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Analysis of The Prevalence and Risk Factors for Malalignment of The Lower Limbs in Rice Farmers in Indonesia

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Abstract

Rice farming processes include extended periods of physical labor and interaction between humans and machines. Extended exposure to agricultural activities has the potential to cause misalignment in the lower limbs. This misalignment may heighten the likelihood of harm to the lower limbs and result in physical disability. Nevertheless, the prevalence and factors related to the misalignment of the lower limbs have not been documented to date. The aim of the current research was to examine the prevalence and risk factors associated with lower limb misalignment in individuals engaged in rice farming. A cross-sectional investigation of 400 rice farmers was carried out. Lower limb alignment evaluation involved pelvic tilt angle, limb length equality, femoral torsion, quadriceps (Q) angle, tibiofemoral angle, genu recurvatum, rearfoot angle, and medial longitudinal arch angle. Individual characteristics and the prevalence of lower limb malalignment were analyzed using descriptive statistics. The risk factors were identified using logistic regression analysis. The most prevalent misalignment was pelvic tilt angle (28.50%), followed by an abnormal femoral antetorsion angle (24.00%), tibiofemoral angle (21.50%), foot pronation (17.75%), limb length inequality (14.25%), genu recurvatum angle (12.75%), Q angle (7.50%), and tibial torsion angle (6.00%). Being underweight was a significant risk factor for experiencing an abnormal pelvic tilt angle. The main risk factors for abnormal genu recurvatum angle were found to be overweight and increased years of agricultural experience. Simultaneously, being female gender was correlated with disparities in limb length, abnormal femoral antetorsion angle, abnormal tibiofemoral angle, and abnormal foot pronation. Aging was identified as a significant risk factor for limb length discrepancy, abnormal tibiofemoral angle, and abnormal genu recurvatum angle. Lower limb screening is intended to aid in detecting foot and knee misalignment in rice farmers. Consequently, this might result in the early prevention of musculoskeletal problems that come from such misalignment.

Keywords: *lower limb malalignment; prevalence; rice farmer; risk factors*

1. Introduction

Rice serves as the primary carbohydrate source in nearly all Asian countries, in contrast to its comparatively lower consumption in the American, Australian, and European regions. In Asia, particularly in Indonesia, rice cultivation is an important agricultural sector. Based on data from the Mundi Index, it can be observed that Indonesia ranked as the fourth largest worldwide producer of milled rice in 2021 (Mundi, 2023). According to statistics provided by the Indonesian Central Bureau of Statistics (BPS), there was an observed 0.61 percent increase in rice production between the years 2021 and 2022 (Badan Pusat Statistik, 2023). This growth trend is expected to continue in the future. Consequently, as a result of this upward trend, it is essential to establish a secure and safe working environment for rice farmers in order to guarantee the continuity of labor supply. The rice planting process generally consists of several stages, including plowing, sowing, planting, nurturing, fertilization, and harvesting (Kristanto et al., 2022). Rice farming activities in Asian countries are commonly conducted by human labor, often under challenging environmental conditions (Kristanto et al., 2019). The majority of rice farming occupations involve engaging in repeated motions, assuming uncomfortable body positions, exerting significant physical effort, enduring prolonged periods of standing, and operating heavy machinery. Farmers engage in agricultural activities without wearing footwear. The plowing of rice involves the utilization of machinery that generates substantial vibrations while operating on surfaces that are both slippery and sloping (Kristanto et al., 2019). Sowing seedlings, nurturing crops, and applying fertilizers to rice entails transporting heavy loads and traversing waterlogged, muddy terrain (Kristanto et al., 2019). The process of rice cultivation entails the frequent and repetitive implementation of a posture including torso flexion and rotation, as well as prolonged periods of standing in muddy conditions (Kristanto et al., 2019). The rice harvesting operation necessitates maintaining a sustained posture of prolonged flexion, coupled with traversing uneven terrain (Kristanto et al., 2019). Apart from the similarities in farming methods, there are important differences between rice farming practices in Indonesia and Thailand, which could influence the prevalence and risk factors of lower extremity malalignment. The methods of rice planting, duration of work, and terrain vary between the two countries. In Indonesia, rice is often planted manually, using a traditional method called *tandur*, where farmers squat for extended periods to place rice seedlings into flooded fields. This process requires repetitive knee flexion and strain on the lower limbs. In contrast, Thailand has increasingly adopted mechanized planting methods in some regions, which may reduce the physical demands on farmers' lower limbs. Indonesian farmers typically work longer hours in the field, often exceeding eight hours per day, due to smaller farm sizes and the need for intensive labor. This extended work duration could lead to cumulative stress on the musculoskeletal system. In contrast, in Thailand, mechanization in certain areas may reduce the physical labor time per day for some farmers. Indonesian rice fields are often located on uneven or terraced landscapes, particularly in regions such as Java and Bali. This uneven terrain requires farmers to navigate slopes and uneven ground, which can lead to additional biomechanical stress on the lower limbs. In contrast, rice fields in Thailand are generally flatter, which may place different physical demands on the body. The presence of this ergonomic risk factor may lead to the development of chronic musculoskeletal disorders (MSDs), particularly in the lower limbs. A study revealed a significant prevalence of MSDs affecting the lower limbs among rice farmers, with a reported incidence rate of 41% (Puntumetakul et al., 2011).

