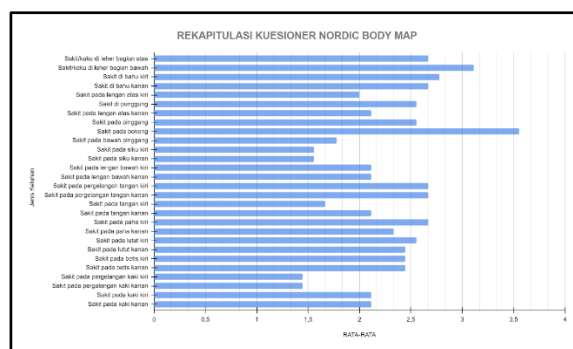


Figure 2: Nordic Body Map Questionnaire Recapitulation

The graph in Figure 2 shows that the highest score was obtained on the buttocks. This part of the body gets an average score of 3.6. The second-largest score was obtained in the lower part of the neck, with an average score of 3.1. Based on the results of interviews with harvesters, they experienced the same pain in their

buttocks because harvesting work using the egrek required repeated shock movements that resulted in pain in that part of the body.

After assessing the condition of workers using the Nordic Body Map questionnaire, the REBA method was applied to one harvester to understand and evaluate the working posture during operation, identify the level of risk, and inform the design of a better tool for the harvester. This can be achieved by collecting data using photos of harvesters at work from the side. To carry out documentation related to REBA data collection, harvesters are first required to carry out the usual work procedures. However, the harvester needs to do his work gradually from start to finish. In the case of this harvester, he is asked to make a plan during the harvest. The initial stage carried out by the harvester is to position the eger right on the part of the palm fronds that can be cut. Positioning the egrets on the palm must be in the right position because not all parts of the fronds can be cut or retracted. This is because there are parts of the palm fronds that are too thick so it is necessary to look for thin palm fronds. At this early stage, the posture appears normal when viewed from the left side. However, in this photo, the harvester does not maintain a straight leg posture between his legs because an interesting movement is required, which necessitates momentum from the right foot to pull the frond. Next is the second documentation, which occurs when the harvester is ready to pull out the palm fronds. In the documentation, the two harvesters have a similar posture, namely a standing posture, but there are some differences in the body parts of the hands and the knees. After the first activity, the second activity involves the harvester positioning the egrets on the part of the fronds that is considered the easiest to cut. In the collection of REBA data related to this second phase of activity, the harvester maintained a posture that was not significantly different in the legs. However, there was a notable change in the arms. This change is calculated during the processing of REBA, resulting in a different value. This position is the real position of a harvester cutting oil palm bunches. This second phase of activity is an activity before the harvester pulls the egrek so that the oil palm bunches are cut. Next is the third stage, where the harvester cuts the palm fronds until they are completely cut.

The harvester has an abnormal posture, especially in the buttocks and legs. This is why, when the Nordic Body Map questionnaire was recapitulated, complaints were noted about the buttocks and knees. This harvesting activity is carried out repeatedly for six hours a day, which can cause the harvester to experience complaints of body pain, potentially leading to MSDs. This final stage is the stage at which the fronds are successfully cut. During the last stage, it can be seen that the position of the harvester's forearm is very crooked, because the need to pull the egrek is very far to make the palm fronds cut. On average, all four activities fall into the High category, indicating that immediate action is necessary to mitigate the risk of contracting STDs. From the overall processing of REBA data, a recapitulation of the four activities above was carried out. The recapitulation is provided to facilitate the identification of data on all oil palm bunch cutting activities. The recapitulation is presented in Table 3.

**Table 3:** Recap of REBA scores

<b>RECAP OF REBA SCORES</b>		
<b>Activity</b>	<b>REBA Final Score</b>	<b>Information</b>
Early stages	7	<i>Medium (Necessary)</i>

Second Stage	9	<i>Height (Immediately required)</i>
Third Stage	10	<i>Height (Immediately required)</i>
Final Stage	9	<i>Height (Immediately required)</i>

The activities carried out by oil palm harvesters using egrek at PT Perkebunan Kelapa Sawit X have a recapitulation, as shown in Table 3. The final REBA score ranged from Medium (Necessary) to High (Urgently needed) for the three harvest activities. This suggests that the harvester has problems with posture while working, which can lead to potential MSD. The tool researched on oil palm harvesters at PT Perkebunan Kelapa Sawit X is Egrek, so data related to Egrek tools currently used by harvesters is collected. Data was collected by taking photos of the tools and conducting brief interviews with harvesters about the tools used daily.

