Risk factors of musculoskeletal disorders among oil palm fruit harvesters during early harvesting stage

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Abstract

This cross-sectional study intends to investigate the associations of musculoskeletal disorders (MSDs) among foreign labourers on a socio-economic background, occupational exposure, social lifestyle, and postures adopted during harvesting tasks. A total of 446 male respondents (263 FFB cutters; 183 FFB collectors) were studied using an interview-assisted questionnaire. OWAS was used to determine the severity of awkward posture based on videos of harvesting tasks recorded for each respondent. Analysis found that increasingly educated respondents had higher risk of developing MSDs. Shorter daily work duration and longer resting duration appear to increase the risk of neck and shoulder disorders among harvesters, which may be attributable to organizational work design. Awkward posture was a particularly significant risk factor of MSDs among FFB collectors. Among the results of the study, occupational exposure, postures and certain socio-demographic backgrounds explained some, but not all, the risk factor of MSDs among harvesters. An in-depth investigation, preferably a longitudinal study investigating the dynamic of work activities and other risk factors, such as psychosocial risk factors, are recommended.

Keywords

musculoskeletal disorders, harvesters, oil palm, risk factors, ergonomics

INTRODUCTION

Elaeis guineensis, more commonly known as oil palm, has been gaining importance in the recent years, especially in developing countries. Oil palm trees thrive primarily in a tropical climate and are usually mono-cultivated over a vast area in plantations where matured fresh fruit bunches (FFBs) bearing the oil palm seeds are harvested all year round.

Unlike other production crops, oil palm is unique with respect to the harvesting activities due to three reason; the crown-canopy arrangement of the oil palm fronds (leaves), the configuration of the (FFBs) stalk attachment to the trunk of the tree, and the height of the tree (hence FFBs) which attributes the ergonomics risk factors in the natural work environment [1].

While the leaves prevent direct access to the FFBs and with the stalks obscured, harvesting FFBs is a labour intensive occupation which presents significantly different ergonomics hazards over time as the trees grew taller corresponding to the age of trees [1]. Moreover, the weight of a single FFB can potentially weigh as much as 50 kg [2].

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Due to the nature of the harvesting tasks which are labour-intensive, there has been a decline in Malaysian working as harvesters. As such, foreign workers, especially from Indonesia, currently make up a large proportion of the workforce on oil palm plantations [3]. Thus, the main objective of this study was to explore the association of MSDs among foreign workers with individual, occupational and ergonomics risk factors during early stage of harvesting activities.

MATERIAL AND METHODS

Using a cross-sectional study design, the data for this study was gathered from 10 oil palm plantations located at the southern region of Peninsular Malaysia. The oil palm plantations were in their early harvesting year, where the heights of FFB were typically at knee to waist level. Harvesters were shortlisted based on a list of fulltime workers provided by each management office.

In this study, the term 'harvesters' used were synonymously defined by all the plantation management where they consist of a pair of individual with separate tasks: one FFB cutter and FFB collector, respectively (2 FFB cutters to 1 FFB collector in certain oil palm plantation). A total of 446 male respondents working fulltime as harvesters gave their consent to participate in this study.

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Questionnaire. A questionnaire for data gathering was developed and compiled to consist of the following sections:
- Socio-demographic background.
- Occupational exposure.
- Social and lifestyle information.
- Prevalence of musculoskeletal disorders (MSDs).

Reliability testing of the translated questionnaire on respondents with similar characteristics and job tasks (harvesters) revealed Cronbach's alpha of 0.92.

The questionnaire included a modified Nordic Musculoskeletal Questionnaire [4] which was translated into the local language of the respondents, and included in the pre-test prior to actual data collection. A distinctively-shaded figure of parts of the body was also used, complementing the questionnaire section on MSDs in order to create uniform reference of parts of the body. The prevalence of MSD symptoms for each part of the body was recorded for 2 periods: in the past year (12 months) and past week (7 days) using a binary (Yes/No) answer.

Postural analysis. The study employed the Ovako Working Posture Assessment System (OWAS) [5] to assess each working posture adopted during harvesting tasks. For quality control of the assessment, a video clip of each respondent performing his job tasks were recorded. The video allowed repeated viewing for a more accurate assessment.

