KEMAS 20 (4) (2025) 825-833

Jurnal Kesehatan Masyarakat

http://journal.unnes.ac.id/nju/index.php/kemas

Ergonomic Risk Assessment on Palm-Oil Harvesting Workers in East Kalimantan

Theresia Amelia Pawitra[1]✉, Lina Dianati Fathimahhayati[1], Farida Djumiati Sitania [1]

[1] Industrial Engineering Department, Faculty of Engineering, Universitas Mulawarman, Indonesia

Article Info

Article History:
Submitted January 2024
Accepted August 2024
Published: April 2025

Keywords:
ergonomics; WMSD; palm-oil plantation; harvesting worker; SNI 9011:2021

DOI
https://doi.org/10.15294/kemas.v20i4.31236

Abstract

Along with the growth of the palm-oil industry in Indonesia, work-related musculoskeletal disorders (WMSD) experienced by palm-oil harvesting workers also increased. This paper aims to evaluate ergonomic risk factors among harvesting palm workers in East Kalimantan and to propose suggestions to mitigate the risks. A total sample of 70 workers from 3 plantations in Muara Wahau, Babulu, and Muara Badak was observed in 2023. Gotrak survey and ergonomic risk factor (ERF) questionnaire of SNI 9011:2021 were utilized for determining the WMSD and identifying the ergonomics risk, respectively. The result showed that 91% of workers experienced pain after work, and 72% frequently experienced physical fatigue. The Gotrak survey on cutting and carrying bunches activity revealed high exposure risk for the neck (97%), followed by the shoulder (77%) and knee (55%). Meanwhile, during the activity of loading bunches onto the truck, high exposure risk occurs in the shoulders (73%), elbows (53%), and knees (53%). The result of the Kruskal-Wallis statistical test indicates that there is a difference in Gotrak levels among the three locations. The Gotrak level in Muara Wahau is the highest, followed by Babulu and Muara Badak. The results of the ERF questionnaire showed that loading to truck, followed by carrying FFB to the fruit collection point, were the two activities with high ERF scores, i.e., 39 and 34, respectively. Finally, improvements such as stretching exercises before and during work, as well as redesigning ergonomic T-hook and egrek, will mitigate the risk.

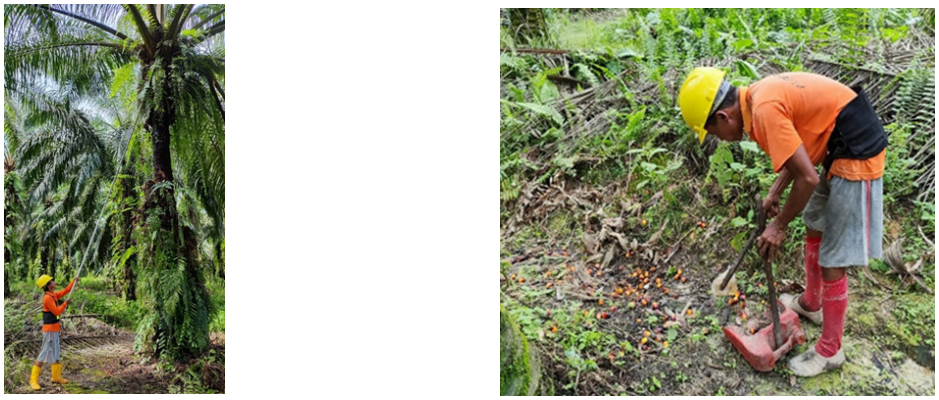
Introduction

Indonesia is a country that produces the main and largest palm oil with a plantation area of Elaeis guineensis in 2021 recorded at 15.08 million hectares. The plantation area increased by 1.5% compared to the previous year. The majority of this area is owned by Private Plantations (PBS), covering 8.42 million hectares (55.8%), followed by People's Plantations (PR), covering 6.08 million hectares (40.34%), and State Large Plantations (PBN), covering 579.6 thousand hectares (3.84%). This increase in plantation area also increased the national palm oil production by 2.9% from 2020, reaching 49.7 million tons in 2021. Most of the palm plantations are located in Sumatra and Kalimantan. East Kalimantan has the fourth-largest palm oil plantation area in Indonesia, after the provinces of Riau, West Kalimantan, and Central Kalimantan.

