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Research article

Risk Assessment of Rubber Tapping A Case Study: Pa Phayom District, Phatthalung Province, Thailand

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Abstract: This cross-sectional study investigated the risks of rubber tapping among rubber farmers in Pa Phayom District, Phatthalung Province, Thailand, utilizing the EART (Ergonomic Risk Assessment Tool for Rubber Tappers) and RULA (Rapid Upper Limb Assessment) approaches. Purposive sampling was utilized to randomly choose 154 rubber farmers, aged 20 to 60 to serve as the sample group. They met the inclusion requirements of being in excellent health, being able to read and write Thai fluently, not having a history of back discomfort or injuries, and having at least a year of experience tapping rubber. The results showed that the mean RTL value was 415, SD = 182, while the mean RTI value was 1.77, SD = 1.35, with Min = 0.31 and Max = 8.64. The RULA analysis gave scores ranging from 2 to 7 as acceptable risk to high risk, suggesting that rubber farmers should improve their working posture or reduce factors that affect risk to ensure better health outcomes. It was discovered that the EART and RULA can be used as an assessment method to identify ergonomic risk problems in rubber tapping operation. It was suggested that the rubber tapping operation needs to be improved, re-evaluated, and implemented immediately.

Keywords: Risk assessment; EART; Rubber tappers; Ergonomics

1. Introduction

Rubber is an economic crop grown throughout Thailand, especially in the southern region, where arable land comprises 60% [1]. Rubber tapping in Thailand is performed manually, and rubber farmers suffer from aches, pains, and musculoskeletal injuries [2] because the work involves repetitive body movements and ergonomics. A survey of rubber farmers recorded pain in the lower back (77.6%), hands and wrists (37.2%), upper back pain (34.4%), knee pain (31.6%), and also pain in other parts of the body [3]. A model was developed for risk assessment to prevent and reduce injuries or muscle pain from work. The working posture consisted of two main factors: 1) risk factors for abnormalities in the skeletal and muscular system, such as repetitive work, posture, exertion or weight bearing and resting time, and 2) personal factors involving various parts of the body such as hands, torso, neck, arms, legs, and knees. Commonly used posture assessments such as the RULA [4], REBA [5], and OWAS [6] were used to assess symptom risk factors. Abnormalities were found in the skeletal and muscular systems when the RULA assessment and the MSD survey were applied to rubber tapping [7]. Injuries occurred in almost

every part of the body, with the highest number recorded in the lower back. Ergonomic risks are used explicitly for rubber tapping work. This research focused on the ergonomic risk assessment and work posture of rubber tappers. Ergonomic principles were used to reduce work risks such as fatigue and work-related injuries and improve the health of rubber tappers.

2. Materials and Methods

An Ergonomic Risk Assessment Tool for Rubber Tappers (EART) was used together with a work posture assessment model for Rapid Upper Limb Assessment (RULA). The sample group of 154 rubber farmers in Pa Phayom District, Phatthalung Province, aged 20 to 60, was randomly selected by purposive sampling. They had 1 year or more experience in tapping rubber with the following inclusion criteria: perfect health, ability to read and write Thai well, and no history of injury or back pain. Exclusion criteria included people who were unable to participate throughout the whole length of the project, had a history of surgery on the shoulder, arm, hand, torso, abdomen, back, hip, or thigh, and suffered from congenital diseases related to bones and muscles. In general, the gesture of rubber tapping is shown in Figure 1.

2.1 Ethics approval

This study was approved by the Ethics Committee of Thaksin University (COA No. TSU 2024_070 REC No.0174). The purpose of the study was explained to all the participants, who signed informed consent forms before data collection.

2.2 Sample size

A survey was conducted among rubber farmers in Pa Phayom District, Phatthalung Province. The sample size was calculated using the Krejecie and Morgan equation (Krejecie & Morgan, 1970)[8]. The study population numbered 256 people, and the sample size was 154, calculated at a significance level of 0.05.

2.3 Statistical analysis

This research used descriptive statistics as percentage and mean values. Standard significance was evaluated at <0.05 according to the RULA and EART methods.

Figure 1. Rubber tapping gestures of a rubber farmer (Shoulder level)

2.4 RULA Method

RULA is widely used for work posture risk assessment using different body parts, namely the neck, arms, legs, and trunk. The RULA assessment provides total points on a scale from 1 to 7, with risk working postures shown in Table 1.

