A COMPARATIVE STUDY OF PHYSIOLOGICAL COST OF CHAPATI MAKING IN SQUATTING AND STANDING POSITIONS

By

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Thesis submitted to the Punjab Agricultural University in partial fulfilment of the requirements for the degree of

MASTER OF SCIENCE

in

HOME MANAGEMENT

College of Home Science
Punjab Agricultural University
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1980

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To

MY PARENTS

CERTIFICATE I

This is to certify that this thesis entitled "A Comparative study of physiological cost of chapati making in squatting and standing positions" submitted for the degree of M.Sc. in the subject of Home Management of the Punjab Agricultural University, is a bonafide research work carried out by Miss Jyoti Bala under my supervision and that no part of this thesis has been submitted for any other degree.

The assistance and help received during the course of investigation have been fully acknowledged.

6.10.80

MAJOR ADVISOR
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CERTIFICATE II

This is to certify that the thesis entitled "A comparative study of physiological cost of chapati making in squatting and standing positions" submitted by Miss Jyoti Bala to the Punjab Agricultural University, in partial fulfilment of the requirements for the degree of M.Sc. in the subject of Home Management has been approved by the Student's Advisory Committee after an oral examination on the same, in collaboration with an External Examiner.

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CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Energy is an internal or inherent power and a capacity for acting, operating and producing an effect whether exerted or not. In human beings, it is supplied by the food and its oxidation provides the force with which the muscles work. Rate of oxygen consumption has been accepted as a measure of energy expenditure since early twentieth century. Researches involving oxygen and sometimes carbon dioxide determinations have been conducted in several phases of human activity, chiefly athletics, and army activities. In recent years, a concern for human energy as a resource in management has led to a change in emphasis in studies of energy, particularly, in those dealing with household tasks.

Technological developments and social changes (attitudes) have enabled many women to participate in dual role of home and outside employment. Hence it is of utmost importance to find out means and methods to change the working habits of the females. However, very little factual knowledge is available regarding the basis for recommending the method of work.

Homemaker's job comprises of many tasks which can be performed either in squatting or standing positions. Working in squatting position may relieve the leg muscles but may not result in enough energy savings (Steidl and Bratton, 1968). Squatting position if maintained for long, may lead to the pain in lower extremities because of restricted circulation of the blood.

In general, a majority of homemakers in the rural set-up perform most of their household activities in squatting position, whereas, urban population prefers standing position. The preference for standing position may be because the movements while working in this position are easier which might affect the energy expenditure also. Therefore, it is important to compare the physiological cost of working in both of these positions. Moreover, Dhesi and Chahal (1975) while studying the physiological cost of chapati making used the heart rate as an index which is an unreliable parameter. Therefore, the present investigation was carried out by using energy expenditure. It is a valid and reliable parameter for determining the physiological cost quantitatively because the energy expenditure is proportional to the amount of physiological labour put in. This is especially true for the physical activities, since mental activities have no measureable effect on it. Age, sex, size of individual, equipment and method of work as well as the rate at which the work is done are influencing factors.

Flat-unleavened bread - henceforth mentioned as chapati - is the staple item of food in the Indian diet, particularly in Punjab. Chapati making is a time consuming process performed in the same body position often three times a day. Therefore, this task was selected for the present investigation.

The main objective of the study was to compare the physiological cost of chapati making in squatting and standing positions in terms of carbon dioxide production, oxygen consumption, energy expenditure and pulmonary ventilation rate.

CHAPTER II

REVIEW OF LITERATURE

Since centuries man has endeavoured to 'save' human energy by means of work simplification. This resulted in the invention of simple machines such as levers, wheels and has continued throughout the history of mankind to the automation of the present twentieth century. While mankind in general has sought to lessen his physical activity, the housewife has been reluctant to deviate from early methods. It has been said, the progress of the homemaker is about a generation behind that of industry. The studies of energy expenditure, heart rate, blood pressure and posture, therefore, are helping to make substantial strides in aiding the homemaker to better manage her human resources in the maintenance of her home.

