



Ergonomic Assessment of Women Tea Leaf Pluckers of Small Garden in Assam

Pramod Chandra Dihingia¹ • Laishram Kanta Singh² • S. Roma Devi^{3*} • Lydia Zimik² • Chitrasen Lairenjam¹ • Wungshim Zimik¹ • Chetan Khobragade⁴

¹Department of Agricultural Engineering and Technology, School of Engineering and Technology, Nagaland University, Dimapur-797112, Nagaland, India

²ICAR-KVK Imphal West, ICAR Research Complex for NEH Region, Manipur Centre, Lamphelpat, Manipur-795004, India

³ICAR-KVK Churachandpur, ICAR Research Complex for NEH Region, Manipur Centre, Lamphelpat, Manipur-795004, India

⁴Department of Agricultural Engineering, Trigunasen School of Technology, Assam University, Silchar-788 011, Assam, India

ARTICLE INFO

Article history:

Received:04thOctober 2021

Revision Received:20thOctober 2021

Accepted:26thNovember 2021

Key words:Energy, Tea leaf Plucking, Cardiovascular, Stress, Fatigue, Musculoskeletal.

ABSTRACT

The study was conducted to evaluate the ergonomics of women tea leaf pluckers in Biswanath District of Assam, North East India. In the present study, the average energy cost of tea leaf plucking was 8.94 kJ/min. The cardiovascular stress index (CSI) and physiological cost of work (PCW) of the pluckers were observed as 33.5 and 32.1 beats/min, respectively. Oxygen consumption rates (OCR) of subjects during plucking were 0.59 l/min. The individual feeling of the subject was collected for assessment of workload. The subjects reported the scour of overall discomfort of tea leaf plucking on the 5-point RPE scale from 2.3 to 3.3, which implies the tea leaf plucking operation is a "light" to "moderately heavy" job. Since, tea leaf plucking operation is moderately heavy job, it is advocated for scientific intervention to upgrade the work organization by designing a work-rest schedule to reduce workload as well as improve efficiency and output of women tea leaf pluckers of small garden in Assam.

1. Introduction

The aromatic non-alcoholic beverage tea (*Camellia Sinensis*) is the most refreshing and popular in the World. India is occupying the second position as far as tea production is concerned and the fourth-largest exporter of tea in the World. Assam is India's largest tea-producing state. There are more than 803 numbers of large and medium-size tea gardens spreading in Assam. During the year 2020, Assam alone produces 618.20 million kg of processed tea (www.hindustantimes.com). It accounts for more than half of India's total tea production in Assam; some tea gardens are operated by Assam Tea Corporation Limited and some are owned by Private Companies. Besides large and medium-sized tea gardens, about 68,465 numbers of small tea growers with 3 to 15 acres of the cultivable area in Brahmaputra valley produce tea and contribute more than 20% of the state's total tea production per year (Anonymous, 2020). They engage women pluckers as seasonal labour according to their needs.

Tea leaf plucking is done by hand in India, and women make up more than half of the overall workforce in the tea plantation business in Assam (Duara and Mallick, 2019). Tea plucking operation is monotonous, done in standing and tilting towards frontward. Due to this nature of work, the health condition of the workers is affected. Bhattacharyya and Chakrabarti (2012) revealed that still age-old technologies are used in tea gardens. Though women are the key workforce in tea plucking, they are ignored by the authority. Generally, the authority of private tea garden uses to engage the pluckers on a contractual basis assigning fix target of work for the whole day. Therefore, the pluckers attempt to complete their target of plucking to satisfy the authority ignoring their health. The plucker's workload and time are exceeded, resulting in health issues among the workers and, resulted low production. Scientific measures such as reduction of load, enhanced work organization with job rotation, and

*Corresponding author: drsroma@gmail.com

adequate rest during work were recommended in research to alleviate musculoskeletal problems in tea leaf pluckers (Dewangan and Dihingia, 2011). They proposed that workers' working conditions and methods be changed at regular intervals to relieve them of physiological strain and exhaustion. If the productivity of workers and the farm needs to be increased, a safe, comfortable, and healthy working environment for pluckers is to be created. In these circumstances, it becomes prime importance to study the physiological and energy cost of tea leaf plucker to advocate further an organized work schedule.