The presence of ergonomic risk factors has the potential to result in atypical biomechanical functioning and structural changes (Moreira-Silva et al., 2022; Alyousef et al., 2023; Kristanto et al., 2023). Malalignment of the lower limbs can lead to musculoskeletal dysfunction, characterized by atypical joint loading, muscle imbalance, and divergence from the neutral alignment (Alahmri et al., 2022; Soni, & Aghara, 2022). There was a correlation between lower limb malalignment and a greater susceptibility to MSDs affecting the lower limbs. These disorders include hip and knee osteoarthritis (Suri et al., 2012), patellofemoral pain syndrome (Nilmart et al., 2022), anterior cruciate ligament damage (Pfeifer et al., 2018), and medial tibial stress syndrome (Winkelmann et al., 2016). Leg and foot pain, decreased mobility in the lower limbs, physical disability, and subsequent impairment of work capacity can arise from lower limb malalignment (Bagwe, & Varghese, 2019). The presence of lower limb malalignment carries significant implications for both individual health and occupational performance.

Lower limb MSDs have been observed to be related to both individual and work-related factors (Moreira-Silva et al., 2022; Kang et al., 2021; Sharifirad et al., 2022). Repetitive abnormal loading can cause MSDs that lead to misalignment in the lower limbs (Alahmri et al., 2022; Mohanty, & Koley, 2018; Chun et al., 2021). Nevertheless, there is a lack of research regarding the prevalence and risk factors of abnormalities in lower body movement among rice farmers, particularly in Indonesia. Besides that, there are important differences between rice farming practices in Indonesia and other countries, which could influence the prevalence and risk factors of lower extremity abnormal alignment. For example, the methods of rice planting, duration of work, and terrain may vary between any countries, potentially leading to different biomechanical stresses on the lower limbs. Additionally, cultural practices and socio-economic factors in Indonesia may also impact the physical demands placed on rice farmers.

While both personal and ergonomic factors can contribute to the likelihood of lower limb malalignment, all rice farmers face comparable ergonomic risks associated with their farming activities. High forces, uncomfortable postures, repeated movement, and harsh environmental conditions are some of these concerns. Moreover, individual characteristics may have an impact on lower limb malalignment. Hence, this study collected data on specific variables pertaining to rice farmers, such as gender, age, body mass index (BMI), daily work hours, and farming experience's years. Women are typically more susceptible to lower limb malalignment due to variations in anatomical alignment, lower pain thresholds, and reduced physical tolerance compared to men (Tschon et al., 2021). Prior research has indicated that females had a higher likelihood of experiencing abnormal anterior pelvic tilt, femoral antetorsion, Q angle, tibiofemoral malalignment, and genu recurvatum (Mohanty et al., 2019a). Nevertheless, there is currently no available data on the disparity in limb length inequality and foot pronation between genders.

Excessive weight (BMI ≥ 25 kg/m2) has been identified as a risk factor for lower limb malalignment, particularly in the pelvis, Q angle, and tibiofemoral angle. This occurs due to the heightened stress placed on weight-bearing joints in the lower limbs, which can result in injury (Mohanty et al., 2019b). Individuals who are obese may compensate for excess weight by adopting improper lower limb alignment. (Vincent et al., 2012). The process of aging is related to the development of degenerative joint diseases, reduced muscle strength, physical activity, and ligament laxity. These factors can lead to anatomical changes in the lower limbs (Ribeiro, & Oliveira, 2007). Individuals who are 40 years old or older exhibit positive indications associated with misalignment of the hip and knee, such as osteoarthritis (OA) (Allen et al., 2022).