There are four main activities in palm oil harvesting. The activities in palm oil plantation harvesting begin with the picking of fresh fruit bunches (FFB) from the palm oil trees. For palm oil trees with a height of less than 3 meters, picking is done using a tool called "dodos," while those taller than 3 meters are harvested using an "egrek." In this process, mature FFBs are harvested by harvesting workers, and the fruits picked must amount to at least 21 bunches that have fallen from the palm oil tree. Afterward, the fallen bunches (i.e., called "berondolan") are collected and taken to the roadside. During this process, the workers are required to pick

✉ Correspondence Address:
Industrial Engineering Department, Faculty of Engineering, Universitas Mulawarman, Indonesia
Email: triciapawitra@gmail.com

pISSN 1858-1196
eISSN 2355-3596



(a) (b)

FIGURE 1. Fresh Fruit Bunch (FFB) Harvesting Activities. (a) Harvesting FFBs with an "Egrek" (Sickle-Shaped Tool), (b) Collecting Fallen Fruit Bunches, i.e., “Berondolan”

up the fallen bunches until the area is clean. The transportation of FFBs and bunches to the main road can be done using a farm tractor or manually transported using pushcarts or baskets. Then, the FFBs are transported to the Palm Oil Mill using trucks or pickups. As seen in Figure 1, workers are adopting unnatural body postures during palm oil harvesting. These activities have the potential to cause injuries to the workers, resulting in decreased productivity. The impact of these awkward postures includes the occurrence of work-related musculoskeletal disorders (WMSD) among workers, such as pain in the neck, back, joints, knees, or hand tremor syndrome (Walker-Bone, 2002).

In manual handling activities, such as loading FFBs into loading carts, baskets, or onto trucks, awkward postures are also involved (Fig. 1© and Fig. 1(d)). These include twisting the torso, raising the upper arms above the shoulders, and manually lifting heavy loads (with FFBs weighing around 20-25 kg). These uncomfortable body postures are repeated by workers over extended periods. This indicates that workers are not following ergonomic principles in their work. According to a study (Sultan *et al*., 2022), working with non-ergonomic postures increases the risk of musculoskeletal disorders (MSDs) complaints. Therefore, studies on WMSD (work-related musculoskeletal disorders) in palm oil workers and ergonomic risk assessments are crucial to minimize the pain experienced by workers and reduce ergonomic risks. Numerous research studies have investigated the potential occurrence of work-related musculoskeletal disorders (WMSDs) among oil palm workers while engaged in the four primary activities of palm fruit harvesting. For example, these studies have been conducted in various locations, including Indonesian palm plantations (Syuaib, 2015), as well as in Malaysian palm plantations (Teo *et al*., n.d.), (Deros *et al*., 2016), (Nawi *et al*., 2016), (Henry *et al*., 2015), (Chan *et al*., 2022), and (Tumit *et al*., 2021). Additionally, research has been conducted in palm plantations across various countries, including Indonesia, Malaysia, Papua New Guinea, Cameroon, Ghana, and Myanmar (Myzabella *et al*., 2019), Thailand (Mongkonkansai *et al*., 2020), (Bhuanantanondh *et al*., 2021). However, such studies have been relatively limited in East Kalimantan. Only one study (Sultan *et al*., 2022) focused on Berau, while another study (Alisha *et al*., 2021) conducted research in West Kalimantan. Enhancing worker safety and health can have a positive impact on job performance, ultimately leading to increased productivity in palm oil plantations. In 2010, the World Bank highlighted that the safety and health of plantation workers posed a challenge to the sustainability of this industry in the future (Myzabella *et al*., 2019)

Methods

This research was conducted in three palm oil plantations located in Muara Badak, Muara Wahau, and Babulu, involving a total of 70 respondents. In Muara Wahau, 34 respondents were responsible for cutting FFBs, collecting

TABLE 1. The Level of Risk for GOTRAK Complaints

Frequency of pain	Severity			
	No issue/problem (1)	Uncomfortable (2)	Painful (3)	Very Painful (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

fallen bunches and FFBs, and transporting them to the collection point, which is usually located on the roadside. Eight respondents were tasked with loading FFBs onto trucks. The size of this plantation is 3,381 hectares. Meanwhile, in Babulu, due to its smaller plantation area of approximately 2 hectares, there is no division of tasks. Ten respondents are responsible for the entire process, from harvesting FFBs to loading them onto the pick-up truck. Furthermore, in Muara Badak, where the plantation covers an area of 7 hectares, there are 5 respondents tasked with picking FFBs and transporting FFBs and fallen bunches to the collection point, 5 respondents responsible for collecting fallen bunches, and finally, 5 respondents tasked with loading FFBs onto trucks. The variables studied include respondent profiles, work-related musculoskeletal disorders (GOTRAK), the severity level, and the frequency of these complaints occurring.