As described by Ismail et al. [6], postural assessment using OWAS are based on four aspects: trunk postures (4), shoulder/arms postures (3), legs (7) and weight of load handled (3). A total of 252 possible combinations can be derived and categorized into 4 actions. These were used to indicate the need for change or ergonomics intervention.

Anthropometric data. Stature heights were measured for each respondent at fully-erect body height on a flat surface using Seca Bodymeter 206. Weight of respondents was measured using a Seca 761 scales. Respondents were instructed to position both their feet, standing straight without wearing shoes or sandals, hands at respective sides, looking forward and not supporting their body on any objects, walls or surfaces.

Procedures. The work tasks of harvesters were recorded for a single work cycle. On average, one cycle took approximately 1 minute for each FFB cutters and FFB collectors, respectively. Respondents were requested to work as naturally as possible to minimize the effect of interviewer bias. The videos were recorded early in the morning, corresponding to their working hour.

For FFB cutters, a single cycle of their work tasks included walking through an allocated block of oil palm plantation to look for ripe FFBs, and detachment of the ripe FFBs from oil palm trees. They sometimes cut fronds to expose FFBs stalks, or withered fronds or leaves. They also stacked the severed fronds to remove them from becoming obstacles in their pathways (Fig. 1).

On the other hand, a single cycle of FFB collector's job tasks were to lift the detached FFBs, collect loose fruits onto a wheelbarrow, and unload them along loading collection route on the oil palm plantation. Depending on their tasks distribution with FFB cutter, FFB collector sometimes arranges the severed fronds in stacks (Fig. 2).

Figure 1. A single cycle of work tasks for FFB cutter

Figure 2. A single cycle of work tasks for FFB collector

The translated and pre-tested questionnaire, including the Nordic Musculoskeletal Questionnaire, was administered in the evening using interviewer-assisted strategy, when workers returned from the oil palm plantation their hostel. Each interview was accompanied by anthropometric measurements to record each respondent's height and weight.

Statistical Analysis. Data entry and statistical analyses were mainly performed using IBM Statistical Package for Social Science (SPSS), Version 20. Respondents' background information, occupational exposures, and other relevant variables, including postures and musculoskeletal disorders were analyzed using descriptive analysis and expressed as percentage, mean and standard deviation.

Subsequently, the bivariate association of the selected MSD (for neck, shoulder, lower back, knees and total MSD only – determined from the highest results of MSD prevalence reported in previous and current study) with the independent variables contained in the questionnaire were analyzed for both durations.

In the bivariate analysis, continuous data were analyzed using Spearman correlation and categorical data using Chi-square test. Continuous data were further dichotomized

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using the mean as the central value, and tested for association as categorical data. Significance level was set at p<0.05 for both analyses.

Successively, only variables significantly associated with selected MSDs outcomes determined from the bivariate analysis, in turn, were examined using logistic regression for each individual part of the body and for both durations.

RESULTS

Characteristics of the respondents. Respondents involved in this study were male adults with average age of mid-20s' and within normal BMI. In terms of education level, most respondents had at least attended primary school (>90%) where a quarter of the respondent had tertiary education background (Tab. 1).

The ratio distribution of FFB cutters to FFB collectors was approximately 3:2. Most had been employed for at least a year, during which the average estimated daily working and resting hour was approximately 7 hours and 50 minutes. More than 75% usually worked overtime, while 25% of the workers did not rest in a typical month.

Prevalence of MSD. The self-reported prevalence of MSDs among harvesters during the past year were considerably high – 86% of the respondents' complained of experiencing pain, discomforts or disorders at any of the nine anatomical body parts.