The studies on energy expenditure in the performance of various household tasks were reviewed under the following headings:

1. Anthropometric data
2. Posture
3. Oxygen consumption
4. Energy expenditure
5. Pulmonary ventilation
6. Methods of approach

1. Anthropometric data

The physiological cost of working is greatly influenced by anthropometric data. It has been reported by several workers (Mahadeva et al, 1953; Brown, 1961; Malhotra et al, 1962; Rajagopal and Ray, 1977) that body weight has a linear relationship with energy expenditure. In dynamic activity, the weight of the body itself was considered to constitute the energy load. It was also reported by them that height, age, sex, race and resting metabolism did not have any significant effect on the oxygen uptake and energy expenditure.

Passmore and Durnin (1955) emphasised, that when the energy consumption was expressed in Cal/min, then body weights of the subjects had to be given along the data since the heavy people had a higher energy consumption than the lighter ones.

Rajgopal and Ray (1977) pointed out that body surface area had a positive relationship with energy expenditure.

2. Posture:

Orsini and Passmore (1951) reported that in carrying loads up and down stairs, most of the energy was used up in maintaining the posture of the body.

Snorrason (1955) emphasised that working position, whether sitting or standing, had to permit the posture which relied on the natural balance over the base of the support and not on the distorted posture which was maintained by the contractions of the muscle groups required for holding the body erect. However, Bratton (1958) compared different postural conditions and reported that standing position was more favourable for arm motion than the sitting position. Average energy cost for standing position was 1.45 Cal/min and it was 1.53 Cal/min while sitting on a stool of medium height and working on a counter 36 inches high.

Carlsoo (1961) reported that those muscles of the lower leg which form the foot joint were very responsive to changes in the body posture. Several of these including the tibialis anterior, located in osteofibrosis space, restricted the contraction of the muscles. As a consequence fatigue and pain was produced in an anterior part of the lower leg. He suggested that any working posture requiring the continuous use of the tibialis anterior should, therefore, be avoided.

Research conducted on "Body movements related to energy used" by Keiser and Weaver (1962) revealed that knee bend correlated more closely with energy expenditure. Correlation coefficients were slightly higher for descending than ascending the stairs.

Fahrni (1966) emphasised that any standing or sitting position was a strain on the back when it increased the lordotic curve of the spine and when the curved position was maintained for a period of time.

Broer (1966) indicated that keeping arms around the knees pulled the shoulders and rounded the upper back. It was also reported that when this position was maintained for a length of time, the pressure exerted on blood vessels and nerves, particularly those running behind the knees, cut off the circulation and nerve supply to the lower legs.

An evaluation of energy expenditure for various work postures and their effect on total energy expenditure led to the conclusion that when the work at heart level was taken as reference, it was increased by 20 per cent at eye level and by 65 per cent at maximum height above the head. The heart rate during effort varied according to the posture adopted (Tarriere and Andre, 1970).

Grieve (1972) studied the heart rate and daily activities of housewives with young children. It was found that average heart rate during sleep ranged from 56-76 beats/min and mean heart rate during work was 82-110 beats/min in the twelve mothers studied. The average for the whole group was 95 beats/min. The variation among the subjects was not correlated with age, body weight, time spent or the number of children in the family. In short, all the standing activities involved in home management and child-care gave rise to the heart rate within five beats per min of the mean daily heart rate. Only a few activities namely heavy house work, walking at 2.7 m.p.h.,carrying loads up to 20 kg, raised the heart rate above this limit.

Ganguli et al(1973) reported that the activity of standing erect required full participation of the lower extremities along with the head and trunk which included some extra work.

