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Occupational Health of Tribal Women Engaged in Weeding Activity in Tea Gardens

Tapsri R Marak[1] • Deepak Bhagat[1*] • Swapnali Borah[2]

[1]Department of Management, North-Eastern Hill University, Tura Campus- 794002, Meghalaya

[2]Department of Family Resource Management, College of Community Science, Central Agricultural University, Tura-794005, Meghalaya

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ABSTRACT

Weeding activities carried out by women in tea gardens demand a high degree of physical effort and thus may lead to musculoskeletal problems and fatigue. However, the weeding activity has not drawn the attention of the ergonomic researchers. Thus, the study primarily aims to measure the physiological workload, cardiovascular stress index and musculoskeletal disorders of women tea garden workers engaged in weeding activity. A sample of forty Garo tribal women working in tea gardens located in hill areas of West Garo Hills, Meghalaya (India) having highest field experience were selected and divided equally in two age group categories (20-35 years and 36-50 years). Their each movement towards completion of tasks were monitored and measured with the help of heart rate monitor, thermometer, sphygmomanometer, grip dynamometer and stopwatch. For data analysis apart descriptive analytical tools, t test was used. The workers considered weeding activity as moderately heavy to heavy. The average cardiovascular stress index in weeding activity was 30.20. In both the age groups and between the two age groups, significant difference was observed between percentage reduction of average strength of back between before lunch and just before end of work. The women workers complained of severe discomfort in the upper and lower back (4.3 and 4.4), knee (3.9), ankle (3.5) and feet/toe (4.5). Significant difference was observed between two age groups in head, neck, elbow, wrist in upper extremity and ankle in lower extremity. Drudgery of women tea garden workers increases on account of the awkward postures and traditional tools. Ergonomic intervention in the form of women friendly rake and angular *khurpi* is suggested to reduce drudgery of women tea garden workers.

1. Introduction

Tea cultivation is the most labour intensive among the plantation crops (Hazarika & Borah 2013). Musculoskeletal pain is common among tea workers and is mostly attributed to awkward posture, workload and long working hours in the tea garden (Bhattacharyya et. al. 2013; Bhattacharyya, 2005; Hunting, et. al. 1980). The activities in tea gardens require a high degree of physical effort, which do impact the health of female workers (Chatterjee, 1990). Women workers generally complaint of body ache, pain in the neck, leg, hand and other parts of the body so their fatigue arise soon which reduce the productivity in tea garden (Hazarika, Bhattacharya, 2001). It is therefore important that the conditions and postures that pose threat to the safety and health of the women tea garden workers are identified and addressed (Oxenburgh, 2004). This necessitates ergonomic assessment of the occupational and posture- related discomfort among women tea garden workers. The goal of ergonomics (the study of human abilities) is to reduce stress and prevent discomforts and injuries due to bad posture, overuse of muscles and repeated tasks (Barbe et. al. 2006; *Clark*, *T. S.* and *Corlett, 1984).*

However, at present, the ergonomic studies in tea gardens are very limited and mostly concentrated on large tea gardens of Assam, West Bengal, Himachal Pradesh, Kerala, Tamil Nadu (Devi, 2014; Sarma, 2013; Kishtwaria, Rana, & Sood, 2009; Goowalla, 2012; Thapa, 2016). However, in a place like Garo Hills (Meghalaya), where tea cultivation is at

*Corresponding author: dip19bhagat@gmail.com

a very nascent stage, and mostly owned and cultivated by ethnic tribals who have very less experience in tea cultivation, no such ergonomic studies have been attempted. This makes the ergonomic studies much more crucial here, so that some suitable techniques and measures can be developed, specific to the hill specificities, to reduce the workload of tea plantation workers and facilitate them to perform at their best level with less proneness to musculoskeletal disorders.

The present study attempted to measure and analyzes the musculoskeletal disorders of Garo women workers due to weeding activity in tea gardens of Garo hills. Weeding was reported as one of the very heavy activities carried out by females in tea gardens which demand a high degree of physical effort and thus may lead to fatigue. Weeding is a time consuming and difficult operation involving a lot of drudgery through adopting bending and squatting body posture due to which their physiological workload increases resulting in musculoskeletal problems leading to decrease in efficiency of women to workers (Sharma 1999). However, unlike tea plucking, the weeding activity has not drawn the attention of the ergonomic researchers, thus selected for the present study. The findings of the study will help in minimizing their drudgery while performing the weeding activities in tea gardens of hills.

