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Assessment of Work Posture During Fresh Fruit Bunch Loading Using REBA and ART to Reduce MSDs Risk

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Abstract
The loading activity of Fresh Fruit Bunches (FFB) at the plantation of PT. ALM is still performed manually by lifting, carrying, and throwing the FFB into truck beds. These repetitive activities, combined with non-ergonomic working postures, have the potential to cause Musculoskeletal Disorders (MSDs) among workers. This study aims to determine the level of ergonomic risk in FFB loading activities using the Rapid Entire Body Assessment (REBA) and Assessment of Repetitive Tasks (ART Tool) methods, as well as to propose an ergonomic improvement to reduce the risk of MSDs. Data were collected through observation, documentation, interviews, the Nordic Body Map (NBM) questionnaire, and anthropometric measurements. The results of the NBM questionnaire indicated that workers experienced discomfort in the back, lower back, shoulders, upper arms, and wrists. The REBA analysis showed that the FFB loading activity falls into a high-risk category, requiring immediate corrective action. Similarly, the ART Tool assessment indicated a high level of risk due to repetitive movements, excessive force exertion, and prolonged working duration. Based on the analysis, an ergonomic improvement in the form of a hydraulic FFB transport and dumping trolley was proposed, designed according to the workers' anthropometric data. The proposed trolley has dimensions of 180 cm in length, 100 cm in width, and 140 cm in height, with a carrying capacity of 200–250 kg, equivalent to 8–10 fresh fruit bunches.
Keywords: *anthropometry, assessment of repetitive tasks, ergonomics, nordic body map, rapid entire body assessment*

Abstrak
Aktivitas pemuatan tandan buah segar (TBS) kelapa sawit di perkebunan PT. ALM masih dilakukan secara manual dengan cara mengangkat, membawa, dan melempar TBS ke dalam bak truk. Aktivitas yang berulang dengan postur kerja kurang ergonomis tersebut berpotensi menimbulkan *Musculoskeletal Disorders* (MSDs) pada pekerja. Penelitian ini bertujuan untuk mengetahui tingkat risiko ergonomi pada aktivitas pemuatan TBS menggunakan metode *Rapid Entire Body Assessment* (REBA) dan *Assessment of Repetitive Tasks* (ART *Tool*), serta memberikan usulan perbaikan untuk mengurangi risiko MSDs. Pengumpulan data dilakukan melalui observasi, dokumentasi, wawancara, kuesioner *Nordic Body Map* (NBM), dan pengukuran antropometri. Hasil kuesioner NBM menunjukkan adanya keluhan pada punggung, pinggang, bahu, lengan atas, dan pergelangan tangan. Analisis REBA menunjukkan aktivitas pemuatan TBS berada pada kategori risiko tinggi yang memerlukan perbaikan segera. Hasil ART *Tool* juga menunjukkan tingkat risiko tinggi akibat gerakan berulang, penggunaan gaya yang besar, dan durasi kerja yang cukup lama. Berdasarkan hasil analisis, diusulkan fasilitas kerja berupa troli pengangkut dan penumpah TBS hidrolik yang dirancang berdasarkan data antropometri pekerja. Alat memiliki dimensi panjang 180 cm, lebar 100 cm, tinggi 140 cm, serta kapasitas angkut 200–250 kg atau setara 8–10 tandan TBS.
Kata Kunci: *antropometri, penilaian tugas berulang, ergonomi, peta tubuh Nordik, penilaian seluruh tubuh cepat*

1. Introduction

Ergonomics is a scientific discipline that studies the relationship between humans, their work, equipment, and the work environment to create safe, comfortable, efficient, and productive working conditions. The application of ergonomics is important because work systems that are not compatible with human capabilities and limitations can cause fatigue, reduce productivity, and increase the risk of occupational health problems [1][2][3]. Therefore, the design and evaluation of work systems need to consider human factors as well as the characteristics of the work being performed [4].

One of the problems that frequently arises from non-ergonomic working conditions is Musculoskeletal Disorders (MSDs). MSDs are disorders of the musculoskeletal system that can be influenced by non-ergonomic working postures, workload, repetitive movements, work duration, and individual worker factors [5][6][7]. Research on sewing workers has also shown that ergonomic risk factors are associated with the occurrence of musculoskeletal complaints among workers [8]. MSD complaints can also occur in occupations involving manual activities and repetitive lifting tasks.

