An ergonomic assessment and fitness evaluation of young male tea factory workers in Dooars, West Bengal

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ABSTRACT

Introduction: There are very few published reports on the heath status of tea garden workers of West Bengal, while reports on cardiorespiratory fineness and body composition of male tea factory workers is almost scanty.

Purpose: The present study was carried out in the Dooars region of the Cooch Behar district, West Bengal to evaluate the physical fitness and morphological characteristics due to the physiological workload of respondents engaged in processing of tea leaves in factories within the tea-estates.

Materials and methods: A cross sectional study was carried out in 18-25 years' young male tea-garden workers (n=15) by random selection from Cooch Behar District, West Bengal (mean age 20.1) and college students (n=15) of Kolkata (mean age 21.9), who served as controls. Cardiorespiratory fitness was estimated in terms of maximum oxygen uptake ($VO_{2\ max}$) and physical fitness index (PFI), while morphological characters were estimated by means of physical anthropometric measures.

Results: A significant difference in body surface area, body mass index, percentage of body fat (% fat), blood pressure, physical fitness index, energy expenditure, anaerobic power, mean upper arm circumference, thigh circumference, waist circumference and buttock circumference were found ($p<0.05$) in tea garden workers. No significant difference was observed in calf circumference and waist-to-hip ratio (WHR).

Conclusions: On the basis of the findings of the present study using morphometric indicators and fitness markers it can be concluded that, the majority of respondents had an ectomorph stature but have good physical fitness level.

Key words: BMI; blood pressure; body fat; physical fitness; tea garden workers; VO_{2max}; WHR.

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INTRODUCTION

Tea is an indispensable beverage used the world over and is brewed from the tea plant *Camellia sinensis.* Manufacture of black tea involves several labor intensive processes. In India, it is done on a large scale. Tea of Darjeeling and Dooars of West Bengal is treasured all over for the fragrant aroma which distinguishes the thin liquor produced by the tea. Tea is an important agro-industry of West Bengal, which contributes immensely to the state's economy [1]. The data compiled by the Labour Bureau of the Government of India from annual returns under the Plantation Labour Act, 1951 showed that nearly 10.9 lakh (one hundred thousand) persons were employed in the plantation sector, comprising about 10.2 lakh persons in the tea sector only. Among them, at all Indian levels, 50 percent of the workers in tea and coffee plantations were women. Similarly, in West Bengal, the women laborers have a greater significance in the plantation establishment and constitute about 52 percent of the labor force. The role of women is at the forefront, because they are deft in tasks related to tea plucking and other related jobs [1].

The young tea shoot when harvested undergoes several treatments prior to the final product is derived. Initially the shoots are withered by blowing warm air over the leaves followed by rolling, a process which breaks up the dehydrated leaf enabling the polyphenol catechins to be oxidized. Then, the leaves are allowed to ferment, during which the oxidized compounds are polymerized into theaflavin and thearubigin which gives the tea its color and quality. The fermented tea is dried and sifted to be sorted according to the different sizes. Once sorted, the tea is blended and packed before export. Sifting and blending are the dustiest processes in the tea industry and the workers involved are exposed to the hazard of inhaling the dust [2].

