Assessment of musculoskeletal disorders among palm oil farmers with SNI 9011:2021 in Muara Wahau

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Abstract. Indonesia is the world's largest producer of palm oil, with millions of hectares of plantations. However, along with the growth of the palm oil industry, various challenges and issues related to the worker welfare have emerged. One important issue is musculoskeletal disorders or health problems associated with work in palm oil plantations. Workers in palm oil plantations are often exposed to heavy and repetitive work conditions, such as carrying heavy loads, performing monotonous movements, and working in non-ergonomic positions. These factors can increase the risk of musculoskeletal disorders, such as back pain, shoulder pain, neck pain, and other health issues. Therefore, this research aims to evaluate existing musculoskeletal disorders and provide recommendations for improvement and management of ergonomic risks in PT. DSN in Muara Wahau. The research methods include direct observation of palm oil farmers during their work, structured interviews to gather information on complaints and ergonomic risks, and the use of ergonomic analysis methods in accordance with the SNI 9011:2021 standard. The data obtained will be analyzed to identify ergonomic risk factors contributing to musculoskeletal disorders. The results of this study showed that all of palm oil harvesting workers experienced high risk level on their neck, while all of palm oil transportation workers encountered high risk on their elbow. Stretching or warm-up exercises before and after work were recommended to reduce the risk of injuries caused by non-ergonomic work positions among harvesting workers. Furthermore, redesigning Hook-T was recommended in order to minimize the MSD among palm oil transportation workers.

Keyword: ergonomics, palm oil, SNI 9011:2021.

1. Introduction

Indonesia is a major and the largest producer of palm oil, with a plantation area (*Elaeis guineensis*) of 16.83 million hectares recorded in 2023 The majority of this plantation area is owned by Large private plantation, followed by People plantation and Large state plantation The plantation area produces 50.77million tons of crude palm oil and 4.77 million tons palm kernel oil. The majority of the palm oil plantations are located in Sumatra and Kalimantan. East Kalimantan, in particular, has the fourth largest palm oil plantation area in Indonesia, following the provinces of Riau, West Kalimantan, and Central Kalimantan.

There are 4 main activities in palm oil harvesting. Firstly, the harvesting process starts with the picking of fresh fruit bunches (FFB) from the palm oil trees. Harvesting from palm oil trees with a height of less than 3 meters use a tool called "dodos," while those with a height of more than 3 meters use "egrek". Secondly, the fresh fruit bunches are collected and brought to the roadside. During harvesting process, sometimes the FFB detaches into small bunches (berondolan). Therefore, harvesters must collect the fallen fruit bunches until the area is clean. Thirdly, the harvester transports the harvested FFB and fruit bunches to the main road can be done using a farm tractor or manually with pushcarts or baskets. Finally, the FFB will be transported to the Palm Oil Mill using trucks.

As seen in Figures 1-4, workers adopt non-neutral/awkward body postures while harvesting oil palm. These activities have the potential to cause injuries to workers, resulting in decreased productivity. The impact of these awkward postures can lead to the occurrence of work-related musculoskeletal disorders (WMSDs) among workers, such as neck pain, back pain, joint discomfort, knee issues, or trembling hand syndrome (Walker-Bone & Palmer, 2002).

Figure 1 Harvesting fresh fruit bunches with egrek.

Figure 2 Quoting loose fruit.

Figure 3 Loading fresh fruit bunches into pushcart.

Figure 4 Loading fresh fruit bunches into truck.

During oil palm harvesting activities using a sickle-ended pole (known as "egrek"), workers can be observed tilting their heads excessively upwards and raising their upper arms above their shoulders (Figure 1). When gathering fallen fruit bunches (berondolan), workers are seen bending or squatting (Figure 2), which also falls under the category of awkward posture.