In light of the preceding, a study was conducted to assess the various ergonomics connected with the plucking of tea leaves in private small tea gardens and the overall discomfort rating of women tea leaf pluckers in Assam.

2. Materials and Methods

2.1 Study Area

The study was conducted during May 2019 at M/s Saikia Tea Garden, Biswanath district of Assam, in the peak season of

tea leaf production. This is a small private tea garden with 8 acres of cultivable area. The experimental site is located at 26°84' N and 93°13' E and 86.7 m altitude situated at north east India (Fig. 1). The average mean temperature and annual rainfall at the site are 22.6°C and 1989.4 mm, respectively.

2.2 Selection of Subjects

The experiment was conducted with six female subjects. The subjects had no physical ailment, cardiovascular problem, deformity, and chronic illness. They had a minimum of 5 years of experience in the plucking of tea leaves. The physical characteristics of the participant subjects are given in Table 1. The range and mean and standard deviation of the age of the subjects were 43 to 50 years and 46.8±2.8 years, respectively. The range of stature of the subjects was 135 to 147 cm, and the mean and standard deviation of stature were 142.5±4.5 cm, respectively. The range of body weight of the subjects was 31 to 45 kg; however, the mean and standard deviation of body weight was 39.1±4.8 kg.

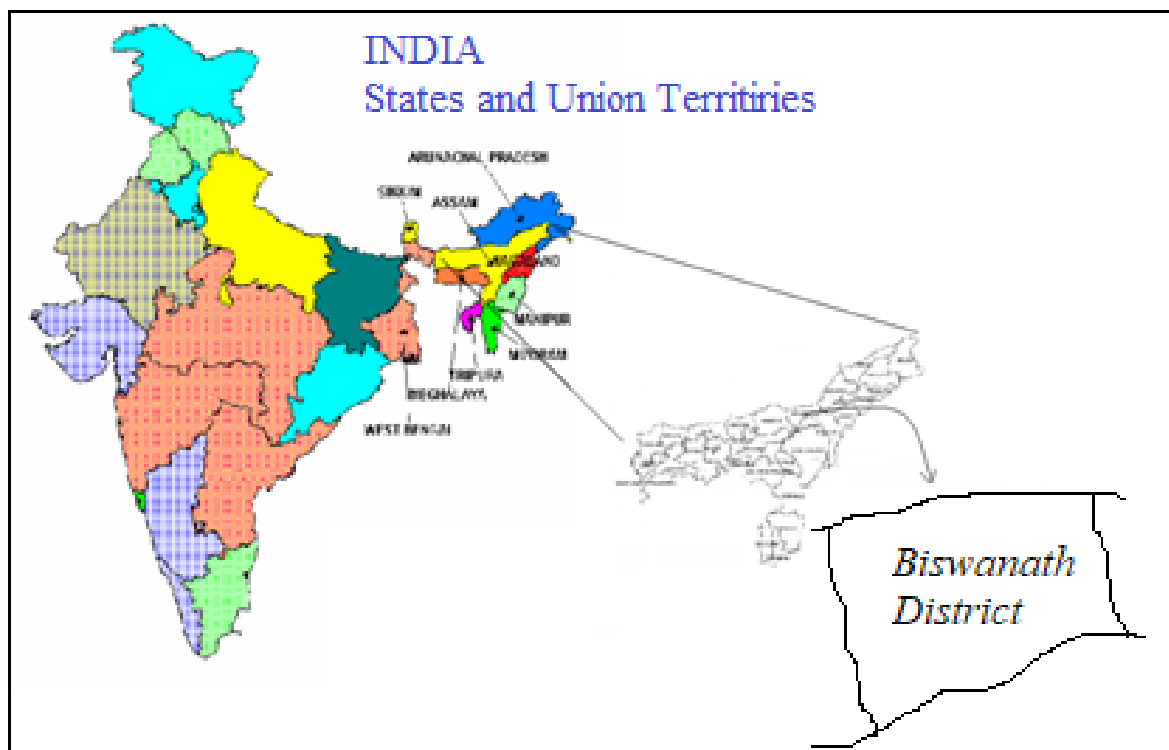


Figure 1. Study area map.