One of the important factors influencing the occurrence of MSDs is working posture. Bending, twisting the body, excessively raising the arms, and working in non-neutral positions can increase the load on muscles and joints. In oil palm harvesting activities, working posture has also been identified as one of the factors associated with musculoskeletal complaints among workers [9]. Therefore, working posture evaluation is necessary to determine the level of ergonomic risk experienced by workers.

The oil palm industry plays an important role in the development of agroindustry and the economy, including Fresh Fruit Bunches (FFB) harvesting and transportation activities [10]. One activity that is still performed manually is loading FFB into trucks. Based on initial observations at PT ALM, workers repeatedly lift, carry, and throw FFB weighing approximately 10–25 kg during working hours. These activities involve bending while picking up FFB, lifting loads, twisting the body, and raising the arms when throwing FFB into the truck bed. Such conditions have the potential to cause MSD risks, particularly in the waist, back, shoulders, arms, and wrists.

Musculoskeletal complaints can be identified using the Nordic Body Map (NBM), an instrument used to determine the body parts experiencing complaints because of work activities. The use of the NBM can serve as an initial step in identifying worker complaints and determining the need for ergonomic improvements [11]. Furthermore, working posture can be assessed using the Rapid Entire Body Assessment (REBA) method. REBA is a method used to assess whole-body postural risk by considering the positions of the neck, trunk, legs, arms, wrists, load, and work activity. The REBA method has been used to evaluate and improve various workstations to identify high-risk working postures [12][13].

In addition to working posture, FFB loading activities also involve repetitive movements of the upper limbs. Repeatedly lifting, carrying, and throwing FFB can increase the risk of disorders affecting the shoulders, arms, and wrists. Therefore, the Assessment of Repetitive Tasks (ART Tool) is used to assess the risk of repetitive work based on movement frequency, force exertion, upper-limb posture, and work duration [14].The ART Tool is suitable for identifying the risk of Upper Limb Disorders in work activities involving repetitive movements of the upper limbs.

If the assessment results indicate a high level of ergonomic risk, improvements to the work system or the design of work facilities that are appropriate to the characteristics of the workers are required. Anthropometric data can be used as a basis for determining the dimensions of work facilities so that they correspond to the body dimensions of the users [15]. The design of work facilities based on anthropometric data can help reduce physiological workload and improve the compatibility between workers and the facilities they use [16]. An ergonomic design approach has also been applied to improve work facilities by integrating worker complaints with ergonomic analysis [11].

Based on the foregoing, an ergonomic analysis of FFB loading activities at PT ALM is necessary to identify musculoskeletal complaints, working posture risks, and repetitive movement risks experienced by workers. This study uses the NBM method to identify musculoskeletal complaints, REBA to analyze whole-body postural risks, and the ART Tool to assess repetitive movement risks in the upper limbs. Furthermore, an anthropometric approach is used as a basis for considering proposed improvements to work facilities.

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2. Material and Methods

Study Area and Research Period

This study was conducted at the oil palm plantation of PT ALM, located in Besitang District, Langkat Regency, North Sumatra Province, Indonesia. The research location is an open working area used for oil palm harvesting and Fresh Fruit Bunches (FFB) loading activities. The research was conducted from March 6 to July 2026.

Research Object

The object of this study was the working posture of workers involved in the manual loading of Fresh Fruit Bunches (FFB) from the plantation into transport trucks. The loading process involved four workers, with a working duration of eight hours per day without a shift system. The activities observed included lifting, carrying, and arranging or throwing FFB into the truck.

Data Collection

The data used in this study consisted of primary and secondary data. Primary data were obtained through direct observation, interviews, documentation, the Nordic Body Map (NBM) questionnaire, and anthropometric measurements. Direct observations were conducted to identify the workers' working postures and work methods during the FFB loading process. Photographs and videos were taken to document the workers' postures and support the measurement of body angles, including the neck, trunk, upper arm, lower arm, wrist, and legs.

The NBM questionnaire was distributed to workers involved in FFB loading activities to identify musculoskeletal complaints in various parts of the body. Anthropometric measurements were also conducted to obtain body dimension data required to support the proposed ergonomic work facility design. Secondary data were obtained from journals, books, theses, research reports, and other relevant articles.