Although the prevalence of acute (7 days) total MSDs were much lower (45%), the trend observed for both durations were similar. The highest number of complaints reported were for lower back disorders, followed by knee, shoulder and neck, which were distinctively higher than the rest of the parts of the body (Fig. 3).
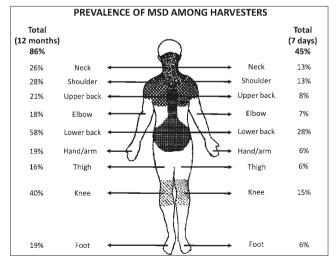

Figure 3. Summary prevalence of MSD among harvesters

Postures of harvesters. Most of the postures adopted by FFB cutters during performing work tasks were potentially injurious (Tab. 2). Specifically, walking with restricted posture require corrective action in the near future while the action of cutting FFB require (before, during and after) were to a certain extend require corrective action as soon as possible for most of the respondents.

Table 1. Characteristics of harvesters

	Frequencies (%)	Mean ± s.d.
Socio-demographic background		
Age		24.48 ± 6.893
Formal education		
None	8.3	
Primary school education	35.9	
Secondary school education	31.3	
Tertiary education (High school, Diploma, Bachelor Degree, etc)	24.6	
Body Mass Index (BMI)		20.61 ± 2.058
Underweight	13.0	
Normal	82.3	
Overweight	4.7	
Occupational history		
Role		
FFB cutters	59.0	
FFB collectors	41.0	
Duration of employment (month)		19.15 ± 12.536
Daily duration of work (minutes)		429.54 ± 61.976
Daily duration of rest (minutes)		50.34 ± 21.916
Work overtime		
Never	23.4	
Once/month	9.2	
Twice/month	25.3	
Three times/month	14.9	
Every week	27.1	
Part time work		
Yes	3.7	
No	96.3	
Social and lifestyle information		
Smoking		
Yes	93.8	
No	6.2	
Gardening		
Yes	6.2	
No	93.8	
Fishing		
Yes	71.3	
No	28.7	
Sports		
Yes	44.6	
No	55.4	

N = 446

Similarly for FFB collectors, the core action of their tasks – pushing wheelbarrow with a load, lifting FFBs (after) as well as collecting loose fruits, were also detrimental so that most required corrective action which was applied in the near future, and as soon as possible. However, lifting FFB (during) were assessed to be among the worst postures adopted by the harvesters, to the extent that immediate corrective action was advised.

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Table 2. Summary result of OWAS action category for each job tasks

POSTURE	Did not perform	No action required	Corrective action in the near future	Corrective action as soon as possible	Corrective action immediately
FFB cutters					
Walking with restricted posture	0%	12%	88%	0%	0%
Cut FFB (before)	0%	10%	50%	40%	0%
Cut FFB (during)	0%	11%	52%	35%	2%
Cut FFB (after)	0%	15%	53%	31%	1%
Arrange fronds	19%	2%	69%	11%	1%
FFB collectors					
Walking with restricted posture	16%	0%	84%	0%	0%
Pushing wheelbarrow with load	1%	12%	4%	83%	0%
Lifting FFB (during)	0%	2%	55%	27%	16%
Lifting FFB (after)	0%	33%	23%	42%	2%
Collect loose fruits	9%	0%	52%	38%	1%

Bivariate analyses. For FFB cutters, during the 12-month period of employment, a significant correlation was found for the prevalence of shoulder disorders, with fishing and cutting FFB (during and after), as well as total MSD, with formal education only. Neck, knee and lower back disorders were not significantly correlated with other independent variables analyzed for the same period among FFB cutters.

On the other hand, 7 days prevalence of neck disorder was significantly correlated with the daily duration of rest (categorical) and cutting FFB (after), shoulder disorders with cutting FFB (during and after), lower back disorders with duration of employment (categorical) and BMI, and total MSD with formal education, daily duration of rest and gardening. Knee disorders were not significantly correlated with any other independent variable analyzed for the same period of 12 months among FFB cutters.

For FFB collectors, a significant correlation was found for the prevalence of neck disorder with daily duration of work, working overtime and fishing, shoulder disorder with daily duration of work (categorical), walking with restricted posture and collecting loose fruit, and lower back disorder with collecting loose fruit. Total MSD was not significantly associated with any independent variables analyzed for the same period among FFB collectors.

On the other hand, the 7 days prevalence of neck and knee disorder were significantly associated with walking with restricted posture only, shoulder disorder with daily duration of work and daily duration of rest, lower back disorder with fishing and collecting loose fruit, and total MSD with collecting loose fruit only.