However, in tea factories, the majority of the workers are male who are continuously being exposed to tea dust and they are practiced to keep on their work in such environment. The major classes of male tea factory workers, who perform this processing, could be classified into the following groups (the term 'workers' refers to all those who provide productive labor): *Operators*, which comprise all employees working on production lines, generally have continuous exposure to tea dust; *Fitters*, which comprise all maintenance fitters working on the production lines, generally have intermittent exposure; *Administration*, which comprises all office employees and managers, has had a minimal role in production areas and has most likely had minimal exposure; *Blenders*, which comprise all employees in the blending area, are the most profoundly exposed in general; *Others*, which comprise all other employees, such as forklift drivers and warehouse employees, have most likely had less exposure than the production group but sufficient exposure that they could not be included in the administration group. The work is being performed by these groups of male laborers in the traditional way, without any knowledge of health impact. Due to this strenuous work, the output of leisure of the worker decreases and the health is also affected [3]. Inhalation of tea dust is known to give rise to both acute and chronic respiratory symptoms. Acute symptoms consist of burning sensation in the throat, nasal discharge and bleeding, irritation of the eyes and headache [4, 5]. Chronic symptoms include byssinosis [6], chronic cough, phlegm and dyspnoea [5, 7]. Allergic reactions such as nasal catarrh and occupational asthma [8-10] too have been reported. Respiratory functions of tea workers, employed in processing different types of tea, showed prevalence of almost all chronic respiratory symptoms; acute reductions in forced expiratory volume in one second were considerably smaller suggesting the bronchoconstrictor effect of the tea-dust that acts mostly on smaller airways. A comparison of ventilatory capacities in tea workers with those in controls indicated that exposure to tea dust leads to chronic respiratory impairment [2].

Table 1. Location of Dooars in West Bengal: at a glance.

a) Location:	Latitude 89°N - 89°9'N Longitude 26°3'E - 26°8'E
b) Average elevation:	61 m (above 200ft.)
c) Total population: (As per 2001census)	156312
d) Total area:	68,000 ha
e) An average family size	6.1
f) Number of tea gardens:	163
g) Total number of tea garden workers:	250,000

In addition, Dooars is located about 61 meters (200ft) above sea level in a cold temperate climate, which may also affect physical and physiological fitness, in addition to the effects of their work load and other exposures in the working environment. There are very few reports about the health status of tea workers in West Bengal. However, reports about the overall physical fitness pattern with special reference to their respiratory and cardiac parameters are scanty. But, reliable information on health status of a population is an essential pre-requisite for formulating health care system to address health needs. Thus, the aim of this investigation was to determine the physical fitness of male tea garden workers and to test the hypothesis that geographical location and workload have an influence on the physical fitness of workers.

MATERIALS AND METHODS

Selection and preparation of subjects

To conduct the study, fifteen male subjects between 18-25 years of age (mean age of 20.1 ± 1.73) are selected randomly as volunteers from tea garden workers' colony of Damanpur village, New AlipurDuar, Cooch Behar District, West Bengal. By house-to-house visit; majorities of the respondents were unmarried, illiterate, belonged to backward classes and followed a nuclear family. On an average, the respondents were employed for last five years. Their sedentary counterparts (n=15) matched for age, sex were selected as the control group from college students of Kolkata, West Bengal (mean age of 21.9 ± 2.25). The sedentary participants had no history of any major disease and did not participate in any physical conditioning program. All the participants were non smokers. The entire experimental protocol was explained to them to allay their apprehension. Consent from each participant was taken for conducting the study and the experiments were carried out following Institutional ethical permission. Subjects were instructed to take their last meal at least two hours before conducting the tests in order to avoid the specific dynamic action (SDA) of food. All the experiments were carried out and measurements were taken in temperature of 20^0-25^0C and relative humidity of about 45-50% in winter season in India, both in control subjects and male tea garden workers, to avoid seasonal influence on fitness pattern. To minimize the experimenter bias each measurement was taken for three times and the mean was represented as final result. Each subject was given sufficient rest before each experiment to get accurate result.

Anthropometric measurements

Anthropometry is the single most universally applicable, inexpensive, and non-invasive method available to assess the size, proportion and composition of the human body. Height was measured using a vertical measuring rod with headpiece without wearing footwear. The volunteers are asked to stand on the flat surface, heels together and head positioned so that the line of vision was perpendicular to the body. The arms hanged freely by the side, and the head, back, buttocks, and heels are in contact with the vertical measuring rods. The individuals were asked to inhale deeply and maintain a fully erect position. The movable headpiece was brought onto the topmost point of the head with sufficient pressure to compress the hair. Height was recorded to the nearest 0.1cm.

Weight was recorded using a digital balance. The accuracy of weighing machine was checked in every session against a known weight. The respondents were asked to stand still in the centre of the weighing machine platform without support, with the body weight evenly distributed between both the feet. Weights were taken with standard minimal clothing. They were also asked to remove shoes, socks, etc. Weight was recorded to the nearest 500gm.