**Improved Egrek Aid Design**



**Figure 3** Egrek PT Perkebunan Kelapa Sawit X

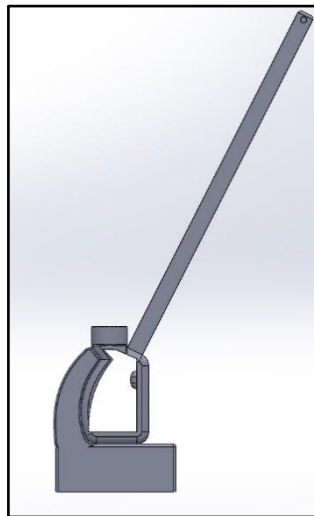
Figure 3 is an egrek aid used by PT Perkebunan Kelapa Sawit X using two extender sticks. The stick used, which is made from a total of two fruits, is eight meters long because the tree being harvested is nine meters tall. At the end of the egrek stick, the harvester uses a black rubber wrap to hold the stick from slipping. Rubber is a modification of the harvester itself because the mill holder does not have a good grip, and often the egrets escape the harvester's grasp. This egrek is a tool used by harvesters to facilitate the harvest of oil palm, but with the calculation of the method, poor results are obtained and can cause MSD (Nasir et al., 2015; Sulistyowati, 2020; Sultan et al., 2022).



**Figure 4** Top Prototypes

Figure 4 is the top of the prototype of an additional design upgrade. In Figure 3, there is a chain, like a saw to facilitate the cutting of palm fronds. At the top of the egrek there is a cover to keep the sharp parts

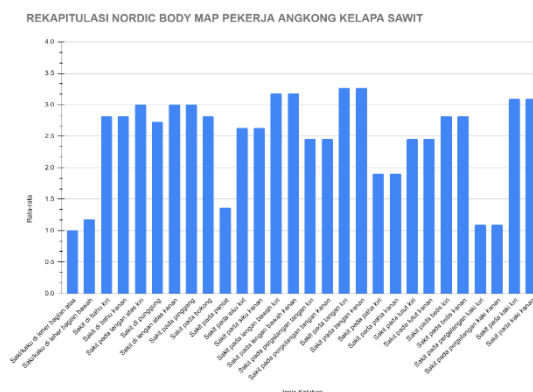
of the egrek and chain from injuring the user. The cover is a safety for the user or people around him so that he or she does not get hurt. At the top of this is a gear that moves the chain, allowing it to cut the fronds easily.



**Figure 5** Prototype Below

Figure 5 is the bottom of the prototype. The bottom consists of a handle for the right hand with a button for cutting and a handle for the left hand so that the tool can be adjusted securely and is more ergonomic in tilt. Under the handle, there is a battery holder to drive the dynamo. The dynamo in Figure 5 can be moved because the battery is connected by a cable that generates power in the dynamo. The dynamo can drive the gears after the power is distributed, allowing the gears to rotate and drive the lower axle. The dynamo can move by pressing the trigger or button on the handle for the right hand. If the button is released, the egrek stops immediately, even if the fronds have not been successfully cut.

Based on the results of data collection using the NBM method, workers received complaints while operating the angkong. The graph of each type of complaint illustrates this result, yielding a total score that indicates perceived dominance. The graph can be seen in Figure 6.



**Figure 6** NBM Employee Recapitulation Chart

After obtaining the NBM results, the REBA method was used to evaluate the worker's posture. The results of REBA indicate that the initial condition when lifting the angkong yields a score of 12, and when pushing the angkong, it yields a score of 11. The score indicates a very high level of risk that requires immediate correction. Therefore, it is necessary to draft proposed improvements to reduce the risk of MSD and poor

posture among workers. The draft improvement proposal is made as a *Prototype Shape Non-Physical* using CAD. The proposed plan involves adding height to the angkong handle. The increase in height was calculated based on the average harvest height of 165 cm. Therefore, the measurement of the hip height of Indonesians was carried out using the 50th percentile of the Indonesian Anthropometric Data, yielding a value of 87.3 cm. The proposal to increase the height of the handle is more ergonomic, allowing workers to operate the handle without bending over.

Additionally, another design is proposed, namely the addition of small wheels at the back of the angle. The wheels used in the angkong are also considered for strength when carrying FFB and shock resistance. Shock-resistant wheels will help reduce vibrations that can cause damage to the palm fruit, which can occur due to shocks. Additionally, it can maintain stability and improve worker comfort, preventing fatigue and injury due to constant vibration. A smaller wheel size can also help when turning corners, making them easier and sharper. Additionally, it can help distribute the load more evenly by prioritizing the load on larger wheels, which helps balance the load without increasing the height of the rear wheels. With a smaller wheel design, it can help workers reduce the force expended as well as strain on the back and muscles when lifting and pushing the hips.

In addition to the wheels, there is also an Ergogrip in the handle, which can be seen as four arches. The arch functions to place the four fingers, namely the index finger, middle finger, ring finger, and little finger, to make it more comfortable when operating the angkong. Ergogrip is designed to provide a more comfortable grip and reduce pressure on the hands and wrists when transporting heavy loads. In addition, it can reduce fatigue in the hands and arms. The Ergogrip design can provide a more ergonomic grip, with better grip, making it easier to operate when rotating on uneven surfaces. The design can also help prevent injuries due to repetitive work systems, thus reducing the risk of wrist pain. The material and shape used are specifically anti-slip, so that the hand does not slip easily when holding the pole, so that when the hand is sweaty or wet, the handle will still provide a strong and safe grip. A draft of the proposed improvements for increased height on the corner handle, wheel at the rear of the corner, and Ergogrip on the corner handle is shown in Figure 7.