Prolonged daily working hours and years of farming experience have been recognized as risk factors for lower limb MSDs (Dianat et al., 2020). Engaging in farming activities that include significant ergonomic risks under harsh environmental conditions increases the likelihood of developing degenerative joint problems and limit farmers' ability to maintain proper or neutral body positions, leading to misalignment of the lower limbs (Tong, & Kong, 2013). Furthermore, engaging in farming activities may correlate with leg pain when bearing weight on muddy terrain (Benos et al., 2020).

2. Objectives

The prevalence and risk factors of misalignment in the lower limbs have not been documented. Hence, this investigation aimed to ascertain the prevalence of and identify the factors correlated to the misalignment of the lower limbs in individuals working in rice farming. To establish prevention guidelines, it is crucial to comprehend the risk factors related to lower limb malalignment. The hypothesis of the current study posited that sex, age, BMI, daily labor hours, and years of farming experience would serve as risk variables for lower limb malalignment. Additionally, this study postulated that gender would be a statistically significant determinant for lower limb malalignment, with females exhibiting a higher incidence compared to males. Other hypotheses posited that elderly farmers would exhibit a higher susceptibility to lower limb malalignment compared to younger farmers. Additionally, this research hypothesized that being overweight would serve as a risk factor for lower limb malalignment. In addition, the current study postulated that farmers who worked longer hours per day and had more years of experience in farming would have a larger likelihood of experiencing lower limb malalignment compared to those who worked fewer hours.

3. Materials and Methods

3.1 Design of Study and Participants

The research used a cross-sectional design and focused on rice farmers living in the South Sulawesi Province of Indonesia. The Agricultural Office of South Sulawesi Province supplied researchers with an individual list of rice farmers obtained from its database. The inclusion criteria for participants in this study were employment in rice farming in the South Sulawesi province and at least 1 year of experience in rice farming. Participants were selected using a multistage random sampling method. The sampling technique employed in this study was using the technique of cluster sampling to randomly choose 16 districts and 32 sub-districts within the South Sulawesi Province. Subsequently, a simple random sampling method was employed during a field survey to include a total of 400 farmers.

All participants worked exclusively on rice farming and did not have any other occupation. Their ages ranged from 16 to 80 years. Rice farmers were eliminated when they reported present symptoms or indications of injury in the lower limbs or any prior history associated with the alignment of the lower limbs, such as fractures or surgical procedures.

The study was conducted after the rice farming process was completed and received ethical approval from the Universitas Ahmad Dahlan Human Ethics Committee (No. 012307161) prior to its initiation. Before participating in the study, farmers were asked to read and sign a consent form. Participants were requested to complete a questionnaire, which required around 10 minutes of their time. Additionally, the participants underwent a physical assessment to evaluate the alignment of their lower limbs, which took roughly 20 minutes per participant.

The data collection occurred in the South Sulawesi Province, Indonesia, between August and October 2023. The response rate for the self-administered questionnaire was 100% (n=400), with no prior history of lower limb surgery. All 400 rice farmers participated in the survey and had a physical assessment to evaluate their lower limb alignment. The survey collected demographic data, such as gender, age, BMI, average daily working hours, and years of work experience. Each participant underwent a physical assessment to evaluate and document their lower limb alignment characteristics.

3.2 Measurement of Lower Limb Alignment

The alignment characteristics of the lower limbs were analyzed to evaluate the presence of (1) limb length discrepancy, (2) pelvic angle, (3) femoral antetorsion, (4) quadriceps (Q) angle, (5) tibiofemoral angle, (6) genu recurvatum, (7) tibial torsion, (8) rearfoot angle, and (9) medial longitudinal arch angle. The measurements were conducted three times by a single examiner who demonstrated exceptional consistency in measuring the lower limbs (ICC range of 0.85 – 0.94). The intrarater reliability was determined by assessing lower limb malalignment in ten participants. The examiner performed a second round of measures on each individual during a 2-day interval following the initial measurements. Lower limb alignment assessments were performed in accordance with the descriptions provided in the subsequent paragraphs.