Curvilinear distances (circumferences) were also taken as the midpoint of mean upper arm (MUAC), mid-thigh (TC), calf muscle of leg (CC), waist (WC) and buttock (BC). WC and BC are used to predict the body-fat content and used to calculate waist-to-hip the ratio (WHR). MUAC is an index of body energy store and protein mass. Sometime it is combined with skin fold thickness to calculate the areas of arm muscle and adipose tissue. TC indicates muscle atrophy due to disease or atrophy, and CC provides an estimate of cross-sectional and adipose tissue areas of calf [11].

Assessment of Body Mass Index

The body mass index (or *Quetelet Index*) is the statistical measure which compares a person's weight and height by the following formula [10, 12]: $BMI = (weight\ in\ kg) / (Height\ in\ m^2)$. The WHO [13] regard a BMI of less than 18.5 as underweight and may indicate malnutrition, an eating disorder, or other health problems, while a BMI greater than 25 is considered overweight, and above 30 is considered obese.

Body-fat percentage measurement

Body fat can be estimated from the Body mass index (BMI). There is a linear relationship between densitometrically-determined body-fat percentage (BF %) and BMI, taking age and gender into account. Based on which following prediction formula has been derived – that showed valid estimates of body fat at all ages, in males and females. However, in obese subjects, the prediction formulas are slightly overestimated. The prediction error is comparable with other methods of estimating the body-fat percentage, such as skinfold thickness measurements or bioelectrical impedance [14-16]. The following formula was used to predict the body-fat percentage is based on current BMI, age, and gender: $Adult\ Body\ Fat\ \% = (1.20 \times BMI) + (0.23 \times Age) - (10.8 \times gender) - 5.4$ [Gender values for male = 1, female = 0].

Body Surface Area

Body surface area (BSA) represents the measured or calculated surface of a human body. Various calculations have been published to get BSA without direct measurement. Dubois &

Dubois's formula was used for estimating body surface area (BSA) [17]: $BSA\ (m^2) = 0.007184 \times Weight\ (kg)^{0.425} \times Height\ (cm)^{0.725}$

Resting on heart rate and blood pressure

Baseline HR was obtained after five minutes rest in the sitting position. The resting heart beat was measured at the carotid pulse. When two successive heart rate scores become equal then it was considered as resting heart rate [18].

Arterial pressure is most commonly measured by a sphygmomanometer, which historically used the height of a column of mercury to reflect the circulating pressure [19]. BP values were obtained after five minutes rest in the sitting position [20].

Physical Fitness Index

PFI was calculated by measuring heart rate after performing Harvard's step test (HST) developed by Brouha et al. in the Harvard Fatigue Laboratories using long form PFI equation [21]. However, following modified HST under Indian condition, using a stool of 51 cm high stepping up and down with a rate of 30 cycles/ minimum for 3 minutes or up to exhaustion. Exhaustion is defined as when the subject cannot maintain the stepping rate for 15 seconds [22, 23]. The recovery pulse was counted at 1 to 1.5, 2 to 2.5 and 3 to 3.5 minutes of recovery. **Long Form Equation-Fitness index** = *[100 × Test duration in seconds] / [2 × Recovery heart rates (1 to 1.5 minutes + 2 to 2.5 minutes +3 to 3.5 minutes)]*

Anaerobic Power Test by Margaria Double Step Method

It is a short-term anaerobic test or power test in which the subject taking two steps at a time; the heights of the stairs are measured by measuring tape. To calculate the anaerobic power; the height of ascend, the body weight, and the duration (seconds) is noted by the stopwatch [24]. At first the work done is calculated by the following formulae: *Work done = body weight × height of ascend × 0.002342*

From the calculated work done, the anaerobic power is obtained by the formulae: **Anaerobic power** = *[Work done (kg/m) / duration (sec)]*

Determination of Aerobic Capacity ($VO_{2\,max}$)

It is the maximum amount of oxygen consumed during rhythmic dynamic progressively increasing exercise done by any kind of ergometer (treadmill, stationary bicycle ergometer, hand cranking, etc.) at sea level under thermally neutral condition when more muscle mass recruited then capacity of O_2 is increased. Nomogram of Astrand was used to determinate the $VO_{2\,max}$ [25].

