

Ergonomic assessment of workers engaged in tea cultivation

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■ **ABSTRACT** : Tea is the most important plantation crop and the largest organized agro-based industry in India. This industry is highly labour intensive industry where both male and female workers are engaged. The present study was conducted in Jorhat district of Assam (India) to ergonomically assess around 150 workers engaged in different activities in tea garden. Majority of the male (81.9 %) and female (75 %) workers had ectomorph body type. Postural analysis showed that angle of deviation was highest during the digging activity for males whereas for females, it was found to be maximum during deep skiffing. The average working heart rate values was highest during digging for male and of the females deep skiffing was considered as moderately heavy. The grip strength of the male workers was found to be higher for both the hands than the grip strength of female workers. Data also revealed that majority of the workers both male (93.33%) and female (100%) were found to suffer from back pain. Hence, a continuous awkward standing posture, adverse environment and working conditions increased drudgery and decrease productivity of the workers.

■ **KEY WORDS** : Ergonomic, Cardio-vascular stress, Physical fitness index, Drudgery

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Assam produces more than half of the tea produced in India which is sold through the auction centre in Guwahati. Around 400 million kgs of tea comes from Assam tea gardens. Most of the tea gardens are situated in Jorhat which is called the "Tea capital of the world". Tea plays an important role in the national and world economy today. The tea industry is highly labour intensive. Thus, this plantation industry employs a large number of labour forces. They are involved at every stage of production starting from nursery development of the young tea plants to the packaging of the made tea. Keeping in view the global market demand besides internal consumption, the production will have to be increased significantly. This is possible only if the existing plantations are managed properly and also the labourers are provided with better techniques of carrying out the work. The work is being performed in traditional way and in open extreme environment conditions without knowing its impact on health. Most of the activities performed by the workers in tea plantation demand a high degree of physical effort leading to fatigue. The main causative factor for fatigue is the static muscular effort resulting from bad working

postures (Bhattacharyya, 2005). The workers perform different activities in different postures which they feel comfortable, but the postures sometimes become harmful and lead to irreparable damage to the body. In mass production industries, workers are engaged in repetitive task with high postural load due to constraints of work method and working condition. It may create frequent complaints of body aches, pain in neck, arm and lumbar region. Due to this back breaking and drudgery prone work, the output and leisure of the workers decrease and the health is also affected adversely. Thus, keeping in view the most neglected and essentially required aspects of the workers drudgery due to different activities the study has been planned with the following specific objectives as to determine the physiological workload of respondents while doing various activities in tea gardens.

■ RESEARCH METHODS

The present study was conducted in Jorhat district of Assam. A multi-stage random sampling technique was

adopted to select the tea gardens .A total of twenty tea gardens and about 150 workers were selected randomly.

The data were collected on well structured interview schedule through survey method as well as with various equipments viz., heart rate monitor, measuring tape, weighing balance and various analytical tools were employed for the analysis and interpretation of data.

Body mass index:

The quetelet’s index was used for the determination of body composition.

$$\text{Quetelet's index} = \frac{\text{Weight (kg)}}{\text{Height (m}^2\text{)}}$$

Body type:

<21.5 = Ectomorph; 21.5-25 = Mesomorph; >25 =Endomorph.

$$\text{Aerobic capacity} = \frac{[\text{VO}_2 \text{ max (l/m)}]}{\text{VO}_2 \text{ max (ml/kg/min)}} \times \text{Step test score (PFI)} - 12.767 = 0.377$$

Evaluation of physiological workload:

The physiological workload of the sample was determined by recording the heart rate after every five minduring work using polar heart rate monitor.

Energy expenditure was calculated with the help of the formula given by Varghese *et al.* (1994).

$$\text{Energy expenditure (kj/min)} = 0.159 \times \text{AHR (beats per min)} - 8.72$$

The workload was categorized as per the workload classification developed by Varghese *et al.* (1994) on the basis of heart rate and energy expenditure. The Total Cardiac Cost of Work (TCCW) was calculated as the sum of Cardiac Cost of Recovery (CCR) and Cardiac Cost of Work (CCW).

Rating of perceived exertion:

A modified rating scale of perceived exertion(RPE) developed by Varghese *et al.* (1994) based on Borgs 10 point scale (Borg, 1982) was adopted to measure the perceived exertion in terms of very light (1), light(2), moderately heavy (3), heavy (4) and very heavy (5).

Grip fatigue:

It was measured by using grip dynamometer before and after completion of activity separately for the right and left hand.