Multivariate analysis. Although fishing and cutting FFB (before and after) were significantly correlated with shoulder disorder (in the previous bivariate analysis), none had been a significant risk factor for FFB cutters in the past 12 months (Tab. 3). For total MSD, the odds of reported disorders of any part of the body increased with education level among FFB cutters, but were only significant for secondary education during the same period.

For MSDs in the past 7 days (Tab. 4), both categorized daily duration of rest and posture of cutting FFB (after),

Table 3. Risk factors associated with 12 months musculoskeletal symptoms among FFB cutters

Body parts	Shoulder		Total MSD	
OR / 95%ile CI	OR	95%CI	OR	95%CI
Education				
Primary	-	-	1.471	0.508, 4.259
Secondary	-	-	**9.412**	**2.139, 41.406**
Tertiary	-	-	1.765	0.558, 5.585
Fishing	1.804	0.887, 3.668	-	-
Postures				
Cut FFB (during)	0.463	0.122, 1.759	-	-
Cut FFB (after)	0.560	0.174, 1.803	-	-

Bold OR (95% CI), significant at $p<0.05$

Table 4. Risk factors associated with 7 days musculoskeletal symptoms among FFB cutters

Body parts	Neck		Shoulder		Lower back		Total MSD	
OR / 95%ile CI	OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI
BMI	-	-	-	-	**0.837**	**0.717, 0.975**	-	-
Education								
Primary	-	-	-	-	-	-	0.747	0.259, 2.158
Secondary	-	-	-	-	-	-	0.865	0.298, 2.510
Tertiary	-	-	-	-	-	-	1.428	0.482, 4.229
Gardening	-	-	-	-	-	-	2.317	0.780, 6.881
Daily working duration (ref: ≤427 minutes)	-	-	-	-	-	-	0.909	0.502, 1.649
Daily resting duration (ref: ≤51 minutes)	**3.705**	**1.046, 13.121**	-	-	-	-	-	-
Duration of employment (ref: ≤20 months)	-	-	-	-	**0.484**	**0.244, 0.961**	-	-
Postures								
Cut FFB (during)	-	-	0.505	0.112, 2.284	-	-	-	-
Cut FFB (after)	**3.318**	**1.252, 8.793**	0.319	0.080, 1.268	-	-	-	-

Bold OR(95% CI), significant at $p<0.05$

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significantly increased the prevalence of neck disorder among FFB cutters. Nevertheless, neither posture was a significant risk factor for shoulder disorder, whereas a significant inverse correlation was observed between lower back disorder with BMI and categorized duration of employment during the same period. None of the variables significantly correlated with total MSD (during bivariate analysis) appeared to be significant risk factors.

For FFB collectors, all variables – daily working duration, working overtime and fishing – were significant risk factors of neck disorder for the past 12 months. However, for shoulder disorder, working duration significantly increased the prevalence of shoulder disorder only when categorized into dichotomous variables. The posture for collecting loose fruit was significantly correlated with lower back disorder in the bivariate analysis, however it was not significantly correlated during the past 12 months (Tab. 5).

On the other hand, a significantly positive correlation with walking with restricted posture was observed with 7 days prevalence of neck and knee pain, respectively, whereas daily working and (categorized) resting duration were also significant risk factors of shoulder pain. The posture for collecting loose fruits significantly increased the odds of lower back pain and total MSD during the same period (Tab. 6).

DISCUSSION

Generally, the respondents were made-up of physically fit young male adults, corresponding to the requirement for the labour-intensive and physically demanding work tasks of harvesting FFB. It was also observed that most of the respondents who were smokers had muscularly-build features, especially of the upper limbs and torso. Most had been working for at least one year in the oil palm plantation.

In terms of self-reported MSDs, the 12 months prevalence of having pain in any part of the body (total MSDs) among harvesters were considerably high, compared to a general survey among workers in the oil palm plantation [7]. The parts of the body most affected in the presented study were the lower back, knee, shoulder and neck.

