



## **Ergonomic assessment of physiological cost of work of tea factory workers**

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### **ABSTRACT**

*Forty women tea factory workers, aged between 30- 60years were investigated in the factories during eleven selected activities such as Lifting bags, Lifting tubs, Handling of bags, Stacking of bags, Filling tea powder in bags etc. purposive random sampling method was used to select the respondent. Physiological cost of work calculated in terms of heart rate and total cardiac cost. On the basis of heart rate it was concluded that the blending, loading wheelbarrow and wheeling was more strenuous than lifting bag, filling tea powder in bag, loading tea powder in sifting machine. On the basis of TCCW loading wheelbarrow was a most strenuous activity and followed wheeling and least exhaustive activity were lifting bag and packing.*

*Key words: Energy expenditure, Hear rate, Physiological cost, Tea factories, Women*

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### **INTRODUCTION**

Tea is one of the most common and low-cost drinks in the world and consumed by an enormous number of people. India is the largest producer and consumer of tea in the world. In India majority of the workers come from socially and economically weaker sections. Most of the workers were women and they do hard jobs even during pregnancy and postnatal period with less payment and safety (Radha and Suji, 2016)<sup>4</sup>. Generally, women working women requires a lot of energy to carry out household activities and outside work with fulfilment and desired standards. Researchers have verified that any work station design or work environment that supports to perform the work with minimum energy and put minimum stress on the cardiovascular system and muscular system is the best design of work (Varghese et al. 1995)<sup>6</sup>. So the workstation should be properly designed and arranged in order to cut the physical, physiological and temporal cost of the worker. If the body is not able to maintain equilibrium during work, it adds to the human energy cost and physiological dynamics such as energy expansion, physiological cost of work, muscular effort etc. Therefore, a need was felt to assess the different physiological stress parameters of the women workers engaged in selected processing activities.

### **MATERIAL AND METHODS**

**Selection of respondents:** The study was piloted in Gudalur small town of Tamil Nadu. The sample size of 40 women respondents from the age of 30 to 60 purposively selected. The main reason for selection of women workers is that there are the categories playing the major role in the processing works.

**Standardization of activities:** based on the preliminary survey conducted prior to the experiment, 11 activities in which the respondents faced problems were selected. These activities lifting bags, Lifting tubs, Handling of bags, Stacking of bags, Filling tea powder in bags, Loading tea powder in sifting machine, blending, packing, cleaning, Loading wheelbarrow, Wheeling. Each activity performed for 15 minutes.

**Collection of data:** A specially designed Performa used to record readings during experiments. Readings were taken while the respondents performed the planned tasks. Respondents encouraged to work in an ordinary way and not to be swayed by the investigator presence. Before starting every activity

respondents were rested for 15 minutes at this point resting heart rate was recorded. Respondents were asked to perform each activity for 15 minutes using the existing tools and equipment. Working heart rate was noted for 15 minutes at the interval of 5 minutes. The resting heart rate was recorded for 5 minutes at the interval of 1 minute each.

#### Calculation of Physiological cost of work:

The following parameters were calculated by using heart rate.

1. Average heart rate during rest, work and recovery period.
2. The energy expenditure per minute was estimated from heart rate using the following formula and the classification of work load was done as per Varghese et al. (1994).

Energy Expenditure (kJ/min) =  $0.159 \times \text{Average Heart rate (bmin-1)} - 8.72$

3. The Total Cardiac Cost of Work (TCCW) was also estimated for the whole day based on the cardiac cost of work and cardiac cost of recovery.

Cardiac Cost of Work (CCW) = Increased Average heart rate x Duration of work  
Increased Average heart rate during work = Average working heart rate – Average heart rate during rest

Cardiac Cost of Recovery (CCR) = Increased average heart rate during recovery x Duration  
Increased average heart rate during recovery = Average recovery heart rate – Average resting heart rate

Statistical Analysis of Experimental Data: Simple averages, percentages were calculated.

#### Result and discussion

##### Physiological cost of work in terms of energy expenditure (Kj / min.) during activities

Table 1 indicate the energy expenditure rate (kj/min.) of respondents while performing various activities. Wheeling, loading wheel barrow, blending and cleaning activities the expenditure rate before work was 3.69 kj/min, 3.70kj/min 3.61 kj/min and 3.60 kj.min and which is increased up to 6. 40 kj/min, 6.16 kj/min, 5.42 kj/min and 5.33kj/min respectively with percent increase of 73.68, 66.65, 50.22 and 48. 32.

For lifting bag the energy expenditure rate before work 3.64 kj/min, after work is 5.08 kj/min, and percent increase was 39.59. Whereas for filling tea powder in bag the percent increase was 40. Stacking bag and loading tea powder in sifting machine the percent increases is 37.20 and 37.18 respectively. Rest of the activities such as lifting tubs, handling of bags and packing the energy expenditure rate percent was found that below 30.