The equipment used for measuring WMSD is the GOTRAK survey questionnaire SNI 9011:2021, which assesses the severity and frequency of pain in various body segments, including the neck, shoulders, elbows, left and right sides of the back, arms, hands, buttocks, thighs, knees, calves, and feet. The assessment begins with a preliminary observation of an activity to identify hazard factors present in each task of the job. This checklist assists in identifying the combinations of hazard factors that pose the highest risks in the job. The assessment of ergonomic hazard potential is conducted by analyzing severity and frequency, and these values can be used to describe workplace conditions (see Table 1). If workers experience complaints with a high-risk level (a value ≥ 8) as shown in Table 1, further analysis is conducted by inquiring about which part of the job is causing the GOTRAK complaints. This analysis employs the ERF (ergonomic risk factor) checklist. If the score in the ERF checklist is equal to or less than 2, then it falls under the category of a safe workplace criterion. If the score falls between 3 and 6, it is classified as needing further investigation. If the score is greater than 7, then the workplace is deemed hazardous.

Results and Discussion

The interview results indicate that 64% of all workers have a dominant right hand for their work. The majority of workers have a length of service of ten years or more (57%). 47% often feel mental stress after work, and 81% often experience physical fatigue after work. This is because palm oil workers have targets to meet, and they work 9 hours a day with a 1-hour break, without any days off. Sundays are used to catch up on unfinished tasks. As a result, 96% of workers experience pain after work. Workers responsible for harvesting FFB until delivering them to the collection point in Muara Wahau experience a high-risk level for the neck (100%), elbow (79%), shoulder (62%), and knee (94%). Meanwhile, workers in Babulu performing all activities from harvesting FFB to transporting to the oil processing factory also face a high-risk level for the neck (90%), elbow (60%), shoulder (70%), and knee (70%). The complaints of neck and shoulder pain align with the research (Rahardjo, 2009) on palm oil harvesters in Ogan Komering Ilir, as well as with the studies (Prabawati & Lidiana, 2021) on PT GM Kalimantan and (Syuaib, 2015) on PT. Astra Agro Lestari in Kalimantan and West Sulawesi. 75% of palm oil harvesters and transporters to the collection point in Muara Badak experience a high-risk level for the neck and upper back. Meanwhile, 40% of fallen bunches (berondolan) gatherers face a high-

risk level for the knee and calf.

Workers responsible for loading fresh fruit bunches (FFB) onto trucks in Muara Wahau experience a high risk level for the upper back (88%), knee (88%), hand (75%), shoulder (75%), elbow (100%), lower back (50%), and hip (50%).In contrast, in Muara Badak, the transport workers experience a high risk level for the shoulder (80%) and hip (60%). The difference is due to workers loading FFB onto trucks in Muara Wahau and pick-up vehicles in Muara Badak, as the plantation in Muara Badak is smaller than in Muara Wahau. In the activity of cutting FFB, the majority of respondents experience severe and frequent pain in the neck. The reason for the high risk to the neck of harvest workers is that when harvesting using a tool called "egrek" on palm trees taller than 12 meters, workers have to look upwards at an angle of more than 5° (see Fig. 1 (a)). This position can exert excessive pressure on the neck muscles and increase the risk of injury. Workers also tend to lift their heads and necks excessively due to the "egrek" tool being insufficient in height, resulting in an uncomfortable or non-ergonomic angle for picking oil palm fruit. The weight of the "egrek" tool and the need to hold it at a height above the abdomen without support cause the majority of harvest workers to experience shoulder pain. The process of "egrek" work is often combined with the activity of moving from one palm tree to another for a relatively long duration (approximately 8 hours) each day, which leads to the majority of harvest workers also experiencing knee pain.