Limb length equality was assessed using an indirect clinical methodology. When an individual was standing, the medical professional felt the greater trochanters and anterior superior iliac spines (ASIS) to determine the length of the limbs. Masonite boards with a thickness of 3.18 mm were positioned beneath the shorter lower limb, as deemed suitable. If the levels of the greater trochanter and ASIS were equal, there was no discrepancy in limb length. However, if there was a difference higher than 6.4 mm, it was considered as an inequality (Figure 1A) (Brady et al., 2003).

The pelvic angle was assessed by measuring the angle formed between a line connecting the anterior superior iliac spines (ASIS) and the posterior superior iliac spines (PSIS) in the horizontal plane (Leard et al., 2009). The normal range for pelvic angle is 7° to 15° (Magee, & Manske, 2020). Abnormal pelvic tilt, also known as anterior pelvic tilt, was identified when the ASIS level was lower than the PSIS by a tilt of more than 15° (Figure 1B) (Shultz et al., 2006; Herrington, 2011).

The femoral antetorsion angle was assessed by applying Craig's test while the individual was lying face down with the knee bent at a 90° (Nguyen, & Shultz, 2009). The femur was rotated internally until the greater trochanter reached its furthest lateral position. The angle was determined by measuring the deviation between an actual vertical line and the axis of the tibia (Figure 1C). The normal range for femoral antetorsion is between 8° and 15°. Femoral antetorsion above 30° was categorized as excessive (Magee, & Manske, 2020).

The Q angle refers to the angle formed by a line from the anterior superior iliac spine (ASIS) to the center of the patella, and a line connecting the center of the patella to the tibial tuberosity (Figure 1D) (Nguyen, & Shultz, 2009). The normal angles for males and females are roughly 10°–13° and 15°–18° respectively. An abnormal classification was assigned to Q angles that exceeded 18° (Magee, & Manske, 2020).

The tibiofemoral angle is created by making a line from the midpoint between the anterior superior iliac spine (ASIS) and the greater trochanter of the femur to the center of the knee, and another line from the center of the knee to the midway between the medial and lateral malleolar distance of the ankle (Figure 1E) (Nguyen, & Shultz, 2009). The normal tibiofemoral angle falls within the range of 173° to 180°. The tibiofemoral angle deviated from the usual range and measured less than 173° (Solberg, 2007).

The genu recurvatum examination was performed with the individual standing on their legs. The knee was passively extended until encountering firm resistance. The angle was determined by measuring the deviation between the line connecting the femur and the tibia and the sagittal plane (Figure 1F) (Nguyen, & Shultz, 2009). The genu recurvatum angle value exceeded 10°, indicating an abnormality (Devan et al., 2004).

Tibial torsion assessment was performed when the individual was lying down with their knees fully extended. The femur was rotated without an active effort to align the femoral epicondyles parallel to the horizontal plane. The angle was depicted as a line connecting the actual vertical and a line dividing the medial and lateral malleoli in half (Figure 1G) (Nguyen, & Shultz, 2009). An angle exceeding 40° indicated an abnormal tibial torsion condition (Fouilleron et al., 2010).

The angles of the rearfoot and medial longitudinal arch were assessed using Jonson and Gross's methodology (Jonson, & Gross, 1997). The rearfoot angle was defined as the angle formed by the line dividing the calcaneus and the line dividing the lower one-third of the leg (Figure 1H). The measurement of the medial longitudinal arch angle involved determining the angle formed by a line from the medial malleolus to the navicular tuberosity, and another line connecting the navicular tuberosity to the medial side of the first metatarsal head (Figure 1I). Abnormal foot alignment was detected when the rearfoot angle exceeded 9° and the medial longitudinal arch angle fell below 134° (Jonson, & Gross, 1997).

Figure 1 Lower limb alignment measurement methods for: (A) limb length inequality; (B) pelvic angle; (C) femoral antetorsion angle; (D) quadriceps (Q) angle; (E) tibiofemoral angle; (F) genu recurvatum angle; (G) tibial torsion angle; (H) rearfoot angle and (I) medial longitudinal angle

3.3 Statistical Analysis

Descriptive statistics were used to analyze the characteristics of the individuals and the variables related to lower limb alignment. The mean and standard deviation (SD) were used to assess continuous data such as age, average working hours per day, and years working. The analysis included categorical factors such as sex, BMI, and lower limb malalignment features, which were assessed in terms of their frequency and percentage. Each independent variable was incorporated into a multiple logistic regression model using simple logistic regression analysis. The multiple logistic regression model included only variables with a P-value less than 0.25. A stepwise regression approach was employed to conduct a multiple logistic regression study. Variables with a P-value less than 0.05 were deemed statistically significant (Hosmer et al., 2013). The data were analyzed using the SPSS version 26 (IBM corporation, USA).