In manual lifting tasks, such as loading Fresh Fruit Bunches (FFBs) onto pushcarts, baskets, or trucks, awkward postures are also involved (Figures 3 and 4). These include torso twisting, lifting upper arms above the shoulders, and manually lifting heavy loads (FFB weights around 20-25 kg). These uncomfortable body postures are repeatedly assumed by workers over extended periods. This indicates a lack of adherence to ergonomic principles in their work. According to (Saputri et al., 2022), working with non-ergonomic postures increases the risk of musculoskeletal complaints. Hence, studies on WMSDs among oil palm workers and ergonomic risk assessments are crucial to minimize worker discomfort and reduce ergonomic risks. However, such studies are still lacking in East Kalimantan. Enhancing worker safety and health will impact work performance, ultimately improving oil palm plantation productivity. In 2010, the World Bank highlighted that worker safety and health in palm oil plantations pose challenges for the industry's sustainability in the future (Myzabella et al., 2019).

Work posture significantly influences oil palm fruit harvesting. According to Susihono & Adiatmika, (2021), work posture is a determinant in analyzing the effectiveness of a job. If workers maintain good and ergonomic work postures, the outcomes will likely be positive as well. Conversely, poor ergonomic work postures lead to fatigue. Susihono and Adiatmika (2021), and Pramestri (2017) stated that jobs involving various muscle movements require proper work postures. Inadequate work postures can lead to muscular health issues. In the short term, this might result in physical fatigue, but in the long run, it can cause damage to muscles, joints, ligaments, and tendons. The discomfort experienced by workers is termed musculoskeletal disorders.

As stated by Hutabarat (2017), musculoskeletal disorders are complaints felt by individuals in skeletal muscle areas, ranging from mild discomfort to severe pain. When muscles endure repetitive static loads over prolonged periods, it leads to damage in joints, ligaments, and tendons. The complaints and eventual damage are collectively referred to as MSDs.

According to Valentine & Wisudawati (2020) and Azzahri et al. (2020), musculoskeletal complaints involve skeletal muscle regions, resulting in mild to severe pain. Causes include excessive muscle stretching, repetitive muscle activities, and unnatural work postures. Furthermore, Hutabarat (2017) classifies muscle complaints into two categories:

1. Temporary discomfort refers to muscle complaints that occur when muscles experience static loads, but these complaints quickly disappear when the load is removed.
2. Persistent discomfort, on the other hand, pertains to muscle complaints that persist even after the load has been discontinued.

Musculoskeletal complaints refer to sensations experienced by an individual in various skeletal muscle areas, ranging from mild discomfort to severe pain. Initially, musculoskeletal disorders (MSDs) manifest as pain, discomfort, numbness, tingling, swelling, stiffness, tremors, sleep disturbances, and burning sensations. The repercussions include an individual's inability to perform movements and coordinate body parts or extremities, leading to reduced work efficiency, work time loss, and decreased work productivity.

In 2018, the Ministry of Manpower of the Republic of Indonesia issued Ministerial Regulation No. 5 of 2018 concerning Occupational Safety and Health in the Work Environment. This regulation mandates companies to implement Occupational Safety and Health (OSH) requirements in the work environment, including the control of chemical, biological, physical, ergonomic, and psychological factors. In implementing ergonomic factor control, the National Standardization Agency of Indonesia (BSN) has established SNI 9011:2021 regarding Measurement and Evaluation of Ergonomic Hazard Potential in the Workplace (Kementerian Ketenagakerjaan Republik Indonesia, 2018)

SNI 9011:2021 is used as a reference for identifying ergonomic hazards, assessing the level of ergonomic risk, and considering the development and implementation of effective controls. SNI 9011:2021 comprises the Gotrak questionnaire (Musculoskeletal Disorder Questionnaire) and the Ergonomic Risk Factor checklist (ERF). Palm oil plantations are also required to adhere to Ministerial Regulation No. 5 of 2018, necessitating the use of SNI 9011:2021 to measure work-related musculoskeletal disorders (WMSDs).