TABLE 2. Result of Kruskal-Wallis Test

	Location	N	Mean Rank
Egrek	Babulu	12	18.00
	DSN	12	27.46
	Badak	12	10.04
	Total	36	
Berondolan	Babulu	12	18.25
	DSN	12	27.54
	Badak	12	9.71
	Total	36	
Transporting to the palm fruit storage area	Babulu	12	17.79
	DSN	12	27.38
	Badak	12	10.33
	Total	36	
Loading onto the truck	Babulu	12	19.50
	DSN	12	24.75
	Badak	12	11.25
	Total	36	

Test Statistic[a,b]

	egrek	Berondolan	Transporting to the palm fruit storage	Loading onto the truck
Kruskal-Wallis H	16.876	17.560	16.124	10.235
df	2	2	2	2
Asymp. Sig.	.000	.000	.000	.006

a. Kruskal-Wallis Test
b. Grouping Variable: location

Transport workers must manually carry and then toss FFB with a weight of 20-25 kg into the truck bed. Based on observations, workers lift FFB weighing ≥ 13 kg with a distance of more than 10 inches from their bodies, and this action is repeated. This is what causes transport workers to frequently experience pain in the shoulders and elbows. Transport workers also perform their tasks by standing continuously for approximately 8 hours per day while carrying FFB, which leads to knee pain. Priyambada *et al*. (2019) also found that the shoulder is the body segment most frequently affected by MSDs. Furthermore, Henry *et al*. (2015) when lifting oil palm fruit, the center of gravity is in the hands, which results in pressure on the deltoid muscles in the shoulder. Therefore, workers who carry oil palm fruit often complain of discomfort in the shoulder area. After the load shifts to the shoulders, to stand upright from a bent position, the center of gravity shifts to the lower back. This occurs when lifting loads such as oil palm fruit and "tojok," in addition to the upper body weight, also concentrating on the lower back. The heavier the load lifted, the greater the pressure on the lower back. Consequently, workers frequently report hip pain.

The measurements taken with the "Gotrak" in these activities show that more than 40% of the respondents have a high level of risk. These complaints arise because the muscles experience pressure due to the repetitive and continuous physical workload without the opportunity for relaxation. Unnatural working postures, excessive muscle stretching, high-frequency vibrations, and direct pressure on soft muscle tissues can lead to complaints of pain. Considering this, it is necessary to analyze Ergonomic Risk Factors (ERF) to further examine the ergonomic risk factors experienced. The results of the ERF analysis will be used as input to design ergonomic risk controls to mitigate the occurrence of MSDs. A non-parametric statistical test (Kruskal-Wallis) was conducted to examine the differences in Gotrak/MSD levels that occurred in Babulu, Muara Wahau, and Muara Badak. The results indicate that there are differences in the level of Gotrak (see Table 2). Table 2 shows that the level of Gotrak in Muara Wahau is higher than in Babulu and Muara Badak across all investigated activities. The average level of Gotrak in Muara Wahau is the highest, followed by Babulu and Muara Badak. This is due to the much larger plantation area in Muara Wahau compared to Muara Badak and Babulu, resulting in larger harvesting targets or other activities for each worker. Additionally, because of the differing areas, transportation in Wahau utilizes large trucks, whereas in Babulu and Muara Badak, smaller pickup trucks are used. Furthermore, the conditions of the oil palm plantations are also different. In Muara Wahau, workers have to manually transport fresh fruit bunches (TBS) to the collection point using manual push carts. Meanwhile, in Babulu and Muara Badak, fruit pickers can use motorcycles equipped with baskets for fruit collection.

There are differences in tool usage in the activities of gathering loose fruit and loading FFB onto transportation equipment in the three researched locations. In Muara Badak and Babulu, for gathering loose fruit, no tools are used as opposed to what is done in Muara Wahau (see Figure 3). Meanwhile, the transportation equipment used for loading TBS into the processing plant is trucks in Muara Wahau and pick-up vehicles in Babulu and Muara Badak. ERF is assessed for each activity, not for each individual. The calculation of ERF is conducted by referring to the checklist found in SNI 9011: 2021. The checklist consists of three parts: upper body posture, lower body posture, and manual handling. In the calculation of working posture, if there is an awkward posture, measurements of the angles of the back and neck are required, as seen in the activity of gathering loose fruit (see Figure 2).

Table 2 shows the ERF scores for each activity. The table indicates that all activities have hazardous working conditions, as all the values are >7. From Table 3, it can be seen that the activity with the highest work risk is loading FFB onto the truck, followed by carrying fresh fruit bunches to the fruit collection point.