##### Physiological cost of work in terms of heart rate (heart beat/ min.) during activities

Data enfolded in table 2 exhibited the mean rest, working and recovery heart rate of selected respondent while working.

**Lifting bags:** It was found that the mean rest heart rate was 78 beats per minute, mean working heart rate 114 beats per minute and recovery heart rate 87 beats per minute. Per cent increase level in heart was 11.63.

**Table 1 Physiological cost of work in terms of energy expenditure (KJ / min.) during activities (n= 40)**

S. No	Activity profile	Energy expenditure rate (KJ/ min.)			Percentage increase in heart rate (recovery period)
		Rest	Work	Recovery	
1	Lifting bags	3.64	9.47	5.08	39.59
2	Lifting tubs	3.70	9.38	4.42	19.49
3	Handling of bags	3.57	10.00	4.46	25.18
4	Stacking of bags	3.57	10.73	4.89	37.20
5	Filling tea powder in bags	3.60	9.14	5.04	40.0
6	Loading tea powder in sifting machine	3.62	10.22	4.96	37.18
7	blending	3.61	12.51	5.42	50.22
8	packing	3.61	9.13	4.22	17.07
9	cleaning	3.60	10.16	5.33	48.32
10	Loading wheelbarrow	3.70	10.16	6.16	66.65
11	Wheeling	3.69	13.26	6.40	73.68

$$\text{Percentage Increase} = \frac{\text{After activity} - \text{Before activity}}{\text{Before activity}} \times 100$$

**Lifting tubs:** Mean heart rate during work was recorded 114 beats/minutes and per cent increase in heart rate was 5.72 from its resting level.

**Handling of bags:** The mean heart rate before work and during work was 77and 117 beats/ minutes respectively and per cent increase in heart rate was 7.27.

**Stacking of bags:** The mean heart rate before and during work was 77 and 122 beats/ minute respectively and percent increase in heart rate was 10.73.

**Filling tea powder in bags:** The mean heart rate rest, work and recovery period was 78,111 and 87 beats/ minute and per cent increase in heart rate was 11.64.

**Loading tea powder in sifting machine:** the mean heart rate during work 120 beats/ minute and per cent increase in heart rate was 10.84 from its resting level.

**Blending:** For blending activity the mean heart during work was recorded was 133 beats/ minute and per cent increase in heart was 14.7 from its resting heart level.

**Packing:** For packing the mean heart of rest, during work and recovery period was 81, 112 and 76 beats/ minute and per cent increase in heart were 7.24.

**Cleaning:** The recorded mean heart rate before and during work were 78 and 119 beats/ minute and per cent increase in heart rate were 14.09.

**Loading wheelbarrow:** The average rest, work and recovery heart rate was 78,130 and 94 respectively and per cent increase in heart rate was 19.84 when compared to other activities high.

**Wheeling:** For wheeling the mean heart rate before and during work recorded were 78 and 138 beats/ minute respectively. The per cent increase heart was 21.87 which is the highest one among all other activities.

It was noticed that there was marked difference in percent increase in heart rate between lifting bag, lifting tubs, handling of bag, packing, stacking of bag, filling tea powder in bag and loading tea powder in shifting machine, loading wheel barrow, blending, cleaning and wheeling.

**Table 2 Physiological cost of work in terms of heart rate (heart beat/ min.) during activities (n=40)**

S. No	Activity profile	Mean heart rate(beats/ min)			Percentage increase in heart rate (recovery period)
		Rest	Work	Recovery	
1	Lifting bags	77.75	114.42	86.8	11.63
2	Lifting tubs	78.17	113.85	82.65	5.72
3	Handling of bags	77.32	117.42	82.95	7.27
4	Stacking of bags	77.35	122.37	85.65	10.73
5	Filling tea powder in bags	77.52	111.12	86.55	11.64
6	Loading tea powder in sifting machine	77.65	119.15	86.075	10.84
7	blending	77.55	132.72	88.95	14.7
8	packing	81.42	112.3	75.925	7.24
9	cleaning	77.5	118.75	88.425	14.09
10	Loading wheelbarrow	78.12	129.75	93.625	19.84
11	Wheeling	78.07	138.25	95.15	21.87

$$\text{Percentage Increase} = \frac{\text{After activity} - \text{Before activity}}{\text{Before activity}} \times 100$$

**Khare, (2013)<sup>2</sup>** studied that the physiological cost of work for the workers performing kitchen related standing activities in restaurants. Preparation, cooking, serving and dishwashing activities were selected. For preparation work the mean rest and working heart rate were 83 and 128 beats/ minute and per cent increase in heart was 18.07. For cooking activity the mean working heart rate was 124 beats/ minute and per cent increase in heart rate was 16.14. Dishwashing activity, the mean heart during work was 118 beats/ minute and per cent increase in heart rate was 15.61 from its resting level. And for serving activity the mean heart rate during work was 123 beats/ minute and per cent increase in heart was 10.71 from its resting heart level.