Previous studies employed the Nordic Body Map to evaluate Gotrak (Saputri et al., 2022; Prabawati & Lidiana, 2021; Alisha et al., 2021) in oil palm plantations in Berau, West Tanjung Jabung, and PT. GM Kalimantan; QEC (Quick Exposure Check) was used in plantations in Malaysia (Teo et al., 2021). However, using SNI 9011:2021 for measuring Gotrak has not been previously done. Utilizing the Gotrak method specified in SNI 9011:2021, this assessment can serve as a reference during internal audits to formulate improvement policies.

Numerous studies have been conducted to analyze the potential occurrence of work-related musculoskeletal disorders (WMSDs) among oil palm workers during the four main activities of palm fruit harvesting. For instance, in Indonesian palm plantations (Teresia & Lestari, 2022; Priyambada & Suharyanto et al., 2019; Suryani et al., 2022; Surya, 2017; Arsi et al., 2020; Hendra & Rahardjo, 2009; Alisha et al., 2021; Prabawati & Lidiana, 2021; Syuaib et al., 2015) in Malaysian palm plantations (Ng et al., 2013; Deros et al., 2016; Nawi et al., 2016; Henry et al., 2015); and in palm plantations across Indonesia, Malaysia, Papua New Guinea, Cameroon, Ghana, and Myanmar (Myzabella et al., 2019). However, from the reviewed literature, only (Saputri et al., 2022) researched in Berau and (Alisha et al., 2021) in West Kalimantan. In East Kalimantan, data from the Provincial Plantation Office of East Kalimantan in 2020 showed that the five largest palm oil-producing districts are Kutai Timur, Berau, Kutai Kartanegara, Paser, and Kutai Barat.

Therefore, this research aims to evaluate Gotrak among palm fruit harvesters at PT. DSN Muara Wahau, Kutai Timur.

2. Method

This research was conducted at the PT DSN Muara Wahau palm oil plantation and involved 42 respondents, comprising 34 workers involved in palm fruit harvesting and 8 workers engaged in transporting palm fruit to trucks. These 42 respondents encompassed all harvesting and transportation workers within Estate LJ2, Afdeling XI, the area under study. The variables examined encompassed respondent profiles, work-related musculoskeletal complaints (Gotrak), the severity level, and the frequency of these complaints. Figure 5 explains the framework of this research.