In harvesting activities using an "egrek," the ergonomic risks are mostly found in the upper body. Further, ergonomic hazards primarily exist in the manual material handling activities, such as carrying fresh fruit bunches to the fruit collection point, loading FFB onto the

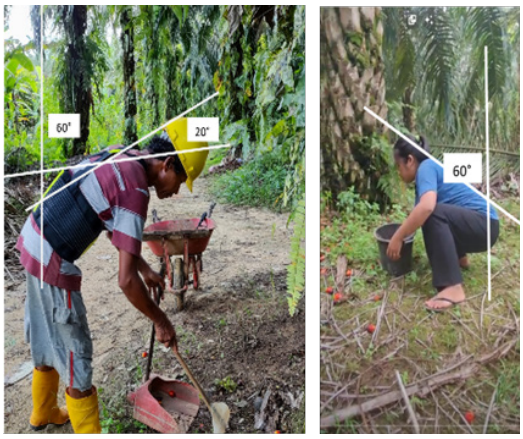


FIGURE 2. Angle Measurement in the Activity of Gathering Fallen Bunches

TABLE 3. ERF Score for Each Activity

	Upper Part	Lower Part	MMH	SCORE
Collecting FFB (MB, MW, B)	**13**	3	8	24
Picking up loose fruit while squatting (MB, B)	7	7	6	20
Picking up loose fruit with a shovel (MB)	5	3	9	17
Carrying fresh fruit bunches to the fruit collection point (MW, MB, B)	7	8	**19**	**34**
Loading TBS to the truck (MW)	**16**	5	**18**	**39**
Loading FFB to pick up (MB, B)	8	2	**14**	24

Note: MB=Muara Badak, MW=Muara Wahau , B=Babulu. MMH=manual material handling

truck or pick-up truck. Table 3 showed that the least safe condition is found during the activity of loading Fresh Fruit Bunches onto trucks (score 39). This is because the arm or elbow is not supported at a position above the waist, the hand gripping the T-hook in a "power grip" position with a force of more than 5 kg. This is due to the weight of the FFB and the T-hook itself; the total weight is approximately 21.2 - 26.2 kg. In addition, the body is also bent at an angle of 20°. The riskiest factor is the lifting of objects weighing more than 13 kg and lifting them from a distance of more than 10 inches. Furthermore, the torso rotates while lifting. This is exacerbated by repetitive lifting activities (more than 5 times per minute). These results are consistent with the research by Abdullah *et al.* (2023) and Yu *et al.* (2023) conclude that workers in palm oil plantations are vulnerable to MSD (Musculoskeletal Disorders)

CTS (Carpal Tunnel Syndrome) is part of MSD, specifically affecting the hands and wrists. Observation results showed that palm oil workers often move their wrists repeatedly, exert force on the wrists, and adopt awkward wrist positions. This position occurs when workers gather fruit bunches. Exertful force is applied when carrying FFB to the pushcart. According to (Nandini *et al.*, 2022), there is a positive correlation between jobs requiring repetitive wrist movements and the occurrence of CTD. Therefore, palm oil workers also potentially suffer from CTS. In addition to facing musculoskeletal problems, oil palm workers are also exposed to the risk of pesticide exposure used to repel pests in oil palm trees. Research (Awantari & Susilowati, 2023) showed that a total of 16 people (80%) from 20 respondents had IgE levels that exceeded the reference limits. Meanwhile, eosinophil levels in eight people (40%) also exceeded the reference limits. Basophil levels in eight people (40%) likewise surpass the reference limits. They concluded that pesticide exposure can increase the probability of allergies.

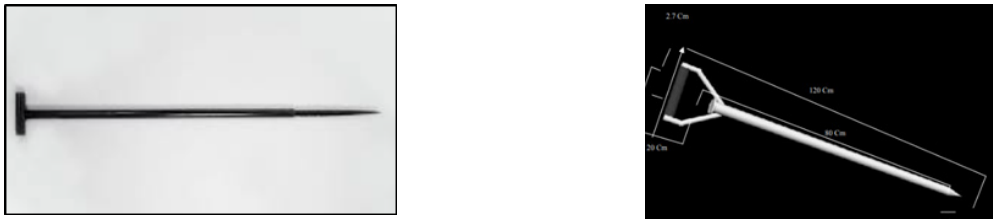
The improvements for these non-

ergonomic activities are the redesign of the T-hook and egrek to make it ergonomic, as well as performing stretching exercises before and between work to reduce discomfort. Stretching should be done because even though the tools have been ergonomically designed, awkward body postures can still be encountered due to unchangeable working conditions, such as the palm tree's height of 12 meters, which forces workers to constantly look up at an angle greater than 5°. The suggested redesign for the T-hook mechanism aims to decrease the likelihood of injuries occurring among palm fruit transportation workers. This redesign concept was previously put into practice in a study (Surya & Gasali, 2014) to reduce worker fatigue and the occurrence of injuries. Alterations have been introduced to the T-hook handle, resulting in a more ergonomic design that aligns with the finger's anatomy and size (refer to Figure 3).