Research Variables

The independent variable in this study was the working posture during the FFB loading process. This variable included the positions of the neck, trunk, upper arms, lower arms, wrists, and legs. Working posture was assessed using the Rapid Entire Body Assessment (REBA) and Assessment of Repetitive Tasks (ART Tool) methods.

The dependent variable was workers' musculoskeletal complaints, defined as discomfort, pain, or soreness experienced in specific body parts because of manual and repetitive FFB loading activities. These complaints were measured using the Nordic Body Map (NBM) questionnaire.

Data Analysis

The NBM method was used to identify the body parts experiencing musculoskeletal complaints and to determine the severity of the complaints. The questionnaire used a four-point scale consisting of not painful, slightly painful, painful, and very painful, with scores of 1, 2, 3, and 4, respectively.

The REBA method was used to assess whole-body working posture during the FFB loading process. The assessment included the neck, trunk, legs, upper arms, lower arms, and wrists. Load and coupling factors were also considered in determining the final REBA score. The final score was then interpreted according to the corresponding level of ergonomic risk and the required corrective action.

The ART Tool was used to assess the risk of repetitive tasks involving the upper limbs. The assessment consisted of four stages: Stage A (Frequency and Repetition), Stage B (Force), Stage C (Awkward Postures), and Stage D (Additional Factors). The assessment considered the frequency of arm movements, number of repetitions, force exerted, neck, back, arm and wrist postures, grip, work duration without rest, work pace, additional factors, and daily working duration. The final exposure score was used to determine the level of risk associated with repetitive work.

Ergonomic Improvement

The results obtained from the NBM, REBA, and ART Tool analyses were used to identify the ergonomic risks associated with the FFB loading process. Anthropometric data were then considered in developing an ergonomic improvement proposal for the work facility. The proposed improvement was designed based on the body dimensions of the workers and the characteristics of the FFB loading activity.

3. Results and Discussion

Nordic Body Map (NBM) Questionnaire Data Recapitulation

The recapitulation of the Nordic Body Map (NBM) questionnaire results is presented in **Table 1**.

Table 1. Recapitulation of Nordic Body Map (NBM) Questionnaire Results

Worker	NBM Score	Risk Level
1	87	High
2	84	High
3	79	High
4	76	High

Based on **Table 1**, all workers experienced a high level of musculoskeletal complaints, with NBM scores ranging from 76 to 87. Worker 1 obtained the highest score (87), indicating more severe discomfort than the other workers. According to the Nordic Body Map classification, these scores indicate that immediate ergonomic improvements are required to prevent further musculoskeletal disorders (MSDs).

The high NBM scores are consistent with field observations showing that workers repeatedly performed manual lifting, carrying, and throwing of Fresh Fruit Bunches (FFB) weighing approximately 10–25 kg. During these activities, workers frequently adopted awkward postures such as excessive trunk flexion, trunk twisting, and arm elevation above shoulder level. Continuous exposure to these postures increases muscle fatigue, particularly in the back, lower back, shoulders, upper arms, and wrists.

These findings support ergonomic theory, which states that repetitive manual material handling combined with awkward working postures significantly increases the risk of Musculoskeletal Disorders (MSDs). Continuous exposure to excessive physical loads causes muscle fatigue, tendon strain, and joint stress, eventually leading to decreased work performance and occupational injuries.

REBA Assessment Results

The ergonomic risk assessment using the Rapid Entire Body Assessment (REBA) method is presented in **Table 2**.

Table 2. REBA Assessment Results

Worker	Final REBA Score	Risk Level
1	12	Very High
2	12	Very High
3	12	Very High
4	12	Very High

Table 2 shows that all workers obtained the same final REBA score of 12, indicating a very high ergonomic risk requiring immediate corrective action. The identical scores suggest that the loading process is standardized and performed using similar working methods and body postures.

The high REBA score resulted from several ergonomic risk factors observed during the loading process. Workers bent their trunks while picking up FFB from the ground, manually lifted heavy loads, twisted their bodies during material transfer, and raised their arms above shoulder height when throwing the FFB into the truck. These postures were maintained repeatedly throughout the working day, increasing mechanical stress on the spine and upper limbs.