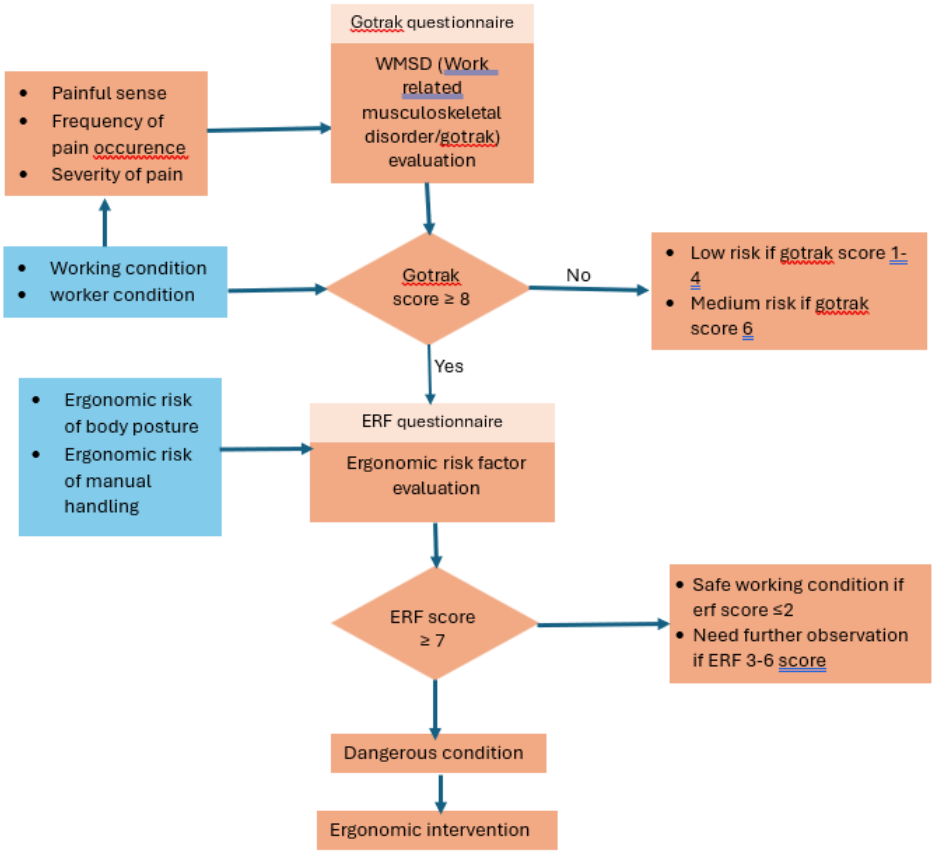

Figure 5 Framework of research.

The tools utilized for Gotrak measurements involved the survey questionnaire as per SNI 9011:2021. Gotrak questionnaire consists of the severity level and frequency of pain in body segments, including the neck, shoulders, elbows, left-right sides of the back, arms, hands, hips, thighs, knees, calves, and feet. The assessment commenced with preliminary observation of each activity to identify potential hazard factors related to each work task. This checklist aided in identifying combinations of hazard factors that pose the highest risks in the job.

Risk assessment was based on frequency and severity indicators (see Table 1). In the Gotrak questionnaire, the severity level is considered “no problem” if there are no complaints and it doesn’t interfere with work, “uncomfortable” if there are complaints that tend to disrupt work, “painful” if there’s discomfort that affects work, and “severe pain” if the discomfort is so intense that work cannot be performed.

The frequency level is indicated as “never” if the pain never occurs, “sometimes” if it happens 1-3 times within a year, “often” if it happens 1-3 times within a month, and “always” if it occurs nearly every day. After severity and frequency have been indicated, each complaint in body segments is assessed for its risk level using Table 1. If both severity and frequency fall within the green range

(values 1-4), it signifies low-risk level; yellow (value 6) indicates moderate risk level, and red (values 8-18) signifies high risk level.

Ergonomic hazard potential assessment is conducted by analyzing severity and frequency, and these values are then used to describe the workplace conditions (see Table 2). If workers experience complaints with a high risk level (value ≥ 8) as shown in Table 1, further analysis is performed by inquiring about the specific aspects of the job causing the experienced Gotrak complaints.

Table 1 Level of risk for GOTRAK complaints

Frequency	Severity			
	No Problem (1)	Discomfort (2)	Pain (3)	Severe Pain (4)
Never (1)	1	2	3	4
Sometimes (2)	2	4	6	8
Often (3)	3	6	9	12
Always (4)	4	8	12	16

Source: SNI 9011: 2021

Table 2 Criteria for assessing ergonomic hazard potential

Value	Criteria
Value ≤ 2	Safe working conditions
Value 3-6	Needs further observation
Value ≥ 7	Dangerous

Source: SNI 9011: 2021

3. Result and Discussion

After administering questionnaires to both palm fruit harvesting workers and transportation workers in the palm oil plantation, complaints from workers in each body segment were obtained. This research employed the Work Sheet for Work-Related Musculoskeletal Complaints (Gotrak) to evaluate the body posture of 34 palm fruit harvesting workers and 8 palm fruit transportation workers to trucks. The results can be seen in Table 3 and Table 4.

Based on the data in Table 3, it is evident that the calf segment has the lowest risk with a percentage of 0%, indicating that no palm fruit harvesting workers reported pain in their calf area. Conversely, the neck segment shows the highest risk with a percentage of 100%, meaning that all respondents experienced severe and frequent neck pain. This indicates that the neck segment has the highest risk associated with injury or health problems. The elevated risk in the neck segment is attributed to the practice of using an "egrek" tool for harvesting on trees higher than 12 meters. In this situation, workers need to tilt their heads at an angle greater than 5°, placing excessive strain on the neck muscles and elevating the risk of injury. Excessive head and neck movement is caused by the inadequately tall "egrek" tool, leading to uncomfortable or non-ergonomic fruit harvesting angles.