Table1.Physical characteristics of the participant subjects

Subject	Age (years)	Stature (cm)	Bodyweight (kg)
S1	43	143	38.5
S2	44	140	40.0
S3	50	135	31.0
S4	47	142	37.5
S5	48	141	42.5
S6	49	147	45.0
Mean	46.8	142.5	39.1
SD	2.8	4.5	4.8

SD: Standard deviation



Figure 2. Plucking tea leaf wearing Heart Rate Monitor Set.

2.3 Experimental Design and Procedure

In small private tea garden tea leaf pluckers are engaged for 7 hours of work and allow for 1 hour rest during the 8-hour shift. The total work and rest periods were arranged in four work-rest schedules as per the procedure designed by Tiwari and Gite (2005). In the study a randomized block design was used to organize the experiment. The replication consisted of six respondent subjects, bringing the total number of subjects in the study to 24. All the subjects were asked to report at the worksite at 8.00 a.m. morning, and before the start of the first

schedule, the subjects were asked to go for 15 minutes of initial rest up to 8.15 a.m., and further asked about discomfort in their body. The subjects' heartbeats were recorded using a Heart Rate Monitor Set (transmitter, receiver, and interface) during plucking. Heart rate data was used to evaluate the ergonomics of the subjects. A coworker attached the transmitter of the heart rate monitor to the subject's chest and the receiver to the subject's right-hand wrist (Fig. 2).

The first schedule comprised of two work bouts, each of 90 minutes duration, which was started at 8.15 a.m. and ended at 11.25 a.m. There was 10 minutes break between the first and second work bout of the first work schedule. Before the start of the second work schedule, the subjects were asked to go for another 15 minutes break. The second schedule was constituted by one work bout of 75 minutes duration. It was started at 11.40 am and ended at 12.55 p.m., and then subjects were asked to go for a lunch break for 30 minutes up to 1.25 p.m. The third schedule also comprised of 90 minutes duration with one work bout which was started at 1.25 p.m. and ended at 2.55 p.m. Then again 5 minutes rest allowance was given to the subjects before the start of the last work schedule. The last work schedule of the experiment was started at 3.00 p.m. and ended at 4.00 p.m. After completion of four work schedules, the subjects were asked to stop plucking and go for the final rest of 15 minutes; thus, the field experiment was ended at 4.00 p.m. Heart rate data was collected for a whole 8-hour period from 8 a.m. to 4 p.m.

2.4 Ergonomics Evaluation

2.4.1 Energy Cost

The energy expenditure during the execution of work is a physiological measurement of the subject. It indicates the level of physical fatigue on work performance. The subjects' energy cost and physiological cost of work during plucking operation were evaluated using heart rate data as proposed by Verghese et al. (1994).

$$EC = 0.159 * AHR - 8.72 \quad (1)$$

where, EC = Energy cost (kJ/min), and HR = Average heart rate (beats/min).

2.4.2 Physiological Cost of Work

The physiological cost of the plucking operation was calculated using the average working heart rate and resting heart rate of the subjects with the duration of plucking based on the following relationship.

$$PCW = \frac{TCCW}{TTW} \quad (2)$$

$$TCCW = CCW + CCR \quad (3)$$

$$CCW = AHR * TTW \quad (4)$$

$$CCR = [\text{Average recovery heart rate} - \text{Average resting heart rate}] * \text{Duration of recovery} \quad (5)$$

$$AHR = [\text{Average working heart rate} - \text{Average resting heart rate}] \quad (6)$$

where, PCW= Physiological cost of work, TCCW = Total cardiac cost of work, TTW = Total time of work, CCW = Cardiac cost of work, and CCR =Cardiac cost of recovery.

2.4.3 Cardiovascular Stress Index (CSI)

A criterion to evaluate stress on the cardiovascular system of the tea leaf pluckers was adopted as suggested by Tritset al. (1993) as given below.

$$CSI = \frac{100' [HRW - HRR]}{HR_{max} - HR_{res}} \quad (7)$$

where, HRW = Heart rate during work, HRR = Heart rate during rest, HR_{max} = Heart rate maximum [Heart rate maximum = 220 – Age (years)], and HR_{res} = Heart rate at rest.