Studies conducted previously in agricultural sectors have reported that musculoskeletal disorders (MSDs) were common among agricultural workers [8, 9, 10, 11, 12, 13]. Review studies have also stated that musculoskeletal disorders cut across agricultural practices, regardless of countries, particularly production agriculture [14, 15, 16, 17].

With the exception of knee pain, the prevalences in the current study were consistent with previously reported postural risks for developing MSDs in early harvesting years [2,7]. Pain in the knee has been associated with bending, kneeling or stooping, adopted particularly while performing agricultural work tasks [18, 19]. In the observations for the presented study, it was found that the oil palm plantation was on hilly terrain. As such, the postural assessment conducted included walking with restricted (bent knees and back) posture, together with other primary tasks.

The dynamic tasks of harvesting which requires varied postures and assessed using OWAS, allowed assessment of individually-adopted postures where the urgency of corrective actions is summarized for each posture [20]. The presented postural assessment shows that primarily the posture adopted specifically during cutting and lifting of FFB, as well as collecting loose fruit, were considerably awkward.

In terms of risk factors, there was no obvious trend of association between MSDs of both duration with socio-demography background, occupational exposure or social and lifestyle information in the bivariate analysis among either FFB cutters or collectors. Nevertheless, the multivariate analysis for risk factors for both duration of MSDs among FFB collectors shows a noteworthy trend.

Table 5. Risk factors associated with 12 months musculoskeletal symptoms among collector

Body parts	Neck		Shoulder		Lower back	
OR / 95%ile CI	OR	95%CI	OR	95%CI	OR	95%CI
Daily working duration (minutes)	**0.993**	**0.988, 0.998**	**2.514‡**	**1.207, 5.237**	-	-
Work Overtime	**2.907**	**1.187, 7.121**	-	-	-	-
Fishing	**3.219**	**1.533, 6.757**	-	-	-	-
Postures						
Walking with restricted posture	-	-	1.657	0.750, 3.659	-	-
Collecting loose fruits	-	-	2.361	0.845, 6.594	3.466	0.962, 12.489

Bold OR(95% CI), significant at $p<0.05$
‡ Dichotomized into categorical variables for analysis; ref: 433 minutes)

Table 6. Risk factors associated with 7 days musculoskeletal symptoms among collectors

Body parts	Neck		Shoulder		Lower back		Knee		Total MSD	
OR / 95%ile CI	OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI
Daily working duration (minutes)	-	-	**0.994**	**0.988, 0.999**	-	-	-	-	-	-
Daily resting duration (ref: 50 minutes)	-	-	**2.857**	**1.083, 7.539**	-	-	-	-	-	-
Postures										
Walking with restricted posture	**2.974**	**1.202, 7.361**	-	-	-	-	**4.621**	**1.046, 20.424**	-	-
Collecting loose fruits	-	-	-	-	**4.139**	**1.502, 11.405**	-	-	**5.571**	**1.548, 20.057**

Bold OR(95% CI), significant at $p<0.05$

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In a quick overview, it can be observed that the 7 days prevalence of MSD yield more significant results, compared to the 12 months prevalence of MSD. Although various individual, occupational, social and ergonomics risk factors were analyzed together, it appears that occupational exposures (such as duration of employment, daily working and resting duration) were prominent risk factors among the harvesters.

Formally educated FFB cutters appear to be at increasingly higher risk of developing chronic MSDs (12 months prevalence) of any part of the body in the long-term, compared to those who did not have an education background. The pattern was the opposite, however, for acute MSDs (7 days prevalence), where (primary and secondary) education decreased risk in the short-term. Nevertheless, the risk was significant only for chronic MSDs with secondary education.

Although a higher educational level has been shown to be correlated with lower risk of developing MSDs in the general population [21], the presented findings were consistent with the findings of adjusted odd ratio among Finnish farmers, where those who spent less time in education appeared to lower the risk of self-reported prevalence of MSDs [22].

Based on the results and additional information gathered from the interviews, it was also found that respondents who had less education had spent their childhood assisting their families in agricultural activities. As such, it may be postulated that they may have better adaptation to labour intensive work tasks, and had developed higher tolerance towards fatigue and pain, compared to those who had spent most of their childhood in school.