Table 1. Risk level of RULA

Risk categories	RULA score	Risk level	Action
1	1-2	Negligible	Acceptable posture if it is not repeated for a more extended period
2	3-4	Low	Further investigation and change may be needed in the future
3	5-6	Medium	Investigation posture and chafe needed soon
4	7	High	Investigation posture and chafe needed immediate

The RULA technique evaluates working posture according to ergonomic principles and assigns scores to different body parts. The upper arm, lower arm, wrist, and wrist twist scores are given in Table A, while neck, trunk, and leg scores are included in Table B, with the sum of muscle and force scores shown in Table C. The final RULA score assesses the posture risks of rubber tappers, as shown in Figure 2.

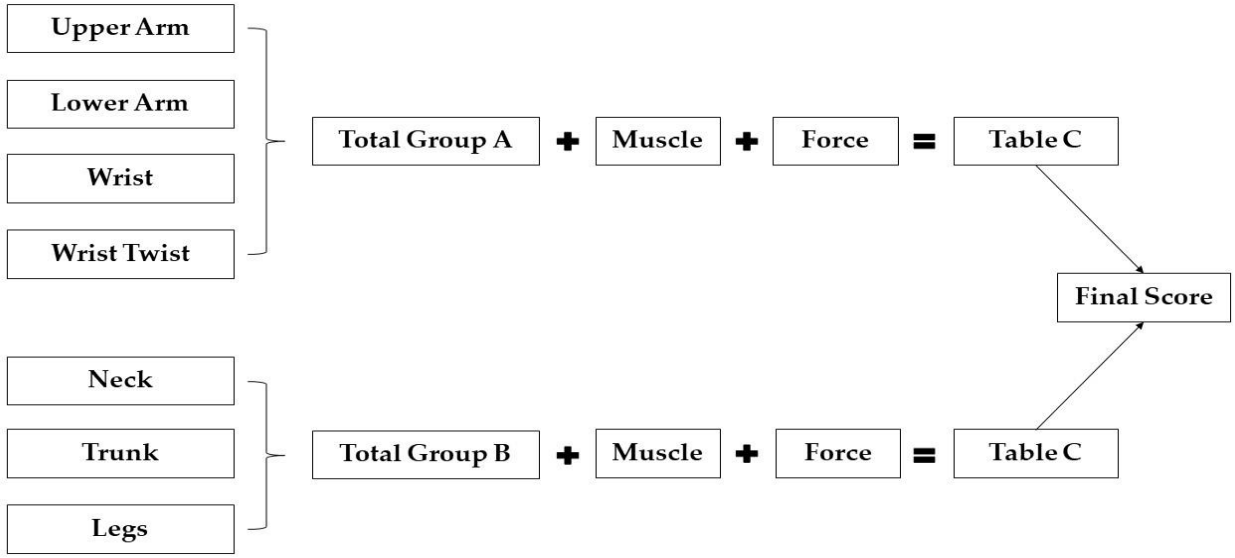

Figure 2. Body parts analyzed by RULA (Adapted from McAtamny and Corlett,1993)

2.5 EART Method

The ergonomic risk assessment tool for rubber tappers (EART)[9] was determined by the rubber tapping risk index as the ratio of the number of rubber trees tapped per day (RTD) divided by the recommended number of rubber trees for tapping per day (RTL), as shown Equation 1:

$$EART = RTD/RTL \quad (1)$$

The recommended number of rubber trees for tapping per day (RTL) was calculated from Equation 2, and the RTL value was substituted in Equation 1 to find the risk index for tapping as:

$$RTL = LC \times HM \times WM \times SM \quad (2)$$

when
HM = Tapping height multiplier factor
WM = Working area multiplier factor
SM = Stroke multiplier factor
LC = Load constant (Set at 700 trees per day for tapping system 1/3)

3. Criteria and procedures

The criteria and processes used to decide and handle the numerous variables involved in computing the rubber-tapping risk index are briefly illustrated and discussed. The styles used in this paper are:

2.5.1 Tapping height multiplier factor (HM)

Analysis of the height level of rubber tapping compared to the body was divided into four levels: 1) above the shoulder, 2) waist-shoulder, 3) knee-waist, and 4) below the knee. Para rubber tapping above shoulder level was assigned a factor of 0.93, rubber tapping at the waist to shoulder level was assigned a factor of 1, rubber tapping at the knee to waist level was assigned a factor of 0.44, and rubber tapping below the knee was assigned a factor of 0.60, as shown in Table 2.

Table 2. Tapping height multiplier factor (HM)

No.	tapping level	Multiplier factor
1	Above the shoulder	0.93
2	Waist –shoulder	1
3	Knee-waist	0.44
4	Below the knee*	0.60

* At a level below the knees, use a kneeling position.