2.4.4 Oxygen Consumption Rate (OCR)

The oxygen consumption rate (OCR) of subjects was estimated based on heart rate with the help of a broad equation as given by Singh et al. (2008) and expressed in liter per min. The equation is given as,

$$OCR = 0.0114X - 0.68 \quad (8)$$

where, X = Heart rate of the participant subject in beats/min.

2.5 Rating of Perceived Exertion (RPE)

Plucking of the leaf is monotonous work performed at unnatural body posture. Therefore, at the end of each work schedule, the subjects were solicited to specify their exertion/discomfort on a 5-point RPE scale developed by Borg (1982). The body parts discomfort intensity according to the RPE scale is 1- 'Very light', 2- 'Light', 3- 'Moderately heavy', 4 – 'Heavy', and 5 – 'Very heavy'.

3. RESULTS AND DISCUSSIONS

3.1 Ergonomics Evaluation

The heart rate data recorded during initial rest, work, lunch time, and recovery time are presented in Table 2. The working heart rate of four work schedules is given in Fig. 3. The average value of the recorded heart rate data was used to interpret physiological responses such as energy cost, total cardiac cost of work, physiological cost of work, cardiovascular stress index, and oxygen consumption rate of the subjects.

Table 2. Heart rate data of the subjects in four work schedules

Sl. No.	HR _{initial} , beats/min	Working heart rate (HR _{work}), beats/min					HR _{recovery} , beats/min
		1 st WS	2 nd WS	3 rd WS	4 th WS	Avg.	
S1	80	115.4	116.3	111.1	101.1	109.2	81.9
S2	80.1	117.3	115.1	108.3	101.9	110.7	84.2
S3	78.2	115.6	117.1	115.1	99.4	111.8	80.9
S4	79.6	117.3	114.5	109.9	101	110.7	82.4
S5	78.9	116.8	116.5	112.2	102.1	111.8	79.4
S6	81.7	118.5	116.1	114.1	100	112.2	83.1
Mean	79.8	116.8	115.9	111.7	100.9	111.1	82.0
SD	1.2	1.2	1.1	2.8	1.1	1.1	1.7