Musculo-skeletal problem faced:

To ascertain musculo skeletal problems in terms of severity of pain in different body parts among respondents, a three point scale was developed by the investigators *i.e* just noticeable pain, moderate pain and intolerable pain.

RESEARCH FINDINGS AND DISCUSSION

The results of the present study as well as relevant discussions have been presented under following sub heads:

Physical characteristics of the workers :

Assessment of the physical characteristics (Table 1) shows that the mean age of the workers was 35.5 years having weight and height as 43.6 kg and 154.9 cm, respectively. Lean body mass calculated was 29.4 kg and fat percentage was 14. For females the mean age was 37.5 with height and weight as 152.1 and 42.2 kg, respectively.

Body type and body mass index of the workers:

Body type was measured using Quetelet index after calculating height and weight of the workers. In case of male, majority (81.9 %) of the workers were having ectomorphic body type, which was followed by mesomorphic body type (18.1 %) (Fig. 1). In case of female workers, it was found that seventy five per cent of the workers were having

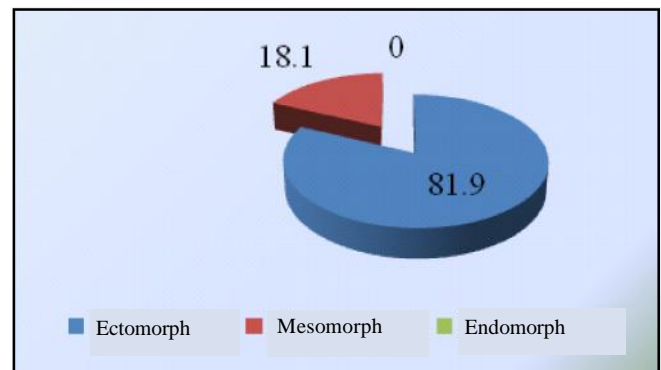


Fig. 1 : Body type (male)

Ectomorphic body type followed by Mesomorphic body type (25 %) (Fig. 2).

Body mass index (BMI), an important indicator of energy adequacy was calculated as 18.2 kg/m² in case of male and 18.4 kg/m² for female (Table 1). As per BMI classification, it was found that only 33.3 per cent of both

Table 1: Physical characteristics of the workers							
Workers	Age (yrs)	Weight (kg)	Height (cm)	LBM (kg)	BMI (kg/M ²)	VO ₂ Max	Fat Wt.
Male	35.5 (9.0)	43.6 (12.0)	154.9 (6.3)	29.4 (2.9)	18.2 (1.8)	27.7 (4.4)	14.0 (1.8)
Female	37.5 (7.0)	42.2 (3.6)	152.1 5.5	28.7 (1.9)	18.4 (1.9)	29.0 (5.3)	12.7 (1.4)

Figures in parentheses indicate S.D.

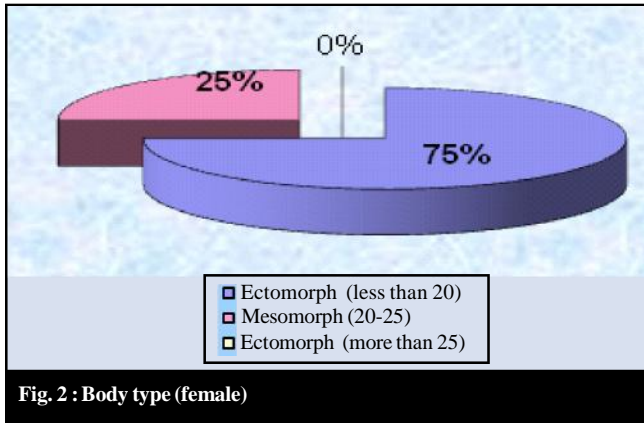


Fig. 2 : Body type (female)

male and female workers fell in the normal category of body type (Fig. 3 and 4). Moreover, 25 per cent of female belonged to Chronic Energy Deficient (Grade II) followed by equal percentage of workers (16.70%) fell in the category of obese (Grade I) and CED Grade I.