2.5.2 *Working area multiplier factor (WM)*

A survey of rubber plantations and results of rubber tapping experiments suggested dividing the inclination into four levels: 1) 0–10°, 2) 11–20°, 3) 21–30°, and 4) >30° to determine the inclination factor of the work area. Rubber tapping in the 0–10° area used a factor equal to 1. Rubber tapping in the 11–20° area used a factor equal to 0.71, rubber tapping in the area 21–30° used a factor equal to 0.52, and rubber tapping in the inclination area >30° used a factor of 0.43, as shown in Table 3.

Table 3. Working area multiplier factor (WM)

No.	Degree	Multiplier factor
1	0-10°	1
2	11-20°	0.71
3	21-30°	0.52
4	>30°	0.43

2.5.3 Stroke multiplier factor (SM)

A survey of the rubber tapping stroke made by rubber tappers and the experimental results of rubber tapping defined the stroke interval into four ranges: 1) 10–20 times per tap, the rubber tap has a multiplier

value of 1, 2) between 21 and 30 times per tap, a multiplier of 0.80, 3) between 31 and 40 times per tap, a multiplier of 0.45, and 4) more than 40 times per tap, a multiplier value equal to 0.25, as shown in Table 4.

Table 4. Stroke multiplier factor (SM)

No.	Stroke	Multiplier factor
1	10-20	1
2	21-30	0.80
3	31-40	0.45
4	>40	0.25

2.5.4 Interpretation

The analysis results were divided into four levels to determine the rubber tapping evaluation criteria. An index value of less than or equal to 1, meaning no risk, indicated that rubber tapping was acceptable. An index value between 1.1 and 2.5, meaning low risk, suggested that rubber tapping was acceptable but may require additional monitoring assessment. An index between 2.6 and 3.5, meaning moderate risk, indicated that the rubber tapping operation must be improved and re-evaluated. An index value greater than or equal to 3.6, meaning high risk, that rubber tapping was unacceptable and must be improved immediately, as shown in Table 5.

Table 5. Risk levels in the assessment of rubber tappers

Risk categories	Exposure index	Risk level	Action
1	≤ 1	No risk	The tapping of rubber was acceptable.
2	1.1-2.5	Low risk	The tapping of rubber was acceptable but may require additional monitoring assessment.
3	2.6-3.5	Moderate risk	The rubber tapping operation must be improved and re-evaluated.
4	≥ 3.6	High risk	The tapping of rubber was unacceptable and must be improved immediately.

3. Results and Discussion

3.1 Demographic data

After collecting data from a sample of 154 people, it was found that the participants were 80 males and 74 females.. The mean age was 43.95 years. In addition, the mean of rubber tapping per day was 3.75 hr., as shown in Table 6.

Table 6. Demographic characteristics of the Rubber Tappers (n = 154)

Demographics	Frequency	Percentage
Sex		
Female	74	48.10
Male	80	51.90
Age (mean ± SD) yrs. = 43.95 ± 10.77		
Rubber tapping experience (mean ± SD) (yrs.) = 13.68 ± 8.87		
Rubber tapping per day (mean ± SD) (hr.) = 3.75 ± 1.52		

3.2 EART Method analysis

The results of the EART analysis found that tapping height multiplier factor (HM) had a mean of 0.68, SD = 0.24. The working area multiplier factor (WM) had a mean of 0.94, SD = 0.15. Stroke multiplier factor (SM) had a mean of 0.91, SD = 0.14, and when considering RTL values, it was found that there was a mean of 415, SD = 182. For the analysis of RTI values, it was found that there was a mean of 1.77 and an SD of 1.35. It was found that the value of Min. = 0.31 and the value of Max. = 8.64, which shows that farmers' rubber tapping has low-to-high risk, as shown in Table 7.

Table 7. The distribution of the multiplier factor of EART

	WM	HM	SM	RTL	RTI
Mean	.94	.68	.91	415	1.77
Std. Deviation	.15	.24	.14	182	1.35
Minimum	.52	.44	.25	98	.31
Maximum	2.00	1.00	1.00	1120	8.64

3.3 RULA Method analysis

The results of the RULA analysis gave score levels 2 (28.6%), 6 (24.0%), 3 (17.5%), 4 (16.2%), 5 (8.4%), and 7 (5.2%). Rubber farmers were at low risk, accounting for 44%, as shown in Table 8. The majority of the time, the RULA score was found to be 2, indicating that rubber tapping poses no risks. On the other hand, it was discovered that 37 individuals in the sample obtained a RULA score of 6, suggesting that they were at moderate risk and required quick changes to their work posture.