SD: Standard deviation

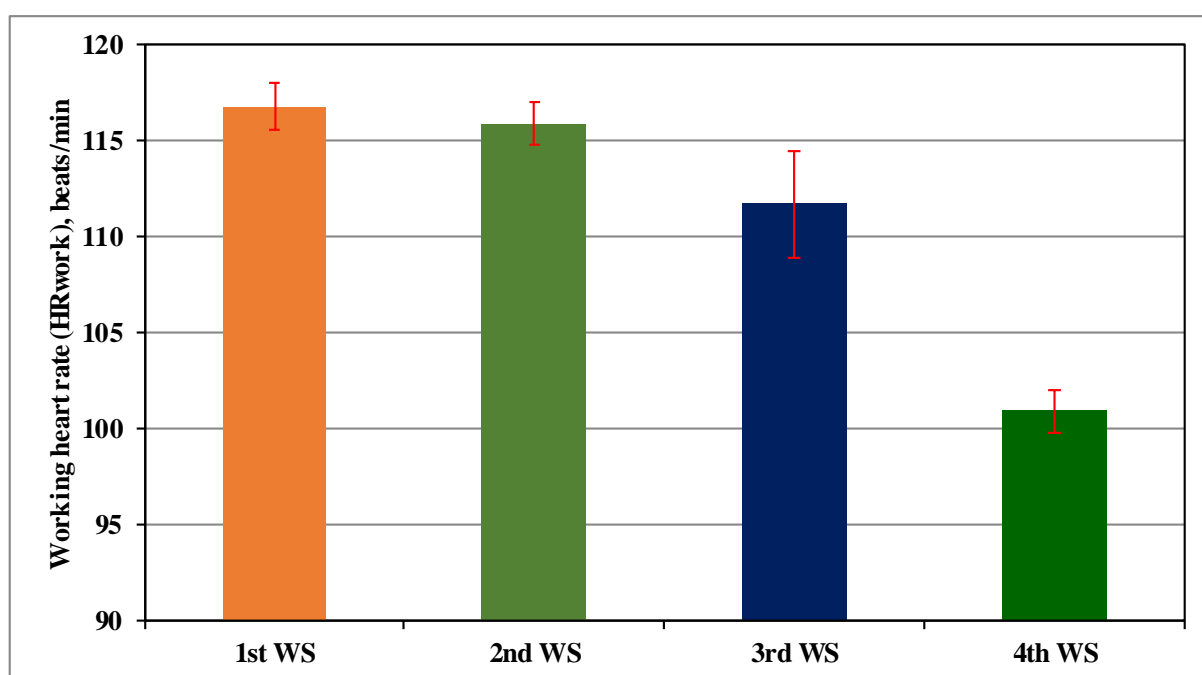


Figure 3. Working heart rate four work schedules.

3.1.1 Energy Cost

The energy cost of the subjects during plucking was computed by substituting the value of the average heart rate obtained during plucking in equation (1) and found to be 8.94kJ/min. Almost similar findings of peak energy expenditure during plucking of the leaf (8.52kJ/min) for the age group of 35 to 40 years were reported by Kishtwaria et al. (2004)

3.1.2 Physiological Cost of Work

From the heart rate data of the subjects recorded in four work schedules, it was pragmatic that the mean and standard deviation of heart rate in rest and work were 79.8±1.2 beats/min and 111.1±1.1, respectively. However, work schedule-wise, the mean and standard deviation of heart rate

was found to be 116.8±1.2, 115.9±1.1, 111.7±2.8, and 100.9±1.1 in the first, second, third, and fourth work schedule, respectively. Due to the execution of work, a change in heart rate from the resting state took place, which was observed as 31.3 beats/min. Taking into account the above parameters, the mean and standard deviation of recovery heart rate was evaluated as 82.0±1.7 beats/min. In the entire experiment, the peak heart rate values during work were found to be 118.5 beats/min. The average data of CCW and CCR were used to evaluate the physiological cost of work (PCW).

In the present study, the physiological cost of work (PCW) was computed using equation (2) and found to be 32.1 beats/min. However, it was found quite high as compared to the outcome of Dihingia et al. (2020) which was revealed as 27.27 beats/min.

This might be due to prolong and insufficient work schedule. The plucker had to roam from one plot to another during plucking by crossing 80 cm to 100 cm width drain in the field. Furthermore, the plucker had to carry around 20 kg of plucked leaf to the weighing point. That might be another cause of the higher physiological cost of work (PCW).

3.1.3 Cardiovascular Stress Index (CSI)

The cardiovascular stress index (CSI) developed due to the workers' occupation was evaluated by substituting the value of average resting heart, working heart rate, and maximum heart rate obtained at the time of plucking in equation (3) and found to be 33.5. However, it was lesser than the study's outcome on the physiological workload of hill-farm women of Meghalaya state of India implicated in firewood collection as reported by Borah S. (2015). This might be due to the different nature of work.

3.1.4 Oxygen Consumption Rate

The subjects' oxygen consumption rate (OCR) during plucking was computed from the heart rate of the subjects using equation (4) and was found to be 0.59 l/min. An almost similar result of oxygen consumption rate (OCR) of 0.54 l/min was reported by Dihingia et al. (2020) while experimented with Ergonomic evaluation of tea leaf plucking in Assam.

3.2 Overall Discomfort Rating of Tea Leaf Pluckers

The overall discomfort ratings of the subjects were measured on the 5-point RPE scale during tea leaf plucking and presented in Table 3. A maximum average overall discomfort rating of 3.33 was observed with the first and third schedules followed by the second schedule (3.2) and fourth schedules (2.3).