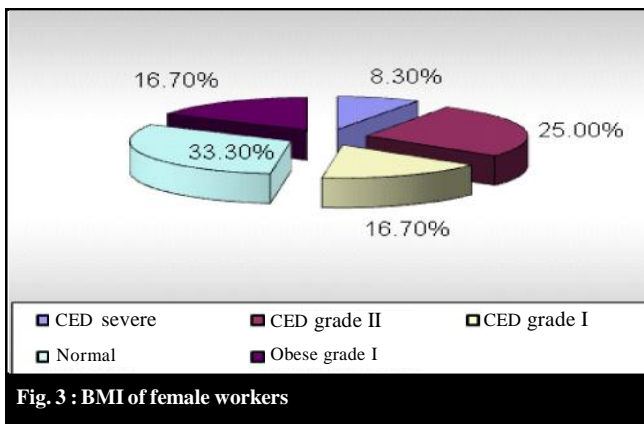


Fig. 3 : BMI of female workers

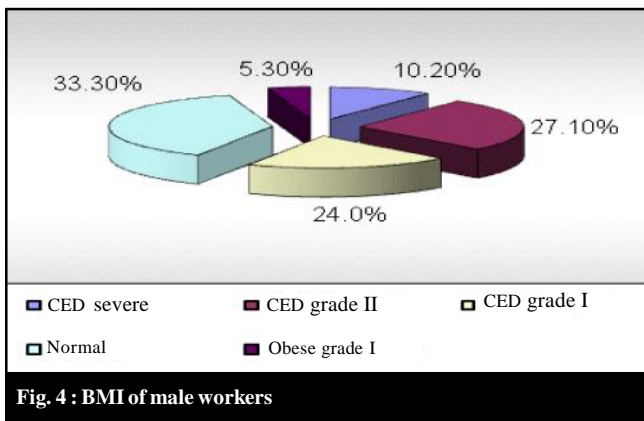


Fig. 4 : BMI of male workers

Regarding male workers, 27.10 per cent belonged to CED Grade II. About 10.20 per cent and 5.30 per cent male fell in severe Chronic Energy Deficient and obese (Grade I)

categories. Nearly twenty four per cent of male workers were found having mild Chronic Energy Deficient.

Physical fitness of the workers involved in different activities in tea fields:

The physical fitness and aerobic capacity (VO₂ Max) are considered as the best measure of an individual’s capability for doing physical work. Physical fitness was determined on the basis of PFI (Physical Fitness Index) through Step Stool method. It was observed that about 47.2 per cent of the workers belonged to the category of high average and almost an equal percentage of both male and female workers had low average (27.8 %) and good (25 %) physical fitness. None of the workers showed poor, very good or excellent physical fitness.

Postural analyses:

In tea fields, the workers were involved in performance of various activities and they assumed a variety of postures. These postures were studied with the help of flexi curve and presented in Fig. 5. It was observed from the data that the angle of deviation of male workers was highest during digging activity (8.5°) and in case of female workers, it was found to be maximum during deep skiffing (6.9°).

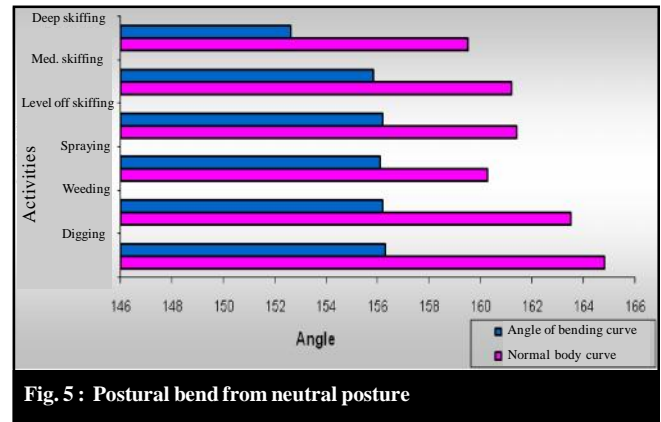


Fig. 5 : Postural bend from neutral posture

Ergonomic cost of activities:

Physiological stress:

Average and peak heart rate and average and peak energy expenditure:

Heart rate measurement during any activity is an indicator of cardiac stress due to physical workload. In any activity requiring physical effort, work is performed at the expense of energy. The energy expenditure rate indicates the level of bodily stress and the efficiency of any physical activity varies according to the type of activity and manner in which it is performed. Energy expenditure was calculated on the basis of average and peak heart rate as shown in Fig. 6 and Fig. 7.