Energy Expenditure

Energy expenditure for any kind of job is normally measured by different calorimetric methods. It has also been determined by the predictive formula [26]: $EE\ (Kcal.\ min^{-2}) = -1.42 + (0.045 \times peak\ H.R)$

Statistical analysis

Data are expressed as mean ± SD. Comparison of parameters between control and male tea garden workers was done by two tailed unpaired *t*-test, using Microsoft Excel- 2007 and the result was considered as significant when the two-tailed $p < 0.05$ [27].

RESULTS

All the respondents under study were employed as casual laborers in the tea estates. The mean age, height and weight of the respondents were 20.1 ± 1.73 years, 163.8 ± 7.50 m and 46.3 ± 3.04 kg, respectively. The physical parameters and fitness variables are presented in Table 2.

Table 2. Physical parameters and fitness variables of control subjects and tea garden workers.

	Control	Tea garden workers
Height (cm)	164.6 ± 7.21	163.8 ± 7.50
Body weight (kg)	59.3 ± 7.50	46.3 ±3.04†
BMI (Kg/m^2)	21.7 ±1.93	17.1±2.40†
Body Fat (%)	20.4±1.74	17.4± 1.95†
Body Surface Area (m^2)	1.68 ±0.08	1.47± 0.12†
Resting Heart Rate (beats/min)	76.2 ±8.10	73.6±6.00†
Systolic Blood Pressure (mm of Hg)	123.0±4.62	115.0 ±2.00†
Diastolic Blood Pressure (mm of Hg)	84.1±6.84	78.0 ±9.16†
Physical Fitness Index (%)	69.9±4.80	81.3 ±6.63†
Anaerobic power (kg.m^{-1}.sec^{-1})	12.3±2.46	15.3 ±3.06†
$VO_{2\,max}$ (liters.min^{-1})	3.12±0.33	3.21 ±0.45†
Energy expenditure (KCal. min^{-2})	5.67±0.57	4.47±0.63†

Values are mean ± SD, sample size (n_1=n_2= 15). Superscript (†) indicates significant difference by two tail unpaired *t*-test (for equal variances) at p<0.05.

VO_{2max} was significantly (P<0.05) higher among the tea factory workers whereas the physical parameters also exhibited significant inter-group variation. Anthropometric measures are given in Table 3.

DISCUSSION

The mean body mass index of the respondents was significantly lower than in the control group. On an average, VO_{2max} was 3.21 ±0.45 l/min for the respondents. Among both the groups, control group had lower VO_{2max} (3.12 ±0.33 l/ min) than tea factory workers. It indicated that people of the larger body build or higher BMI to have lower VO_{2max}.

Table 3. Comparison of anthropometric measures between control and male tea factory workers.

Group	Control	Tea garden workers
Mean Upper Arm Circumference (cm)	27.0±4.11	24.5±2.40*
Thigh Circumference (cm)	47.1±5.49	44.4±3.06*
Calf Circumference (cm)	32.7±3.54	32.4±2.34
Waist Circumference (cm)	75.9±4.53	70.2±4.48*
Buttock Circumference (cm)	81.3±6.03	77.1±2.05*
Waist-to-Hip Ratio	0.93±0.02	0.91±0.01

Values denote mean ± SD, sample size (n_1=n_2= 15). Superscript (*) indicates significant difference by two tail unpaired *t*-test (for equal variances) at p<0.05.