2. Materials and Methods

Study design and sampling procedure

The study was conducted on forty Garo women working in hill tea gardens in West Garo Hills district of Meghalaya. Women tea Garden workers having highest field experience were selected because there exists a significant positive correlation between years of involvement and perceived exertion; and years of involvement and musculoskeletal problems (Borah, 2015). These forty (40) women workers were divided in two categories with twenty belonging to 20-35 years and twenty belonging to 36-50 years. The subjects were free from muscular and vascular abnormalities and they should have the following conditions of the body (Body Temperature: Not above 99-degree Fahrenheit; Blood Pressure: 120/ 80 ± 10 and Heart Rate: 70-90 beats/min). Their each movement towards completion of tasks were monitored and measured during weeding activity (April-Nov).

In order to collect the reliable experimental data, the selected subjects were given enough rest before putting them on the selected activity. Efforts were made to get maximum cooperation of the subjects; they were encouraged to respond the way they behave in real life-setting. Good rapport was established with the subjects in order to get their maximum co-operation. They were told, at the very outset, that it was a part of a scientific study and the collected data shall not be used for any professionals or healthcare evaluation. The confidentiality of the results and information provided by them was assured. It was also told that they would be informed about their position on different experiments if they desire so. The instructions and administrative procedures were the same for all the subjects.

Measurement Instruments

Some of the instruments and equipment's used for monitoring and measuring the variables are heart rate monitor (polar sport tester), thermometer, sphygmomanometer (blood pressure apparatus), grip dynamometer and stopwatch. Data were collected on the following indicators/parameters:

Strength of Back

Back Dynamometer was used to measure the strength of the back. It was measured by making the subject stand on the platform with their feet about 15 cm apart from each other. Then they were made to hold the handles with both hands and adjust the length of chain so that their straightened back tilts at a forward angle of 30 degrees. The handle is then made to pull by gradually raising their upper body taking care that their legs were not bent at the knee.

Cardiovascular Stress

Heart rate (beats/min) was measured with polar heart rate monitor, which consisted of one transmitter and one receiver to transmit and receive the ECG signals. Transmitter was tied on the chest of the subject receiver was tied on the wrist and ECG signals were recorded at rest, during the entire period of work and recovery thereafter for a period of 5 minutes.

Energy Expenditure

The energy expenditure was estimated from average heart rate during rest and during work by using following formula (Varghese et. al. 1994).

Energy Expenditure (kj/min) = 0.159 × Average heart rate (beats/min) -8.72

Physiological Workload

Physiological workload was classified on the basis of heart rate as very light (up to 90), light (91-105), moderately heavy (106-120), heavy (121-135), very heavy (136-150), extremely heavy (above 150).

Total Cardiac Cost of Work (TCCW) and Physiological Cost of Work (PCW)

TCCW and PCW were determined by using formulas:

Total Cardiac Cost of Work = Cardiac Cost of Work + Cardiac Cost of Recovery

(TCCW) (CCW) (CCR)

Where, CCW = AHR × Duration of work

AHR = (Average working heart rate – Average resting heart rate)

CCR = (Average Recovery heart rate – Average resting heart rate) × Duration of recovery

Physiological Cost of work = $\frac{Total\ Cardiac\ Coct\ of\ Work}{Total\ Time\ of\ Work}$

Cardio Vascular Stress Index (CSI)

CSI was determined by using following formula (Trites et. al. 1993).

CSI = $\frac{100\,(Heart\ rate\ during\ work - Heart\ rate\ during\ rest)}{Heart\ rate\ maximum - Heart\ rate\ at\ rest}$

Where, Heart rate maximum =220 – Age (years)

Rated Perceived Exertion (RPE)

In this study a modified 5-point scale of perceived exertion (1: Very Light, 2: Light, 3: Moderately Light, 4: Heavy and 5: Very Heavy) was used (Varghese et. al. 1994).

Intensity of Pain in Different Parts of the Body

To study the resultant chronic effects of selected activities, a suitable body map was used along with questionnaire. The questionnaire covered the following regions of the body for measuring the intensity of pain: the back (the upper back and lower back); the upper extremity (head, neck eyes, ears, chest, upper arm and lower arm); and the lower extremity (thigh and legs) and the joints (shoulder, elbow, wrist, knee and ankle). In order to ascertain the degree of severity of pain, a five point scale (5: Very severe, 4: Severe, 3: Moderate, 2: Mild and 1: Very Mild) was used (Varghese et. al. 1996).