The weight of the "egrek" tool and the requirement to hold it above the abdomen without support result in the majority of harvesting workers experiencing pain in the elbow (79.41%) and shoulder (61.76%) areas. The task of "egrek" harvesting is carried out for a relatively long duration (approximately 8 hours) per day, leading the majority of harvesting workers (94.12%) to experience knee pain due to the prolonged activity.

Table 3 Percentage of high risk (value ≥ 7) in oil palm harvesting workers

Body Segment	Number of respondents experiencing high risk	Number of Respondent	Percentage (%)
Neck	34	34	**100%**
Elbow	27		**79,41%**
Arm	6		17,65%
Hand	7		20,59%

Body Segment	Number of respondents experiencing high risk	Number of Respondent	Percentage (%)
Thigh	3		8,82%
Calf	0		0%
Shoulder	21		**61,76%**
Upper Back	11		32,35%
Lower Back	12		35,29%
Hip	13		38,24%
Knee	32		**94,12%**
Leg	4		11,76%

Source: Worker Questionnaire Data.

Table 4 Percentage of high risk in transportation workers

Body Segment	Number of respondents experiencing high risk.	Number of Respondent	Percentage (%)
Neck	2	8	25%
Elbow	8		**100%**
Arm	3		38%
Hand	6		**75%**
Thigh	4		50%
Calf	1		13%
Shoulder	6		75%
Upper Back	7		**88%**
Lower Back	4		50%
Hip	4		50%
Knee	7		**88%**
Leg	2		25%

Source: Worker Questionnaire Data.

Table 4 indicates that the risk of injury in the calf segment is relatively low, as only 12.5% of respondents experience prolonged pain in this area. Conversely, all respondents consistently experience pain in the elbow. When compared to oil palm harvesters, the number of workers transporting palm oil to trucks who have ergonomic risks > 7 is almost the same, namely 85.17% for oil palm harvesting workers and 87.75% for palm oil transport workers. These figures are obtained by averaging the top 4 percentages. The body segments with ergonomic risks >7 in oil palm harvesters and palm oil transporters are different, and this is due to working conditions.

Transportation workers need to manually carry/lift Fresh Fruit Bunches (TBS) weighing 20-25 kg and then throw them into the truck container. Based on observations (see Figure 4), workers lift TBS weighing ≥ 13 kg from a distance of more than 10 inches away from the body, and this action is repeated frequently. This leads transportation workers to frequently experience pain in the elbow, upper back, and hands. Transportation workers also perform their tasks while standing continuously for approximately 8 hours per day while carrying TBS, resulting in knee pain.

Based on the analysis of palm fruit harvesting workers, the risk of complaints in the neck segment is caused by the elevated head position when picking palm fruit. The non-ergonomic viewing angle is a result of the "egrek" tool's inadequate length, leading to excessive tilting of the neck/head upwards. Another contributing factor is the height of the palm trees; when the trees are too tall, the harvesting workers need to tilt their heads upwards by ≥ 5° to perform the fruit picking.

Meanwhile, for transportation workers carrying fruit to the truck, the risk of complaints occurs in the elbow segment. Complaints in the elbow area arise from the excessive weight of the fruit being lifted onto the truck, resulting in pain and discomfort. Carrying and lifting loads beyond capacity can exert high pressure on the elbow joints and muscles, thereby increasing the risk of injury.

Proposed Improvement

The proposed improvement for palm fruit harvesting workers is to implement warm-up and stretching exercises before and after work, while for transportation workers, it involves improving the design of the Hook-T tool.