4. Results

4.1 Characteristics of Participants

The demographic characteristics of the study population are displayed in Table 1. The study had a higher proportion of male participants compared to females. The majority of participants (65.75%) had a BMI value within the normal range. The mean age of participants was 43 years with a standard deviation of 14.66. The average daily working hours for farmers were 7.81, with a standard deviation of 0.57. The average years of experience in rice farming were 24 years, with a standard deviation of 14.54.

4.2 Prevalence and risk factors of lower limb malalignment

Table 2 displays the prevalence of lower limb malalignment characteristics among rice farmers. The highest prevalence of malalignment was observed in the pelvic tilt angle (28.50%), followed by the femoral antetorsion angle, tibiofemoral angle, foot pronation, limb length inequality, genu recurvatum angle, Q angle, and the lowest prevalence was found in the tibial torsion angle.

Table 1 Characteristic of participants (N = 400)

Characteristic	N (%)	Mean ± SD	Min - Max
Sex			
Male	245 (61.25)		
Female	155 (38.75)		
Weight (kg)		55.68 ± 8.05	39.00 – 84.00
Height (m)		1.58 ± 0.07	1.42 – 1.76
BMI (kg/m^2)		22.44 ± 3.30	14.50 – 31.23
Under weight	46 (11.50)		
Normal	263 (65.75)		
Overweight	78 (19.50)		
Obese	13 (3.25)		
Age (years)		43.09 ±14.66	16.58 – 80.75
Daily working hours (hours/day)		7.81 ± 0.57	6.17 – 8.83
Experience (years)		24.00 ± 14.54	1.25 – 62.33

Table 2 Prevalence of lower limb malalignment in rice farmers

Characteristic	N	%
Pelvic tilt angle	114	28.50
Femoral antetorsion angle	96	24.00
Tibiofemoral angle	86	21.50
Foot pronation	71	17.75
Limb length inequality	57	14.25
Genu recurvatum angle	51	12.75
Q angle	30	7.50
Tibial torsion angle	24	6.00

Abbreviation: Q angle = quadriceps angle.

Table 3 Lower limb malalignment and related characteristics in univariate analysis

Characteristic	Limb length	Pelvic tilt angle	Femoral antetorsion	Q angle	Tibiofemoral angle	Genu recurvatum angle	Tibial torsion angle	Foot pronation
Sex	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Male								
Female	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
BMI	1.64 (0.94 – 2.89)*	1.16 (0.74 – 1.80)	1.47 (0.93 – 2.34)*	1.42 (0.67 – 3.00)	1.51 (0.93 – 2.44)*	1.23 (0.68 – 2.23)	1.14 (0.49 – 2.63)	1.66 (0.38 – 1.15)*
Normal								
Under weight	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Overweight	1.25 (0.06 – 1.09)*	1.94 (1.02 – 3.71)*	1.12 (0.55 – 2.29)	0.73 (0.209 – 2.53)	1.31 (0.62 – 2.75)	1.09 (0.46 – 2.63)	1.47 (0.47 – 4.61)	0.94 (0.41 – 2.15)
Obese	1.33 (0.69 – 2.56)	0.95 (0.53 – 1.69)	0.89 (0.48 – 1.62)	1.28 (0.06 – 1.19)*	1.63 (0.91 – 2.92)*	1.41 (0.16 – 1.10)*	0.83 (0.27 – 2.57)	0.81 (0.41 – 1.62)
Age	0.00	1.72 (0.55 – 5.44)	1.42 (0.42 – 4.74)	1.89 (0.39 – 9.09)	0.76 (0.16 – 3.52)	1.11 (0.24 – 5.21)	0.00	1.34 (0.36 – 5.07)
Daily working hours	1.72 (0.89 – 3.30) *	1.08 (0.62 – 1.87)	1.02 (0.57 – 1.84)	1.38 (0.57 – 3.34)	1.58 (0.29 – 1.17) *	1.82 (0.93 – 3.58) *	0.87 (0.29 – 2.64)	0.36 (0.73 – 2.54)
Experience	1.27 (0.72 – 2.24)	0.83 (0.53 – 1.31)	1.08 (0.67 – 1.72)	1.13 (0.53 – 2.43)	1.06 (0.65 – 1.74)	1.54 (0.28 – 1.04) *	0.68 (2.80 – 1.68)	1.49 (0.89 – 2.49) *
	1.37 (0.78 – 2.41)	1.25 (0.81 – 1.94)	1.17 (0.74 – 1.85)	1.09 (0.52 – 2.31)	0.88 (0.55 – 1.43)	3.58 (1.81 – 7.07) *	0.95 (0.42 – 2.16)	1.28 (0.77 – 2.15)