As suggested in Hidayat *et al*. (2013), the egrek is suggested to be redesigned by installing a spring or hydraulic mechanism between the sickle and the pole. The diameter of the pole needs to be adjusted to be as wide as the workers' grip (i.e., 4 cm). Furthermore, the poles' handles should be layered with padding or foam with a thread pattern to make them comfortable and not slippery. Hidayat *et al* (2013) implemented the newly designed egrek to minimize the WMSD that occurred among harvesting workers in North Sumatra. During the activity of loading Fresh Fruit Bunches onto trucks, the majority of workers experience pain in the lower back (88%), knees (88%), and elbows (100%). Therefore, stretching is focused on the lower back, knees, and elbows. Stretching for the lower back and knees is performed in both sitting and standing positions. The positions for stretching focused on the lower back and knees. These positions are held for 5 breaths and then repeated 4 times. The same sequence is then repeated for the opposite hand/leg (Panjaitan & Budhyanti, 2019).

Conclusion

From the analysis conducted, it can be concluded that palm harvesting activities carry a risk of musculoskeletal disorders. This is evidenced by the results of the Gotrak survey, which indicated that more than 40% of respondents experienced musculoskeletal disorders in all activities. Further observation using the ergonomic risk factor questionnaire revealed that all harvesting activities are classified as unsafe conditions for workers (because the score is >7). Manual handling activities such as loading Fresh Fruit Bunches onto trucks and carrying TBS to the fruit storage area are two activities with the highest ERF scores, namely 39 and 34. These disorders occur because muscles endure pressure due to the continuous and repetitive physical workload without the opportunity for relaxation. Unnatural working postures, excessive muscle stretching, and direct pressure on soft muscle tissues can also lead to complaints of pain. Redesign ergonomic T-hook and egrek that are comfortable for workers and conducting stretching are the proposed improvements for reducing the risk of WMSD among palm-oil workers. Stretching is focused on the neck, lower back, and knees. This stretching is conducted before starting work and after a work break. Furthermore, the use of protective gloves should also be considered for the safety needs of palm oil workers (Khanlari *et al*. 2023)



(a) (b)

FIGURE 3. (a) Current T-hook Design (b) Proposed Design Improvement for T-hook (Surya & Gasali, 2014)

Acknowledgement

This work was supported by the Engineering Faculty, Mulawarman University [research grant 2023]

References

Abdullah, N.A., Shaberi, M.N.M., Nordin, M.N.A., Ripin, Z.M., Razali,M.F., Amri, W.M., Ali, W.M., Awang, B., & Ridzwan, M.I.Z., 2023. Field Measurement of Hand Forces of Palm Oil Harvesters and Evaluating the Risk of Work-Related Musculoskeletal Disorders (WMSDs) Through Biomechanical Analysis. *International Journal of Industrial Ergonomics,* 96.

Alisha, N., Halim, Rd., Syukri, M., Aswin, B., & Hidayati, F., 2021. Determinan Keluhan Muskuloskeletal Pada Pekerja Bongkar Muat Tandan Buah Segar (TBS) Kelapa Sawit. *Jurnal Ilmu Kesehatan*, 5(2), pp.366-374.

Awantari, A., & Susilowati, I.T., 2023. Humoral Inflammatory Markers of Total Immunoglobulin E (IgE) Exposure on Palm Oil Plantation Pesticide Sprayers. *Kemas*, 19(2), pp.203-211.

Bhuanantanondh, P., Buchholz, B., Arphorn, S., Kongtip, P., & Woskie, S., 2021. The Prevalence of and Risk Factors Associated with Musculoskeletal Disorders in Thai Oil Palm Harvesting Workers: A Cross-Sectional Study. *International Journal of Environmental Research and Public Health*, 18, pp.5474.