For the 7 days prevalence of MSD, the odds of acute neck pain significantly increased by more than threefold when the FFB cutters adopt awkward posture of (after) cutting FFB and rested for more than 51 minutes. The neck muscles was particularly and necessarily strained when their head twist to look left or right during cutting FFB, whereas the increased resting duration may had cause workers to work at a faster pace.

During further investigation for the current study, it was also found that although the daily working duration of harvesters varied slightly from day-to-day, it was constant as the entire group of workers were fetched by trucks. Thus, those who took a longer rest duration for recovery from fatigue may then be forcing themselves to work at a much more rapid work pace to complete their designated harvesting block (area assigned to cover) during limited days of the harvesting cycle.

On the other hand, analysis also found that increase of BMI and categorized duration of employment lowered the odds of lower back pain among FFB cutters. Initially appearing to be astonishing, the presented results are attributed to the physique of respondents, where those who had longer work experience were generally more muscular and had athletic features (and hence may develop higher tolerance, improved range or motion or adaptation [14] than their peers who had less experience working as harvesters.

As a surrogate to measure body fat, BMI can be significantly affected by muscle mass where the measurement of weight lacks consideration of bone mass, muscle or excess fat [23]. Nevertheless, the protective effect of increasing BMI in decreasing lower back pain may have a ceiling limit, which was not investigated in this study. The use of BMI as a continuous variable were opposed to the commonly used categorical variable where obesity has been reported to be attributable to MSDs [14, 24].

For FFB collectors, working overtime and fishing significantly increased the prevalence of neck disorders in the past 12 months, while extended daily working duration (each minute) reduced the risk with a borderline protective effect. On the contrary, working for more than 433 minutes significantly increased the prevalence of shoulder disorders in the past 12 months, but the increase of risks by awkward posture was not significant.

Ergonomics observation did not reveal any significant twisting or straining of the neck during FFB collector work tasks. However, shoulder strength was constantly utilized, particularly during lifting FFB. In the current analysis of social and lifestyle data, although fishing was considered as leisure or a hobby, the fish caught were generally for their daily consumption as a source of protein in order to further cut down living costs.

Longer resting duration appeared to increase the risk of shoulder disorders for acute MSD among FFB cutters, but decreased when working for longer duration (borderline protective effect). On the other hand, awkward postures, particularly walking with restricted posture and collecting loose fruits, were significant risk factors for neck, lower back, knee and total MSD, with increased risk approximately three-fold and up to five-fold.

Where posture is concerned, biomechanical stress during awkward or unnatural body position has been associated with MSDs of various parts of the body, particularly in agricultural practices [16, 19, 8, 25]. As previously identified [2, 7, 1], postural analysis of harvesting tasks using different methods has shown that there is an urgent need to correct the awkward posture adopted, which is consistent with the presented study. study.

Limitations of the study. Time was a primary constrain, specifically during field data collection. In addition, the healthy cohort effect is particularly significant considering the cross-sectional study design (as only physically-fit individuals were involved in the study), which was consistent with the requirement of Malaysia's legislative requirement for foreign labour to attend a medical checkup before working in the country.

Besides that, the responses given by the respondents in the questionnaire may have been biased. There were three type of limitation in this category: 1) recall bias, as several questions required respondent to report past occurrences, 2) the presence of management during the completion of the several interview-assisted questionnaire, may have prevented the workers to respond truthfully (worried about future complications).

Furthermore, the analysis of posture using OWAS relied solely on the observer's assessment, although even a trained ergonomist may be biased. While it may have been perceived as awkward posture for the observer, the harvesters may not have experienced awkwardness due to adaptation (increased range of motion and tolerance) of the dynamic harvesting activities. Moreover, the use of self-reported prevalence of MSD in this study was also a major limitation.

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CONCLUSIONS

In conclusion, this study suggests an inverse relationship of MSDs with daily working and resting duration of work, which is contrary to the common perception (dose-response), and should be subject to further in-depth investigation. The study also indicate that the labour-intensive harvesting tasks, specifically during the early stage (when the FFB were below waist), were commonly performed in awkward posture which increases the risk of MSDs among the workers.

Acknowledgements

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