Muscular Fatigue of Hand Grip

The grip strength was measured with the help of a grip dynamometer. It consists of a handle for handgrip connected with a spring to a pointer on the marked dial. The subject was asked to pull the handle separately with right and left hand before and after end of work and the reading given on the dial in kilogram was recorded for both the hands. The percent reduction in grip muscular strength (muscular fatigue) was calculated from the following formula:

Percent reduction in grip muscular strength $= \frac{Sr - Sw}{Sr} \times 100$

Where, S_r = Strength of muscles during rest (kgs); S_w = Strength of muscles during work (kgs)

Data Analysis

For data analysis apart descriptive analytical tools, t test was used.

3. Results and Discussion

Basic Information Pertaining to Sample Respondents Engaged in Weeding Activity

Table 1 presents some of the basic information pertaining to weeding activity performed by women tea garden workers in West Garo Hills district of Meghalaya. The work in tea gardens of West Garo Hills is being performed in a traditional way without knowing its impact on health of the tea garden workers. It was observed that majority of women do manual weed control by using age old hand tools like sickle and khurpi. Weeding was done through push and pull action and the workers are under constant pressure to complete weeding operation before weeds increase in height and become difficult to uproot. In the age group 20-35 years, it was observed that women tea garden workers covered an average distance of 0.55 km which required 744.85 steps per day to complete an area of 0.06 Ha. They perform weeding for 5.45 hour per day in weeding activity. In the age group 36-50 years, it was observed that women tea garden workers covered a distance of 0.71 km and the required number of steps was 744.5 steps per day with an area of 0.12 Ha. The women workers in the age group of 36-50 years were found to cover significantly more distance and more area per day than women workers in age group of 20-35 years. However, no significant difference was observed between the two age groups the parameters like time spent and frequency of involvement. To study the physical characteristics of tribal women workers engaged in tea plantations hand grip strength and average strength of back was calculated. The average hand grip strength and average back strength for sample respondents was measured as 21.32 kg and 48.09 kg respectively.

Assessment of Workload among Women Tea Garden Workers Engaged in Weeding Activity

Table 2 indicated physiological workload while performing weeding activity. Among the sample respondents the average heart rate was measured as 120.13 (bpm), average peak heart rate was measured as 122.25, energy expenditure was measured as 10.380 kj/min and peak energy expenditure was measured as 10.72 kj/min. The acceptable limits of physiological workload among women workers as determined from energy expenditure and heart rate were found to be 10 kj/min and 110 bpm, respectively for eight hours continuous work (Varghese et. al. 2000). The perceived workload of the activity by the female workers were also reported in literatures as heavy to very heavy and they felt severe to very severe pain in both upper and lower

Table 1. Basic information pertaining to sample respondents engaged in weeding

Parameters	Total (20-50 yrs) N=40	20-35 yrs n=20	36-50 yrs n=20	t-Stat (between two age groups)
Distance covered(km)	0.63 (0.124)	0.55 (0.05)	0.71 (0.12)	-5.685**
Required steps(steps)	744.68 (92.398)	744.85 (70.00)	744.5 (112.36)	0.012^{NS}
Area covered per day(hectare)	0.09 (0.038)	0.06 (0.01)	0.12 (0.02)	-12.674**
Time spent (hours per day)	5.60 (0.496)	5.45 (0.51)	5.75 (0.44)	-1.983
Frequency of doing work (Seasonal)	1.96 (0.175)	1.95 (0.22)	1.98 (0.11)	-0.999
Average hand grip strength (kg)	21.32 (4.62)	20.24 (4.24)	22.41 (4.83)	-1.510 ^{NS}
Average Strength of back (kg)	48.09 (3.2)	47.32 (2.8)	48.88 (3.4)	-1.565 ^{NS}

Note: Figures in parenthesis indicate standard deviation; ** :: Significant at 0.05 level of significance; NS::Non Significant

extremities and most of the joints of the body (Borah, 2009; Borah and Borah, 2020). Women spent more energy in this activity where weeds were uprooted by hand and cutting was done through traditional equipment using sickle. During weeding activity, physical strain, fatigue and drudgery was noticed by maximum number of women workers especially in the back and thighs (Singh & Arora 2010).