Note: *Significant at P < 0.25 level was included in the model of logistic regression.
Abbreviations: Q angle = quadriceps angle; OR = odds ratio; CI = confidence interval; BMI = body mass index.

Table 4. Lower limb malalignment and related characteristics in multivariate analysis

Characteristic	Limb length	Pelvic tilt angle	Femoral	Q angle	Tibiofemoral	Genu	Tibial torsion	Foot pronation
	OR (95% CI)	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**
Sex								
Female	1.66 (0.93 – 2.97)	1.16 (0.74 – 1.84)	1.47 (0.93 – 2.34)		1.55 (0.96 – 2.53)			1.73 (0.41 – 1.29)
BMI								
Under weight	0.25 (0.06 – 1.08)	1.94(1.02 – 3.71)*						
Overweight			0.83 (0.45 – 1.54)	0.28 (0.06 – 1.19)	1.55 (0.86 – 2.80)	1.76(0.14 – 0.98)*	0.84 (0.27 – 2.58)	0.90 (0.45 – 1.81)
Age	1.81 (0.93 – 3.54)				0.56 (0.28 – 1.12)	1.73 (0.87 – 3.44)	0.87 (0.29 – 2.64)	
Daily working hours				1.09 (0.50 – 2.35)		0.68 (0.34 – 1.37)		1.36 (0.79 – 2.33)
Experience						3.58(1.82 – 7.07)*	0.98 (0.43 – 2.24)	

Note: *Significant at the P-value < 0.05 level.
Abbreviations: Q angle = quadriceps angle; OR = odds ratio; CI = confidence interval; BMI = body mass index.

4.3 Relationship between Lower Limb Malalignment and Risk Factors

The univariate logistic regression analysis presents the crude odds ratio, while the multiple logistic regression analysis provides the adjusted odds ratio. Tables 3 and 4 display these results for the correlation between lower limb malalignment and risk variables. In the crude odds ratio analysis, Individuals with a body mass index (BMI) below 25 kg/m^2 had a significantly higher risk of developing an abnormal pelvic tilt angle, with a 1.94 times greater likelihood compared to those with a normal BMI (OR = 1.94, 95% CI: 1.02 – 3.71). In the adjusted odds ratio analysis, being overweight (BMI ≥ 25 kg/m2) significantly increased the likelihood of having genu recuvartum angle by 1.76 times compared to individuals with a normal weight (OR = 1.76, 95% CI: 0.14-0.98). The presence of an abnormal genu recuvartum angle was found to be significantly associated with farming experience. Each additional year of farming experience resulted in a 3.58-fold increase in the odds ratio for abnormal genu recurvatum angle (OR = 3.58, 95% CI: 1.82-7.07).

5. Discussion

This study is the first research that examines the prevalence and risk factors of lower limb abnormalities among rice farmers in the South Sulawesi Province. This study demonstrated that the highest prevalence of lower limb abnormalities, namely 29%, was seen in the pelvic tilt angle. Similarly, Puntumetakul et al., (2011) also reported that lower limb MSDs were more prevalent among rice farmers. The study also indicated that the hip was the joint with the highest prevalence in the lower limbs (41%), which was consistent with this research showing that pelvic tilt angle had the highest prevalence of abnormalities.