Chan, Y.S., Teo, Y.X., Gouwanda, D., Nurzaman, S.G., Gopalai, A.A., & Thannirmalai, S., 2022. Musculoskeletal Modelling and Simulation of Oil Palm Fresh Fruit Bunch Harvesting. *Scientific Reports*, 12, pp.8010.

Deros, B.M., Ali, M.H., Mohamad, D., & Indah, D.D., 2016. Ergonomic Risk Assessment on Oil Palm Industry Workers. *Iran Journal of Public Health,* 45(1), pp.44–51.

Henry, L.J., Jafarzadeh, E.A., Ramli, A., Ishak, I., Justine, M., & Mohan, V., 2015. Patterns of Work-Related Musculoskeletal Disorders Among Workers in Palm Plantation Occupation. *Asia Pacific Journal of Public Health,* 27(2), pp.1785–1792.

Hidayat, R., Huda, L.N., & Poerwanto., 2015. Analisis Perancangan Alat Bantu Kerja Operator Angkut Di Stasiun Pemanenan Pada PT. Perkebunan X. *e-Jurnal Teknik Industri FT USU*, 4(1), pp.25-32.

Khanlari, P., Ghasemi, F., & Heidarimoghdam, R., 2023. Protective Gloves, Hand Grip Strength, and Dexterity Tests: A Comprehensive Study. *Journal Heliyon*, 9(2).

Mongkonkansai, J., Thanapop, C., Madardam, U., Chekal, A., Epong, A., & Arwae, A., 2020. Factors Related to Musculoskeletal Disorders in Quality Control Palm Workers at Palm Purchasing Establishments in Sichon District, Nakhon Si Thammarat, Thailand. *Annals of Agricultural and Environmental Medicine*, 27(2), pp.207–210.

Myzabella, N., Fritschi, L., Merdith, N., El-Zaemey, S., Chih, H., & Reid, A., 2019. Occupational Health and Safety in the Palm Oil Industry: A Systematic Review. *International Journal of Occupational and Environment Medicine*, 10(4), pp.159–173.

Nandini, R.F., Lestari, M., Novrikasari., Andarini, D., Camelia, A., & Fujianti, P., 2022. Carpal Tunnel Syndrome Complaints in Female Packing Workers. *Kemas*, 17(3), pp.354-361.

Nawi, N.S.M., Deros, B., Rahman, M.N.A., Sukadarin, E.H., & Nordin, N., 2016. Malaysian Oil Palm Workers Are In Pain: Hazards Identification And Ergonomics Related Problems. *Malaysia Journal of Public Health Medicine*, 16(1), pp.50-57.

Panjaitan, L., Budhyanti, W., 2019. *Panduan Peregangan Mandiri.* Program Studi Fisioterapi. Universitas Kristen Indonesia, Jakarta.

Sultan, M., Isnaniah, S.A., Ramdan, I.M., 2022. Postur Kerja dan Keluhan Musculoskeletal Disorders Pada Pemanen Sawit di PT. Inti Energi Kaltim Kabupaten Berau. *Tropical Public Health Journal*, 2, pp.54–59.

Syuaib, M.F., 2015. Ergonomic Of The Manual Harvesting Tasks Of Oil-Palm Plantation In Indonesia Based On Anthropometric, Postures And Work Motions Analyses. *Agricultural Engineering International the CIGR e-journal*, 17(3), pp.248-262.

Tumit, N.P., Rambely, A.S., & Deros, B.M., 2021.The Effects of Age and Initial Shoulder Posture on the Upper Limb Range of Harvesting Movements among Oil Palm Harvesters. *Applied Science*s, 11, pp.10280.

Teo, Y.X., Chan, Y.S., Gouwanda, D., Nurzaman, S.G., & Thannirmalai, S., 2021.Quantification of Muscles Activations and Joints Range of Motions During Oil Palm Fresh Fruit Bunch Harvesting and Loose Fruit Collection, *Scientific Report*, 11, pp.15020.

Walker-Bone, K., 2002. Musculoskeletal Disorders in Farmers and Farm Workers. *Occupational. Medicine*, 52(8), pp.441–450.

Yu, X.T., Yon, S.C., Nurzaman, S.G., Gouwanda, D., & Gopalai, A.A., 2023. Investigation of Muscle

Synergies and Their Consistency Among Fresh Fruit Bunches Manual Harvesters in a Real-Life Oil Palm Industry. *International Journal of Industrial Ergonomics,* 97.