Workers in weeding activity adopt bending and squatting body posture due to which their physiological workload increases involving a lot of drudgery on account of the awkward postures and traditional tools. It was noticed that women performed the activity for five to six hours continuously to complete the task as soon as possible and end up fatiguing themselves which depicts severe discomfort in the lower extremities in the upper and lower back, knee, ankle and feet/toe of workers in weeding activity. Further analysis indicated that workers considered weeding activity as moderately heavy to heavy as was mostly done manually which was most effective but slow between and along the rows in squatting posture (measured as rated perceived exertion). The average total cardiac cost of work and average physiological cost of work of women workers was 12644.20 beats and 37.51 bpm respectively. The average cardiovascular stress index in weeding activity was 30.20 for the entire sample age group.

No significant difference was observed between the two age groups physiological workload. Energy expenditure was calculated on the basis of average and peak heart rate. No significant difference was observed between the two age groups Total Cardiac Cost of Work (TCCW) and Physiological Cost of Work (PCW) while performing weeding activity. The average cardiovascular stress index in weeding activity was 30.20 for the entire sample age group. The average cardiovascular stress index in weeding activity in age group 20-35 years was 31.44 and in age group 36-50 years 30.66. The workers considered weeding activity as moderately heavy to heavy. However, no significant difference was observed between the two age groups with respect to cardiovascular stress index and rated perceived exertion.

Table 2. Assessment of workload among women tea garden workers engaged in weeding

Parameters	Total (20-50 yrs) N=40	20-35 yrs n=20	36-50 yrs n=20	t-Stat (between two age groups)
Average heart rate (bpm)	120.13 (1.951)	120.15 (2.621)	120.10 (1.795)	-0.080 ^{NS}
Average Peak heart Rate (bpm)	122.25 (1.481)	121.80 (1.576)	122.70 (1.765)	-1.994 ^{NS}
Energy expenditure (kj/min)	10.380 (0.31)	10.38 (0.417)	10.378 (0.15)	-0.080 (NS)
Peak energy expenditure (kj/min)	10.72 (0.24)	10.64 (0.251)	10.79 (0.20)	-1.994 ^{NS}
Total Cardiac Cost of Work (beats)	12644.20 (2162.69)	12045.82 (2423.38)	13242.58 (1724.56)	-1.799 ^{NS}
Physiological Cost of Work (bpm)	37.51 (4.34)	36.70 (5.52)	38.40 (4.19)	-1.097^{NS}
Cardiovascular Stress Index	30.20 (6.438)	31.44 (4.165)	30.66 (6.597)	0.446 ^{NS}
Rated Perceived Exertion	3.98 (0.768)	3.9 (0.788)	4.05 (0.759)	-0.163 ^{NS}

Note: Rating for RPE: 5-Very heavy, 4-Heavy, 3-Moderately Heavy, 2-Light, 1-Very Light; Figures in parenthesis indicate standard deviation; **:: Significant at 0.05 level of significance; NS::Non Significant

Musculoskeletal Disorders among Tribal Women Tea Garden Workers

To understand musculoskeletal disorders among tribal women tea garden workers, the percentage reduction of hand grip strength in weeding was measured by using grip dynamometer for before and after completion of activity for the right or the left hand whichever is used by the workers while performing the weeding activity. In both the age groups, significant difference was observed between percentage reduction of average strength of back between before lunch and just before end of work. Weeding was perceived as very heavy task resulting in severe discomfort in upper and lower back (4.4 and 4.5) due to frequent bending posture while working in continuous bending. Women perform weeding operation by bending and squatting causing pain in the knee (3.7), ankle (3.9) and feet/toe (3.9). Significant difference was observed between two age groups in head, neck, elbow in upper extremity and ankle and feet/toe in lower extremity. Significant difference was observed between two age groups in head, neck, elbow, wrist (RH), wrist (LH) in upper extremity and ankle in lower extremity. Weeding was also perceived as very heavy task resulting into severe to very severe pain in back and MSD problems with the use of traditional tools (Kishtwaria & Rana, 2012). Borah and Borah (2020) also noted that after assessment of upper limb of workers involved in weeding activity resulted in pain in different parts of the body i.e. neck, lower back, trunk, wrist and shoulders.