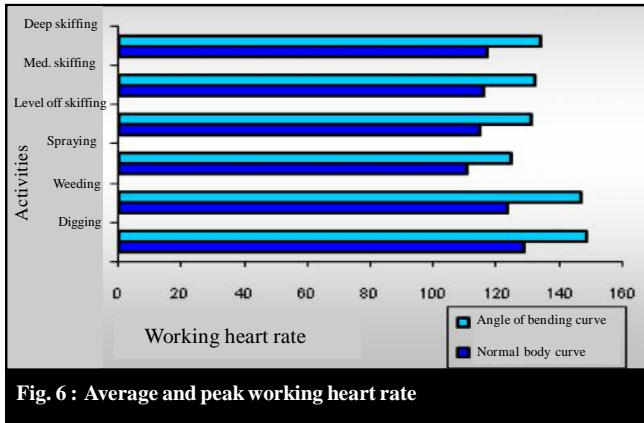


Fig. 6 : Average and peak working heart rate

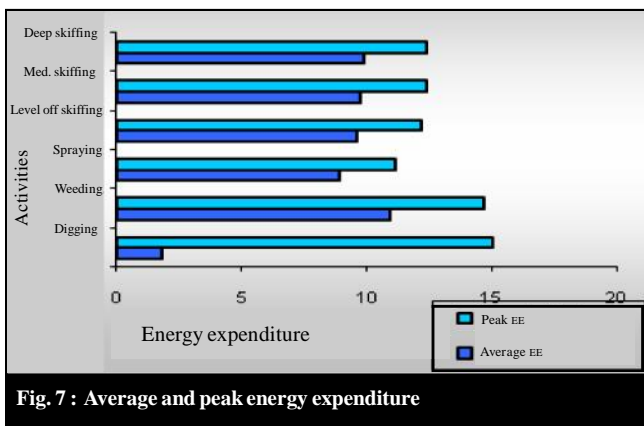


Fig. 7 : Average and peak energy expenditure

The average heart rate (beats/min) of the male workers was highest while digging (129 b/min) and that of female workers was during deep skiffing activity (117.1 b/min) which was considered as moderately heavy. The average energy expenditure (kj/min) was maximum for male workers while doing digging activity (11.8 kj/min) and for female workers while doing deep skiffing (9.89 kj/min). In case of male workers, the heavier activity next to digging was weeding.

Total cardiac cost of work (TCCW) and physiological cost of work (PCW):

The physiological cost of work (PCW) was calculated on the basis of TCCW and duration of the activity. Table 2

Activity	TCCW (beats)	PCW (beats/min)
Digging	1877.7	53.6
Weeding	1788.3	51.1
Spraying	1322	37.8
Deep skiffing	1514.6	43.3
Level of skiffing	1367	39.1
Medium skiffing	1477	42.2

exhibits that the average TCCW of male workers was found to be highest while performing digging activity (1877.7 beats) followed by weeding activity (1788.3 beats).

Likewise the average PCW of the male workers was more during digging activity (53.6 beats/min) followed by weeding (51.1 beats/min). In skiffing activities performed by female workers, the average TCCW and PCW were highest while doing deep skiffing (1514.6 beats and 43.3 beats/min). However, it was worth to be noted that the average TCCW and PCW was higher while doing level off skiffing (1477 beats and 42.2 beats/min) as compared to medium skiffing (1367 beats and 39.1 beats/min).

Classification of workload on the basis of heart rate and energy expenditure:

The knowledge of physiological workload in any occupation is of great practical value, particularly in giving attention to the economic use of human resources in order to provide comfort and consequently to promote health and well being of the workers.

Based on the working heart rate, recorded while performing different activities by the workers and indexed by Varghese *et al.* (1994), physiological workload was categorized and is presented in Table 3.

Activity	Classification of workload	
	Male	Female
Digging	H	-
Weeding	H	VH
Spraying	MH	-
Deep skiffing	MH	H-VH
Medium skiffing	MH	H
Level off skiffing	MH	H

(VL: Very light, L: Light, MH: Moderately heavy, H: Heavy, VH: Very heavy)

The findings on classification of workload showed that digging and weeding was found to be heavy activity for male respondents whereas deep skiffing was found to be heavy to very heavy for female respondents.

Rating of perceived exertion:

While performing an activity, individuals complain of tiredness or fatigue which is merely a subjective feeling providing reliable information for the assessment of work load (Borg, 1982). Exertion perceived by the workers in performance of various activities were recorded as very light to very heavy according to the modified Borg’s Rating of Perceived Exertion (RPE) scale which is presented in Table 4.

Pruning was perceived as heavy activity by 55 per cent of female respondents whereas 56.66 per cent male workers found it as moderately heavy activity. Spraying activity was perceived as heavy activity by 46.66 per cent of the male respondents.