**Physiological cost of work in terms of total cardiac cost of work during activities (table 3)**

**Lifting bags:** It was found that the cardiac cost of work, cardiac cost of recovery, total cardiac cost of work were 183.75(beats/min), 45.25(beats/min), 228.625(beats/min) respectively and physiological cost of work for while lifting bags was 15.24 beats/min.

**Lifting tubs:** The mean cardiac cost of work was 174.75(beats/min), cardiac cost of recovery 22.375(beats/min), total cardiac cost of work 197.125(beats/min) and physiological cost of work faced by workers while lifting tubs was 13.14(beats/min).

**Handling of bags:** For handling tubs the mean CCW, CCR and TCCW were recorded 200.5(beats/min), 30.37(beats/min) and 230(beats/min) respectively. Thus the physiological cost of work faced by during handling of bags was 15.39 (beats/min).

**Stacking bags:** The mean cardiac cost of work 225.12 (beats/ min), cardiac cost of recovery 183.625 (beats /min) and total cardiac cost of work 408.75 (beats/min) were recorded for stacking bags. Physiological cost of work 27.25 (beats/min) was faced by workers during the activity.

**Filling tea powder in bag:** It was found that the average cardiac cost of work was 168 (beats/ min), cardiac cost of recovery was 45.125 (beats/ min) and total cardiac cost of work was 213.12 (beats/ min). Physiological cost of work faced by workers during this activity was 14.20 beats.

**Loading tea powder in sifting machine:** The mean of CCW, CCR, TCCW 183.5 (beats/min.), 42.12(beats/min.) and 225.62(beats/min.) were recorded respectively for this activity. The physiological cost of work faced by worker during the activity was 15.04 beats.

**Blending:** For blending activity the physiological cost of work was 22.19 beats/min and also the mean cardiac cost of work, cardiac cost of recovery and total cardiac cost of work were recorded 275.85 (beats/min), 57 (beats/min) and 332.87(beats/min.) respectively

**Packing:** During packing found that the mean of cardiac cost of work, cardiac cost of recovery and total cardiac cost of work were 206.25 (beats/min.) , 54.625 (beats/min) and 260.875 (beats/min) respectively. The mean physiological of cost work was 13.95 beats /min was faced by worker while performing packing.

**Loading wheelbarrow:** The mean of CCW, CCR, TCCW 708(beats/min), 306.12(beats/min) and 1014.125(beats/min) were recorded for this activity. Thus the physiological cost of work faced workers during was 67.60 beats.

**Wheeling:** In wheeling activity the CCW, CCR and TCCW were 300.87 beats/min, 85.37 beats/min and 386.25 beats/min respectively and physiological cost of work was 25.75.

In addition Moharana *et al.*, (2011)<sup>3</sup> stated that the average total cardiac cost of work was found that front housekeeping activity was 1093.37 beats min and it is similar to TCCW value 1014.125(beats/min) of loading wheel barrow activity. **Bhatt *et al.*, (2011)<sup>1</sup>** indicated the physiological cost for grating was found maximum 26.26 beats and followed by kneading 18 beats, cutting 15.32 beats, and dish washing 12 beats.

**Table 3 Physiological cost of work in terms of total cardiac cost of work during activities (n = 40)**

s.no	Activity	Cardiac cost of work(CCW)	Cardiac cost of recovery(CRW)	Total cardiac cost of work(TCCW) (beats)	Physiological cost of work (beats)
1	Lifting bags	183.375	45.25	228.625	15.24167
2	Lifting tubs	174.75	22.375	197.125	13.14167
3	Handling of bags	200.5	30.375	230.875	15.39167
4	Stacking of bags	225.125	183.625	408.75	27.25
5	Filling tea powder in bags	168	45.125	213.125	14.20833
6	Loading tea powder in sifting machine	183.5	42.125	225.625	15.04167
7	blending	275.875	57	332.875	22.19167
8	packing	181.875	27.5	209.375	13.95833
9	cleaning	206.25	54.625	260.875	17.39167
10	Loading wheelbarrow	708	306.125	386.25	25.75
11	Wheeling	300.875	85.375	1014.125	67.60833

## CONCLUSION

On the basis of heart rate it was concluded that the blending, loading wheel barrow and wheeling was more strenuous than lifting bag, filling tea powder in bag, loading tea powder in sifting machine; and the activities such as lifting tubs, handling of bags and packing was least strenuous one. On the basis of TCCW loading wheelbarrow was most strenuous activity and followed wheeling with highest physiological cost of work i.e., 67.60 beats; least exhaustive activity were lifting bag and packing with the physiological cost of work i.e., 13 beats min.

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