4. Conclusion

It was observed that majority of women do manual weed control for 5-6 hours on an average twice a week by using age old hand tools like sickle and *khurpi*. The use of traditional tools accompanied with awkward postures increases the drudgery of women tea garden workers. The women workers grouped weeding activity in moderately heavy to heavy category. Women workers complained of severe discomfort in the upper and lower back, knee, ankle and feet/toe. Ergonomic intervention in the form of women friendly rake and angular *khurpi* was suggested to improve drudgery and maintain correct body posture while doing weeding activity in order to minimize drudgery of women tea garden workers. Women friendly personal protective hand gloves should be introduced to protect their hands while performing the tasks. Farm women should get help in getting loans to procure various ergonomically designed tools and implements. There should be co-ordination between central/state departments and NGOs to promote these improved tools and implements to maintain occupational health and safety at workplace.

Table 3. Percentage reduction in hand grip strength and back strength of women tea garden workers engaged in weeding

Parameters	Age group				t-Stat between two age groups		Total Sample	
	20-35 yrs n=20		36-50 yrs n=20				(20-50 yrs) N=40	
A. Percentage reduction in hand grip strength								
Grip Strength	Right hand	Left hand	Right hand	Left hand	Right hand	Left hand	Right hand	Left hand
Before Lunch	8.18 (3.94)	7.47 (4.56)	9.12 (5.78)	8.64 (6.47)	-0.605^{NS}	-0.659 ^{NS}	8.65 (4.90)	8.05 (5.56)
t-Stat	0.528^{NS}		0.252^{NS}		-		0.512^{NS}	
Just after end of work	17.38 (6.82)	18.96 (11.80)	15.80 (8.03)	15.84 (6.80)	0.669 ^{NS}	1.027 ^{NS}	16.59 (7.39)	17.40 (9.64)
t-Stat	-0.519 ^{NS}		-0.014 ^{NS}		-		-0.421 ^{NS}	
t-Stat (before lunch and just after end of work)	-5.227**	-4.063**	-3.019**	-3.431**	-		-5.659**	-5.314**
B. Percentage reduction of average strength of back								
Before lunch	2.66(1.3)		5.70(2.2)		5.238**		4.18 (2.38)	
Just after end of work	8.61(2.6)		12.02(3.3)		-3.612**		10.31(3.42)	
t-Stat (before lunch and just after end of work)	-9.057**		-7.069**		-		-9.313**	

Note: Figures in parenthesis indicate standard deviation; ** :: Significant at 0.05 level of significance; NS::Non Significant

Table 4. Musculoskeletal problems of women workers in weeding activity

Different parts of the body	Age Group			t-Stat (between two age groups)
	20-35 yrs n=20	36-50 yrs n=20	20-50 yrs N=40	
A. Upper Extremity				
Head	2.65	2.10	2.38	3.333**
Eye	1.70	1.75	1.73	-0.346^{NS}
Neck	3.55	2.85	3.20	2.702**
Shoulder Joint	3.80	3.45	3.63	1.601^{NS}
Upper Arm	3.10	3.35	3.23	-1.387^{NS}
Elbow	3.05	2.30	2.68	3.039***
Lower Arm	3.00	3.00	3.00	0.00^{NS}
Wrist (RH)	4.20	4.45	4.33	-0.991^{NS}
Wrist (LH)	3.30	3.70	3.50	-1.925^{NS}
Fingers (RH)	4.05	3.95	4.00	0.335^{NS}
Fingers (LH)	3.90	3.70	3.80	0.541^{NS}
Upper Back	4.40	4.20	4.30	1.042^{NS}
B. Lower Extremity				
Low Back	4.50	4.20	4.35	1.552^{NS}
Buttock	3.50	3.40	3.45	0.567^{NS}
Upper leg/thigh	3.30	3.60	3.45	-1.086^{NS}
Knee	3.70	4.15	3.93	-1.533^{NS}
Calf muscle	3.25	3.30	3.28	-0.167^{NS}
Ankle	3.90	3.10	3.50	3.556**
Feet/Toe	3.85	4.40	4.13	-2.574**

Note: Five point scale (1=very mild, 2=mild, 3= moderate, 4=severe, 5=very severe)

**: Significant at 0.05 level of significance; NS::Non Significant

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