Lower limb malalignment was associated with individual factors. Body mass index (BMI) and length of employment were important risk factors for lower limb abnormalities. There was a significant correlation between pelvic tilt angle abnormalities and body mass index (BMI). Being underweight was a risk factor for the prevalence of pelvic tilt angle abnormalities. Farmers classified as underweight had a 1.94-fold higher risk of experiencing pelvic tilt angle abnormalities compared to farmers with normal body weight (OR = 1.94, 95% CI: 1.02 – 3.71). Individuals who are underweight may have reduced muscle mass and strength, particularly in the core and lower back muscles, which are essential for maintaining proper pelvic alignment. A lack of sufficient muscle support and stability around the pelvis could contribute to abnormal pelvic tilt angles. Additionally, decreased physical activity associated with underweight individuals could further exacerbate muscle weakness and postural imbalances, increasing the risk of musculoskeletal disorders, including abnormal pelvic tilt. Zawojska et al., (2019) discovered consistent findings in their study, namely that the pelvic tilt angle indicator decreased as BMI values increased. Therefore, respondents with a BMI < 18.5 kg/m2 had a higher risk of experiencing pelvic tilt angle abnormalities. Another study conducted by Pal et al., (2019) demonstrated that being underweight was a risk factor that might contribute to the prevalence of MSDs. Attar (2014) also found similar results, indicating that the risk of MSDs among underweight individuals was 2.66 times higher compared to respondents with normal body weight. This might occur due to the association between underweight and decreased muscle strength, as well as weakness and reduced physical activity (Artero et al., 2010).

Being overweight was a significant risk factor for lower limb abnormalities. Being overweight was a risk factor for developing genu recurvatum. Farmers classified as overweight were 1.76 times more likely to have genu recurvatum abnormality compared to farmers with normal body weight (OR = 1.76, 95% CI: 0.14-0.98). The study conducted by Viester et al., (2013) discovered a correlation between overweight and musculoskeletal symptoms, including increased mechanical demands and metabolic factors associated with overweight. The number of participants who were overweight in this study might clarify the differences. Currently, 23% of the participants were overweight and obese, but Puntumetakul et al., (2011) reported that the percentage of overweight participants in their study was 41%. El Shemy et al., (2019) reported similar findings in their study, namely that genu recurvatum abnormalities might occur due to the impact of being overweight. The findings of the study indicated that uncontrolled overweight might be a cause of the development of genu recurvatum deformity in the future, which might need intensive medical or surgical intervention. Excess body weight increased the risk of genu recurvatum deformity. This was because farmers who were overweight could exert pressure on the knees due to gravitational force and prolonged walking activities. Therefore, the heavier the farmer's body weight, the greater the burden on the knees.

Many years of farming experience were significantly associated with genu recurvatum deformity. This might be attributed to occupational risk factors. Agricultural activities with high ergonomic risk factors might increase chronic musculoskeletal symptoms in the lower limbs (Reid et al., 2010; Jaffar et al., 2011). Farmers who worked in risky environmental circumstances might find it difficult to maintain a neutral posture, and this might affect malalignment adaptation (Reid et al., 2010). Lower limb abnormalities might occur in long-term rice farmers due to high physical workloads associated with knee joints. This presentation was associated with degenerative joint disease, namely the risk factor of malalignment (Jaffar et al., 2011). Furthermore, previous research has shown that more experienced farmers report higher levels of pain in their lower limbs due to increased body instability during the push-off phase of walking on muddy terrain. The agricultural activities performed with high levels of lower limb activity might lead to fatigue and chronic musculoskeletal symptoms (Swangnetr et al., 2014). The findings of this study indicated that agricultural work experience was associated with genu recurvatum deformity. Farmers whose longer farming experience had 3.58 times higher risk of developing genu recurvatum compared to those with shorter farming experience (OR = 3.58, 95% CI: 1.82-7.07).

Based on the results of univariate analysis, it was known that some factors did not show a statistically significant association with lower limb abnormalities. The factor of gender did not have any influence on the prevalence of quadriceps angle, genu recurvatum, and tibial torsion abnormalities. Furthermore, working hours and duration of employment did not have any influence on limb length inequality, pelvic tilt angle, femoral antetorsion, tibiofemoral angle, and tibial torsion. The findings of Karukunchit et al., (2015) study indicated that gender had an influence on quadriceps angle and genu recurvatum abnormalities. The differences in the findings might be attributed to the percentage of female samples used. In the study, the proportion of female samples was 57.03%, however in the current study, the proportion of female samples is only 38.75% of the total sample. This might be the cause of the differences in the results obtained in this current study. In addition, the research conducted by Karukunchit et al., (2015) found similar results for the factors of working time and length of employment. The factors of working time and length of employment did not have any influence on limb length inequality, pelvic tilt angle, femoral antetorsion, tibiofemoral angle, and tibial torsion. The study identified several factors that could influence the obtained results, such as respondents with underlying conditions not reporting work absences and respondents alleviating pain caused by farming activities with analgesics or taking 2-3 breaks of 2-3 hours each day.