Proper warm-up can prepare the neck muscles and joints for intensive physical activities, while post-work stretching can help reduce tension and aid muscle recovery. According to Yamtana et al. (2022), muscle stretching not only reduces pain but also decreases the accumulation of lactic acid in muscles. Lactic acid is formed as a result of metabolism and can accumulate in muscle fibers, causing discomfort. Physiologically, lactic acid serves as a signal for muscles to rest during work. Stretching is performed for 15 minutes twice a day, before starting work and during the lunch break. This intervention was conducted for two consecutive weeks with batik workers, and the results showed that 73.3% of the respondents reported reduced pain complaints, 90% reported decreased stiffness and fatigue, and 96% felt an overall improvement in their well-being.

Proper stretching can help reduce lactic acid buildup in muscles. Stretching is a crucial part of active recovery methods that aid in clearing muscles from lactic acid, which can lead to pain and fatigue. The benefits of active recovery include rapid reduction of muscle pain, repairing damaged muscle tissue, enhancing psychological/mental recovery, and improving mental and physical relaxation. Considering the benefits observed in batik workers, these stretching and exercise routines are also recommended for palm fruit harvesting workers to mitigate complaints related to muscles and skeletal issues.

Based on the findings related to complaints among transportation workers carrying palm fruit to trucks, the proposed improvement involves enhancing the design of the tool used for fruit transportation, specifically the Hook-T mechanism.

Figure 5 The current Tojok or T-hook being used.

The proposed redesign improvement for the Hook-T mechanism is aimed at reducing the risk of injuries experienced by palm fruit transportation workers. This redesign suggestion has been previously implemented in a study (Surya & Gasali, 2014) to lower the level of worker fatigue and injuries. Changes are made to the handle of the Hook-T, creating a more ergonomic design that conforms to the anatomy and size of the fingers (see Figure 6).

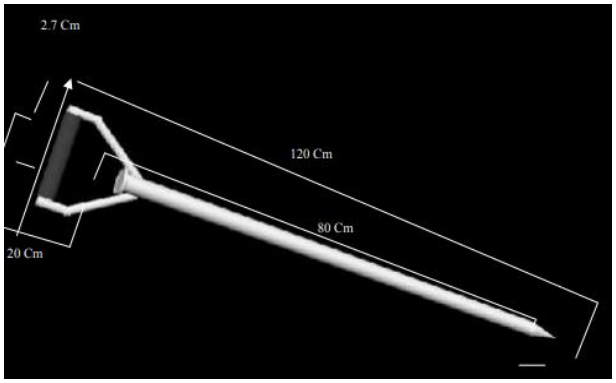

Figure 6 Proposed design improvement for T-hook.

The implementation of this new design (Figure 6) reduced the complaints experienced by palm fruit workers by 27.81% compared to the previous product (Figure 5). This is because the new design is more tailored to the anthropometry of workers' fingers. In addition, the grip, which used to be only in the shape of a T, in the new design has been changed as shown in Figure 6, where the diameter of the grip is adjusted to the dimensions of the worker's hand grip. This grip is also coated with rubber, making it non-slippery. This study conducted by Surya and Gazali (2014) provided evidence that the application of ergonomic principles can alleviate physical complaints among palm fruit workers during after completing their work.

4. Conclusion and Suggestion

Based on the analysis results, the highest risk for palm fruit harvesters is found in the neck and elbow segments, where pain is experienced by all respondents. To reduce the risk of injuries for harvest workers, it is advisable to perform stretching or warm-up exercises before and after work to prevent stiffness in the muscles. Additionally, redesigning the Hook-T mechanism is necessary to mitigate complaints among palm fruit transportation workers. The contribution of this research is to provide examples of using the Gotrak and ERF questionnaires from SNI 9011:2021 and to provide information on the risk of WMSDs (Gotrak) experienced by workers in oil palm plantations. The limitation of this research is the lack of utilization of technology for ergonomic interventions. Therefore, future research is expected to develop tools used in oil palm plantations using technology, such as fruit harvesting with drones or fruit ripeness selection with a scanner-like device.

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