Figure 7 Draft Proposed Improvement for Angkong

Figure 7 is a draft of the proposed improvements for Angkong. The results of the proposed design are simulated using the EasyPose application as it is up to the proposed repair design to decide. The results of the

simulation are measured using degrees. The extent to which the body is formed is larger than before, indicating that the posture formed is more upright than the initial condition.

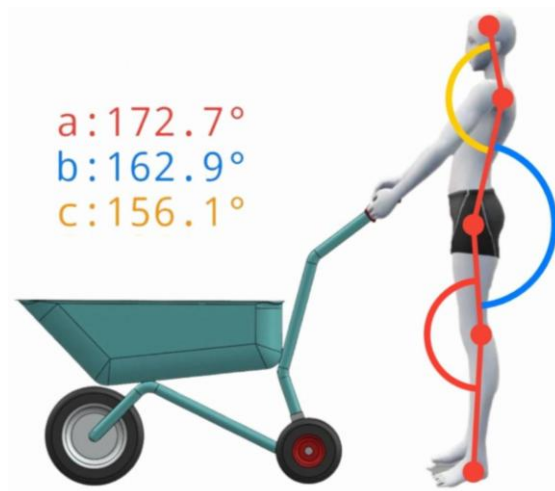


Figure 8: Simulation of Angkong Repair Proposal

The results of this simulation used workers with an average height of 165 cm. For the height of the handle, we took into account the hip height of Indonesians at the 50th percentile, as the dominant individuals had the same height, and there were no extreme individuals. In addition, the size of the bathtub, large wheels, and height from the ground to the angkong are still the same, according to the existing specifications. Then, the Ergogrip on the handle can entertain workers when operating at an angle.

Based on the results of the proposed improvement simulation, it can be seen that the worker's posture has become more upright than in the initial condition. This upright posture is evident in the head, shoulders, neck, legs, and wrists. Following the draft improvement proposal, the REBA score results were analyzed, yielding a score of 7. The score decreases due to differences in posture, which becomes more upright in the head to neck, then in the back and arms, when holding without the need to endure heavier weights. The results of the score decrease showed a decrease in MSD, and the posture improved compared to before (Figure 8). Comparison of the initial condition with the proposed repair design, considering the dominant pain results perceived. The results are further analyzed to identify areas for improvement in the painful parts.

The proposed improvement also uses the REBA method to find differences from the initial condition. In the results of the REBA score, the proposed improvement was obtained at seven, indicating a medium/medium level of risk. This result can be compared with the initial condition of the REBA score obtained of 12 when lifting the angle and 11 when pushing the angle, where the score indicates a very high level of risk. The REBA score shows a decrease from the initial condition to the proposed improvement of around seven. A decrease in score indicates that existing improvement proposals can be considered for implementation according to the designed plan.

The results informed the design of the repair proposal of a study on the posture of workers who experienced pain in specific parts of their bodies. This design takes into account the position of the worker when operating the angkong in a dynamic/moving state. The first draft proposal is to lift the handle on the angkong so that workers do not bend excessively when operating it. Angkong handles can help improve the posture of workers. Consider raising the handle, as the field conditions have less undulating soil from the FFB

transfer position after cutting to the TPH, allowing workers to use it comfortably. The second proposed repair design involved adding two small wheels at the rear, as the perceived weight was believed to cause discomfort in the workers' hands (Ningsih et al., 2021).

The measurement also takes into account the 50th percentile of Indonesian hip height, 87.3 cm, because no height is too extreme for a worker. This size is also designed to prevent the worker's hands from bending too much, as this can interfere with pushing the angkong. Both small wheels can help stabilize and distribute the load to the larger wheels. Workers no longer have to lift overloads with their hands when pushing the ankle. The final draft proposal includes the addition of Ergogrip to the corner handle to help provide comfort for workers in their hands. The material is also anti-slip, making it less likely to slip due to sweat generated when operating the angkong.

## CONCLUSION

The results of the Nordic Body Map calculation for oil palm harvesting have a medium value and a REBA value of 12 (a very high value), indicating that the ergonomic intervention is correct. The researcher designed a modified egrek aid (Figures 4 and 5) to make it easier for harvesters to cut palm fronds. The results of improving this new tool have reduced the REBA value to four (safe category). The results of the Nordic Body Map calculation showed that oil palm fruit bunches were 69.54 high (because workers had to bend over and use extra force on their hands, arms, and feet), and the REBA nilia was also high. The researcher designed an ergonomic angle tool (Figures 7 and 8). The result of the improvement by using a new angkong (addition of handle height and Ergogrip) was able to reduce the REBA value to 4 (safe category).

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