The univariate analysis results also revealed that female farmers were a risk factor for limb length inequality, femoral antetorsion, tibiofemoral angle, and foot pronation abnormalities. Female farmers were more susceptible to disorders due to their inherently lower strength compared to male farmers. In the study conducted by Kok et al., (2018), it was shown that women are positively correlated with a high level of musculoskeletal disorders. This occurred due to the physiological fact that women have lower muscular strength compared to men. Women had smaller muscle fibers compared to men, resulting in generally less muscle strength in women compared to men (Pinfildi et al., 2018).

As age increased, the risk of developing limb length discrepancy, tibiofemoral angle, and genu recurvatum in rice farmers also increased. The age range of the farmers who participated in this study was 17 to 80 years, with an average age of 43 years. Tarwaka (2010) stated that workers under the age of 35 had a low risk of experiencing MSDs. Age was directly proportional to the physical capacity up to certain limits. The peak of physical ability occurred at the age of 25. At the age of 50-60 years, there was a 25% decline in muscle strength and a 60% decline in sensory-motor abilities. The physical abilities of those beyond the age of 60 were only able to reach 25% of the work capacity of individuals below the age of 60 (Tarwaka et al., 2004). The research conducted by Stanton et al., (2004) elucidates that at the age of 30, degeneration occurred in the form of tissue damage, replacement of tissue by scar tissue, and reduction of fluid. This led to a decrease in the stability of bones and muscles. The older people became, the higher the risk of experiencing a decrease in bone elasticity, which triggered the onset of symptoms of MSDs.

The duration of work in a day was one of the risk factors for genu recurvatum and foot pronation abnormalities. The research findings indicated that rice farmers in the South Sulawesi Province spent an average of nearly 7 hours per day engaging in agricultural activities. The task required a significant amount of energy since it was performed manually on a daily basis. If this activity continued for years, it would undoubtedly increase the perceived risk of MSDs among farmers. The impact of repetitive strain from extended work hours or improper posture and biomechanics. These factors can cause repeated stress on the knee joints, weakening the ligaments and muscles that support the knee, thereby increasing the risk of developing genu recurvatum. The study conducted by Sani, & Widajati (2021) revealed a significant correlation between work duration and musculoskeletal disorder complaints among workers in the informal sector. The musculoskeletal complaints would increase if individual's working hours were longer. This would subsequently decrease work productivity, result in fatigue, and might lead to occupational diseases or work-related accidents. An individual's productivity would begin to decline after working for 4 hours. Therefore, resting and taking advantage of the chance to eat may help restore the body's condition. The designated break time is a 30-minute break after working for 4 consecutive hours (Aykin, 1996).

This study has several limitations. First, this research did not record or evaluate the prevalence of lower limb malalignment in the general population Therefore, the prevalence rates of lower limb abnormalities of current study were not compared to the general population. Further study should be carried out on the prevalence of lower limb abnormalities in the general population and other occupational groups. Comparing the prevalence of lower limb abnormalities between rice farmers and non-laborers would strengthen the findings of this research. Secondly, the findings of this study do not take into account other ergonomic risk factors, such as strength, movement, and repetition, which are also predicted to be associated with lower limb disorders. Future prospective epidemiological studies should be conducted to identify other risk factors for lower limb abnormalities in order to guide the development of health and occupational safety programs aimed at reducing and preventing lower limb abnormalities.

6. Conclusion

Overall, abnormal pelvic tilt angle was highly prevalent in rice farmers. years of experience, gender, and age were significant factors associated with lower limb malalignment. Research has shown that being underweight was a significant risk factor for experiencing an abnormal pelvic tilt angle. The primary risk factors for aberrant genu recuvartum angle were shown to be overweight and increased years of agricultural experience. Concurrently, being of the female gender was correlated to disparities in limb length, abnormal femoral antetorsion angle, abnormal tibiofemoral angle, and abnormal foot pronation. Older age was identified as a notable risk factor for limb length discrepancy, abnormal tibiofemoral angle, and abnormal genu recurvatum angle.

These results highlight the need for medical practitioners to consider the relationship between occupational activities and lower limb malalignment. Exploring preventive measures to reduce injury risk factors in rice farming could be beneficial. Providing health education on body weight management and discussing job-related factors such as employment duration could be beneficial.

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