Table 3. Overall discomforts rating of different subjects

Subject	Work Schedules and discomfort rating			
	First	Second	Third	Fourth
S1	3.0	3.0	3.0	2.0
S2	4.0	3.0	4.0	2.0
S3	3.0	4.0	3.0	3.0
S4	3.0	4.0	3.0	2.0
S5	4.0	2.0	4.0	3.0
S6	3.0	3.0	3.0	2.0
Mean	3.3	3.2	3.3	2.3
SD	0.5	0.8	0.5	0.5

SD: Standard deviation

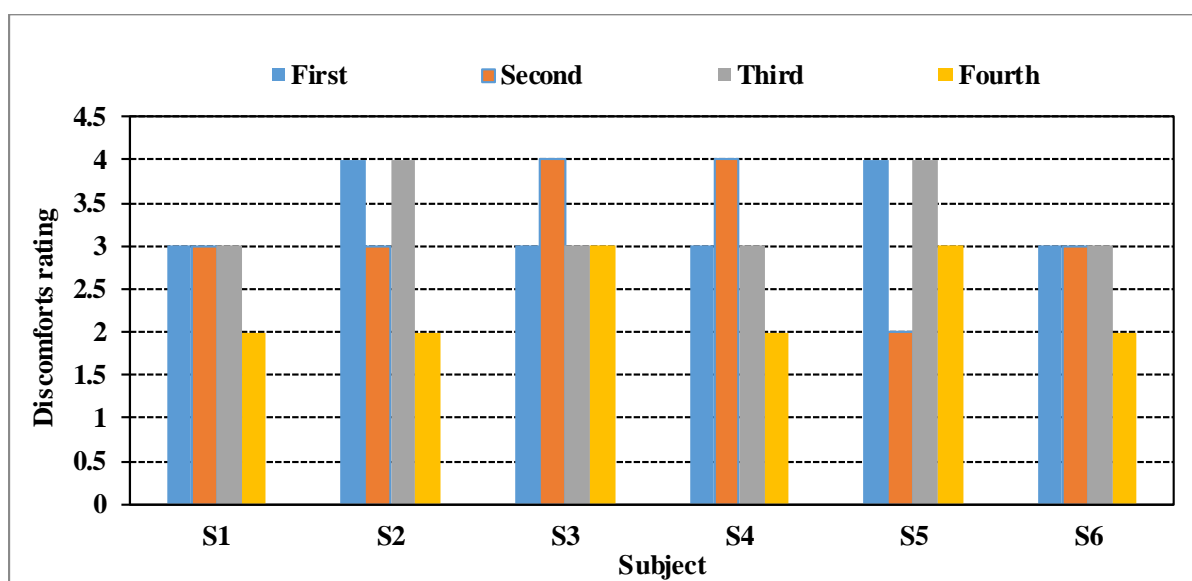


Figure 4. Graphical representation of discomfort rating.

From Table 3, it was evident that the average overall discomfort score varied from 2.3 to 3.3 during tea leaf plucking. The overall discomfort rating of all the subjects is presented graphically in Fig. 4. Based on the average discomfort rating, it may be concluded that the tea leaf plucking activity is a "light" to "moderately heavy" job. A similar study was conducted on the plucking of tea leaf in Himachal Pradesh by Kishtwaria et al. (2009) and categorized the plucking activity as a challenging task.

Table 4 shows the results of statistical analysis (ANOVA) of the data (Table 3) of total discomfort rating when plucking tea leaves with varied work-rest schedules, which revealed a significant difference ($p > 0.05$).

According to the workers overall discomfort rating, the first and third schedule generated discomfort after a total of 8 hours. The first schedule may cause more discomfort owing to constant exposure to diverse job stresses for a more extended period. According to the pluckers, rest periods should be at least 15 minutes long, and lunch breaks should not be less than 45 minutes.

3. Conclusion

In private small tea gardens, as per the direction of the authority tea leaf pluckers work for a long time at a stretch ignoring their health so as to obtain job opportunity regularly in the tea garden, which caused health-related problems among the tea leaf pluckers. In some gardens, pluckers are engaged at peak season only on a work contract basis. The owner does not bother with the health-related issues of the workers. Since it is revealed that tea cultivation in India is not only the source of income generation for the country; it also generates employment for the rural population, for the betterment of the tea leaf pluckers, it is advocated for scientific intervention to upgrade the work organization by designing a work-rest schedule to protect tea leaf pluckers interest in private small tea gardens.

Conflict of Interest

No conflict of interest exists associated with this publication.

Funding

No funding was received for this work

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