Biomechanical stress:

Grip fatigue:

Muscular stress includes grip fatigue of hand muscles. Grip dynamometer was used to measure the strength of hand muscles of the respondents before and after completion of the activities separately for right and left hand. The grip strength of the male respondents was found to be higher for both the hands than the grip strength of female respondents. The changes of grip strength were higher while doing digging and medium pruning for male workers. In case of female workers, changes of grip strength were higher in light skiffing activity (Fig. 8).

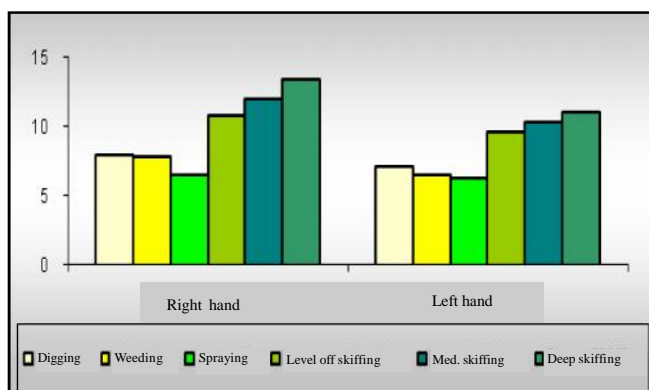


Fig. 8 : Average grip fatigue

Musculo-skeletal problems faced by the workers in performance of various activities in tea cultivation:

Occupational injuries and illness, particularly those known as work-related musculo-skeletal disorders (WMSD), result in pain and discomfort in different body parts of a significant numbers of workers in tea industry. A body map was used to study the WMSD among the workers and the findings are presented in Fig. 9.

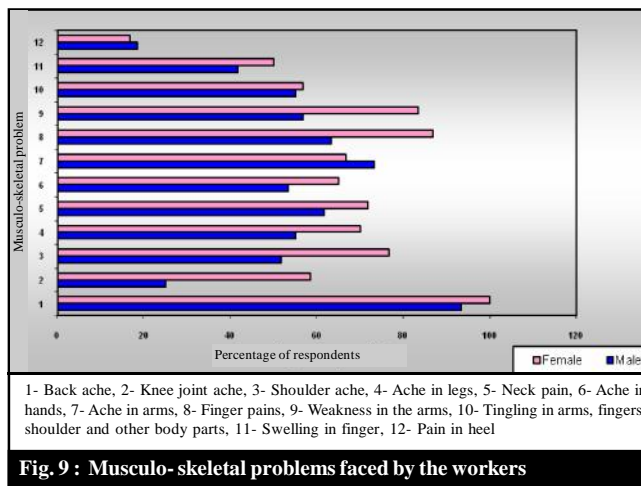


Fig. 9 : Musculo-skeletal problems faced by the workers

Data revealed that majority of the respondents both male (93.33%) and female (100%) were found to suffer from back pain. Evidence of MSP were more in case of female respondents than male. On the whole, finger pains, shoulder joint pain weakness in arms were common among both male and female workers.

Conclusion:

From the above discussion it can be concluded that among the different activities male workers considered digging as heavy activity and for the females it is the deep skiffing. It was observed that average heart rate and average energy expenditure of the male workers was highest (129 b/min and 11.8 kj/min) while digging and for the female deep skiffing activity was considered as moderately heavy with average heart rate as 117.1 b/min and energy expenditure as 9.89 kj/min. The grip fatigue was more during digging and medium skiffing activity of male workers and in case of female workers, it was higher during level off skiffing.

Recommendation:

Awareness regarding drudgery due to traditional working methods and faulty working habits must be imparted with the help of visits in teagardens, so as to enhance the work output and improve the health of workers.

Activities	No. of respondents	Rating of perceived exertion (RPE)					Total RPE	Mean RPE
		Very light (1)	Light (2)	Moderately heavy (3)	Heavy (4)	Very heavy (5)		
Weeding- male	45	-	17 (37.77)	23 (51.11)	5 (11.11)	-	123	2.73
Female	23	-	6 (26.08)	17 (73.91)	-	-	63	2.73
Pruning- male	60(100)	-	-	34 (56.66)	18 (30)	8 (13.33)	214	3.56
Female	60(100)	-	-	17 (28.33)	33 (55)	10 (16.66)	233	3.88
Digging- male	60	-	-	40 (66.66)	12 (20)	8 (13.33)	208	3.46
Spraying-male	60	-	-	30 (50)	28 (46.66)	2 (33.33)	212	3.53

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