Table 8. The distribution of the RULA score

RULA score	Frequency	Percent
2	44	28.6
3	27	17.5
4	25	16.2
5	13	8.4
6	37	24.0
7	8	5.2

3.4 Risk categories by the EART and RULA methods

The risk categories for EART and RULA are shown in Figure 3. The EART assessed were 50(32.5%), 78(50.6%), 12(7.8%), and 14(9.1%) respectively, whereas 1, 2, 3 and 4. The RULA assessed were 44(28.6%), 52(33.8%), 50(32.5%), and 8(5.2%), respectively, which indicate that need to change posture immediately.

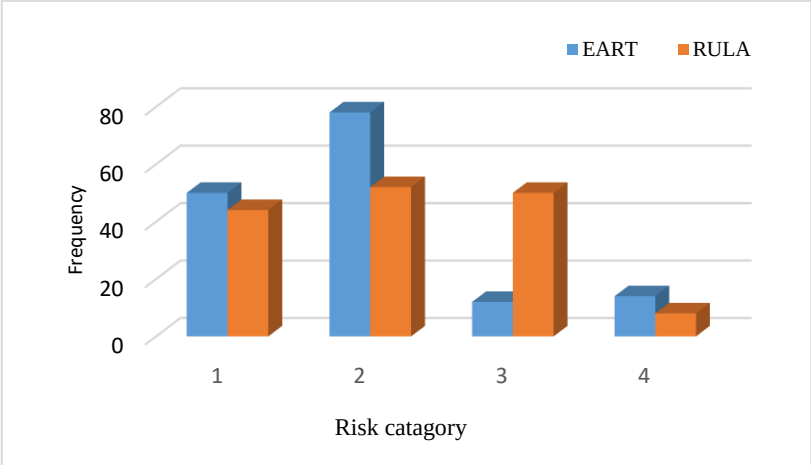

Figure 3. Distribution of risk categories by EART and RULA method

3.5 Mann-Whitney Test

Data on the estimated determined statistical significance of the differences between the crossing variables and the z-values are shown in Figure 4. The Z-value in this study was -2.371. The statistical significance of the differences, approximately calculated (p=0.018), was demonstrated to be the same. Therefore, statistically significant differences were found between the risk evaluation of the EART and RULA approaches in the research results. Comparison of risk assessment by EART and RULA methods

	Rubber tapping assessment
Mann-Whitney U	10112.000
Wilcoxon W	22047.000
Z	-2.371
Asymp. Sig. (2-tailed)	.018

3a. Grouping Variable: Risk assessment

Figure 4. Mann-Whitney Test analysis

4. Discussion

Risk assessment for rubber farmers was performed using the EART and RULA methods. The RULA analysis gave scores ranging from 2 to 7, meaning acceptable risk to high risk [10-11], and offered suggestions to change working posture[12]. However, rubber tapping is a specific gesture that depends on the rubber-tapping knife and the characteristics of the rubber tree, making it quite difficult to change the rubber-tapping posture. Consequently, using an ergonomic rubber tapping knife will be advantageous and lower the risk of tapping rubber [13]. The EART analysis gave scores ranging from 0.38 to 8.64, meaning that rubber farmers were exposed to no risk to high risk. Following the EART method, rubber trees were recommended for daily tapping amounts. To prevent the risk of working beyond the limits of the body from all three factors, if the results of the analysis reveal that the high level of rubber tapping is a risk, it is recommended that the incision be rubber-tapped using a double tapping system (Double Cut Alternative: DCA) [14-15] by alternating cuts on the rubber at the high and low tapping levels. As for the risk from the inclination of the area or rubber plantation, this research recommends that rubber farmers adjust the inclination of the area to be reduced or as close to 0° as possible. Furthermore, safety risks and working space must also be considered [16-17].

5. Conclusions

The study found that risk assessment for rubber farmers was done using the EART and RULA methods. Comparing the results, it was found that the RULA method focused on evaluating the hands, arms, legs, and body in the rubber-tapping posture. Most rubber farmers are at medium to high risk, and adjusting the posture for tapping rubber according to ergonomic principles will help reduce the risk of tapping rubber. In the EART method, the emphasis was on evaluating the multiplier factor from the rubber-tapping process. Most farmers are at risk, from low risk to high risk. However, due to the EART method, appropriate rubber trees will be recommended for tapping per day. Therefore, rubber farmers can improve the tapping factors, such as tapping height, working area, and stroke, when tapping rubber trees.

Suggestions

Future studies can evaluate the degree of complementarity of the EART and RULA methods based on inferential statistics. This research can be extended using Nordic Musculoskeletal. A questionnaire will link musculoskeletal illnesses with EART and RULA results.

Limitations

This research used a jabong knife to cut the rubber tree. The tapping system is 1/3 of the trunk. Therefore, you should also study other types of rubber-tapping knives and tapping systems. There should be research in various rubber plantation areas in the future.

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