According to the REBA method, awkward postures involving trunk flexion, shoulder elevation, and repetitive lifting substantially increase biomechanical loading on the musculoskeletal system. Therefore, the loading process at PT. ALM requires immediate ergonomic intervention to reduce the risk of MSDs.

ART Tool Assessment Results

The results of the Assessment of Repetitive Tasks (ART Tool) are presented in **Table 3**.

Table 3. Overall Exposure Score of ART Tool

Stage	Score	Category
Stage A – Frequency and Repetition	12	High Exposure Level
Stage B – Force	10	High Exposure Level
Stage C – Awkward Postures	12	High Exposure Level
Stage D – Additional Factors	10	High Exposure Level
Overall Exposure Score	44	High Exposure Level (Action Required)

Based on the ART Tool assessment, the loading activity obtained an Overall Exposure Score of 44, which is classified as High Exposure Level (Action Required). This score exceeds the HSE action threshold (≥22), indicating that workers are exposed to a high risk of upper-limb musculoskeletal disorders.

The highest contribution to the ART score originated from repetitive movements and awkward working postures. Workers repeatedly lifted and threw heavy FFB while maintaining non-neutral postures for prolonged periods. In addition, the high force required to handle the loads, and the long working duration further increased the ergonomic risk.

These findings complement the REBA assessment, demonstrating that the loading process involves not only whole-body postural risk but also repetitive upper-limb movements. Therefore, combining REBA and the ART Tool provides a more comprehensive ergonomic evaluation than using either method independently.

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Proposed Ergonomic Improvement

Based on the REBA and ART Tool analyses, an ergonomic improvement was proposed in the form of a hydraulic FFB transport and dumping trolley, as shown in **Figure 1**.

Figure 1. Proposed Hydraulic FFB Transport and Dumping Trolley

The proposed trolley was designed according to workers' anthropometric dimensions to improve working posture during the loading process. The trolley has dimensions of 180 cm in length, 100 cm in width, and 140 cm in height, with a handle height of 95 cm. The loading compartment can carry approximately 8–10 Fresh Fruit Bunches (200–250 kg), corresponding to the average weight handled during daily operations.

The hydraulic lifting mechanism enables workers to unload the FFB into the truck without manually lifting or throwing the bunches. Consequently, excessive trunk bending, shoulder elevation, and manual lifting can be substantially reduced. The proposed ergonomic design is expected to reduce physical workload, improve occupational safety, minimize musculoskeletal complaints, and increase workers' productivity.

Working Posture After Ergonomic Improvement

The expected working posture after implementing the proposed trolley is illustrated in **Figure 2**. The proposed hydraulic trolley allows workers to transport and unload FFB while maintaining a more neutral body posture. The handle height of approximately 95 cm enables workers to push the trolley with elbow flexion of about 95°–100°, minimizing shoulder and wrist strain. Furthermore, the hydraulic system raises the loading compartment to the height of the truck bed (approximately 120–135 cm), eliminating the need to manually throw the FFB into the truck.

As a result, trunk flexion, body twisting, and shoulder elevation are significantly reduced compared with the existing working method. These improvements are expected to decrease biomechanical loading on the musculoskeletal system and lower the risk of Musculoskeletal Disorders (MSDs), while simultaneously improving worker comfort and operational efficiency.

Figure 2. Working Posture After Using the Proposed Hydraulic Trolley

4. Conclusion

Based on the results of the REBA, ART Tool, and anthropometric analyses, it can be concluded that the manual loading of Fresh Fruit Bunches (FFB) at PT ALM has a high ergonomic risk. The REBA and ART Tool assessments indicated that workers performed repetitive manual lifting with non-ergonomic postures and high force, increasing the risk of Musculoskeletal Disorders (MSDs), particularly in the back, neck, shoulders, wrists, and legs, as confirmed by the Nordic Body Map (NBM) questionnaire.

To address these issues, a hydraulic FFB transport trolley was designed based on workers' anthropometric data. The proposed trolley is expected to improve working posture, reduce manual lifting and physical workload, and enhance workers' safety and comfort. Although it is not intended to increase loading speed, the design provides a more ergonomic and sustainable material-handling process.

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