The body type of the respondents categorized assuming the body mass index showed that majority of the respondents had ectomorphic body type (BMI value <20). A result of present study reveals that physical parameters of tea garden workers significantly differ from the control group, which may be due to their less body weight; this resembles, in general; data of West Bengal were more than 22 percent of people are reported to be underweight, which has been corroborated with our earlier findings [28]. The BMI is an index of weight adjusted for stature. It is one of the useful tools for diagnosing obesity or malnutrition. However, such diagnosis should take into account a person's age, sex, fitness and ethnicity. In contrast, young tea garden workers were found to have less body-fat percentage than sedentary population. Some earlier studies also reported lower body mass index in adolescents among tea garden workers. They as well reported prevalence of stunting and thinness among different age groups of tea garden workers [29].

Cardiorespiratory fitness is a measure of how well; a physiological system is capable of transport oxygen to muscles during prolonged exercise. Resting on heart rate and aerobic capacity or maximum oxygen uptake capacity (VO_{2max}) has been extensively considered to be a reliable and valid measure of cardiopulmonary or aerobic fitness [30, 31] along with endurance. Energy required by muscle for physical movement normally is originated through aerobic metabolism. Therefore, workload could be measured through calculation of $VO_{2max.}$ As tea garden workers (for example, fitters, blenders) on average perform work related to muscular strength, no significant change was found in these parameters. High levels of productivity demand adequate energy intake as well as expenditure and reasonable health to those who are associated with labor-intensive and work-related activities. This result may have some correlation with the findings of Bailey et al. [32] who have found that lower VO_{2max} levels in men were associated with an increased probability of being overweight or obese. Therefore, it can be presumed that higher body weight of control subjects, in the present study, thus, influenced over their oxygen uptake capacity. Strength exercise increases ventricular muscle mass [33,34], which results in increased force of contraction and hence cardiac output, but, in this study, a significantly lower systolic blood pressure was observed among tea garden workers. However, in contrast, their pulse rate recovered quickly, which is an indicator of better fitness, which is reflected in considerably higher PFI and lower energy expenditure, and they also have better anaerobic power than sedentary workers (Table 2). This may be the possible explanation of energy balance in workers. PFI scores are useful measures of fitness for strenuous exercises. Physical fitness has three main aspects: static fitness (absence of disease), dynamic fitness (ability to perform strenuous work) and motor skills fitness. Of this three, dynamic fitness is very important and can be measured by Harvard Step Test [35].

Functional correlates of nutritional status can be a useful adjunct to anthropometric and laboratory indicators in the assessment of nutritional health and well-being. It also provides a practical perspective to reference values and cut-off points, which would otherwise only be a reflection of given populations nor, but not necessarily of its health and vitality. Anthropometry offers a reliable method to assess the nutritional status. In the present study, young tea garden workers found to have less MUAC than control subjects, which is an estimate of energy store and protein mass of the body which is an indirect estimate of strength. There are many ways in which nutritional status may affect productivity and well-being of workers. WHR [36] is found to be insignificant in tea garden workers than control subjects, which are another indicator of less fat percentage in tea garden workers than control subjects, which is caused by their poor nutritional status and economic condition. BMI along with waist circumference has been used to evaluate health risks associated with obesity, because fats redistribute centrally with increases in waist circumference and results in altered WHR [33, 37]. However, no significant difference was calf circumference and WHR between two groups (Table 3). Thus, it may be inferred that workload as well as nutritional status has influence over the ergonomic and physical fitness status of young tea garden workers.

The present study, being a cross-sectional one, has inherent limitations and cannot depict the true picture of physical fitness status in the community. Variation in the data may occur due to the locations of the garden and other factors.

Further research should be carried out to understand more precisely the factors contributing to the health profile in this community, which will help in undertaking interventional measures to ameliorate their health status. The study also emphases the need for more research on health problems more specifically linked their occupation.

CONCLUSIONS

The majority of respondents had ectomorphic body build and had higher VO_{2max} than the control group. A significant difference in BSA, BMI, BF%, SBP, DBP, PFI, energy expenditure, anaerobic power, MUAC, TC, WC and BC were found in tea garden workers. However, in contrast, CC, and waist-to-hip ratio was found to be non-significant.

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Conflict of interest/competing interest

Authors declare that they do not have any conflict of interest about the publication of this article.

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