The postural effect on the relation between oxygen consumption and heart rate was studied by Sato and Tanaka (1973). Significant differences for different postures were more frequently observed for mean heart rate levels than for oxygen consumption. Analysis of covariance indicated that changes in heart rate were independent of the oxygen intake. Vos (1973) pointed out that bending and kneeling required less energy than squatting. Squatting appeared the most favourable posture, when the work was carried out on the ground level.

Dhesi and Chahal (1975) studied the effects of stages of chapati making and angles of body bend on heart rate during sitting and standing postures. It was found that heart rate was maximum during rolling stage of chapati-making both in sitting and standing postures and increase in heart rate was more in case of sitting levels than in standing level kitchens.

The effect of leg and arm exercise in sitting and standing body positions on energy expenditure and heart rate revealed significantly higher uptake of oxygen and heart rate in arm cranking than in cycling at submaximal work load (Vokac et al, 1975). No significant difference was found in arm work done at sitting and standing body postures.

3. Oxygen Consumption:

It has been reported by several workers (Robinson, 1938; Taylor et al, 1955; Mitchell et al, 1958) that maximum oxygen consumption was the best single physiological indicator of a man's capacity for maintaining extremely heavy work.

Astrand (1960) reported that the maximum oxygen consumption declined with age in men, from an average of 50 ml/kg/min at 18 years of age to 26 ml/kg/min at 75 years of age. The maximum oxygen was also reported to be independent of the capacity to ventilate lungs and oxygen diffusing capacity of the lungs.

Royce (1962) measured the oxygen consumption over ten second intervals during seven minutes of static leg work and seven minutes after recovery. He found that the rate of rise of oxygen consumption did not appear to be related to the intensity of the task, but the more intense the task, the larger the recovery time. It was also indicated that at the end of the particular task, oxygen consumption sudden ly increased and then gradually declined.

Margaria et al (1963) reported that oxygen consumption did not rise instantly at the start to the level required to supply by oxidation all of the energy being expended even in light work, nor did it return instantly to the resting level when the work was stopped. Oxygen consumption, beginning at the resting level was rapidly accelerated in the first two minutes and leveled off at the steady rate after the second minute. As the work continued at the constant rate, the oxygen consumption remained constant.

Schnauber and Müller (1970) found that maximum working time decreased with increased elevation of hands during work and increase in heart rate became faster.

Oxygen consumption was also increased with increased elevation of hands so that mechanical efficiency decreased from 13 per cent (work at heart level) to 2 per cent (maximum elevation).

Wald and Harrison (1975) emphasised that for oxygen consumption, the rise time for the light tasks was significantly shorter as compared to heavy tasks.

The effect of dynamic, static and combined work on heart rate and oxygen consumption was studied by Sanchez et al (1979). They found that oxygen and cardiac costs increased linearly with the load for static and combined work, and with the speed for dynamic work.

4. Energy Expenditure

Swartz (1933) conducted a series of experiments on energy cost of different household activities by indirect calorimetry. It was reported that for most of the activities the energy cost did not exceed 2 Cal/min. For only the most strenuous activities like hanging clothes from the basket on the floor, the energy cost went beyond 3 Cal/min.

Bratton (1958) found that the energy expenditure when seated to work with the knee forced to one side was 1.5 Cal/min, which was slightly higher than that for standing to work(1.4 Cal/min.).

A study of human energy expenditure as a criteria for the design of household storage facilities by McCracken and Richardson (1959) revealed that for the floor cabinets, energy requirements were increased as shelf was raised above or lowered below 36 inches. For the open shelf cabinet above the work surface, energy requirements increased more rapidly with increased vertical height. For storage on open shelves above a work surface, less energy was required while sitting as compared to standing at lower shelf heights. However, at higher shelf heights more energy was required when sitting.

Richardson (1960) showed that there was an increase of 31 per cent in energy expenditure in case of ironing while sitting than that of required for sitting at rest. The increase was only 28 per cent in case of ironing while standing than that for standing quietly.

Richardson (1966) studied the energy expenditure of women during cleaning carpets with three types of vacuum cleaners and found that the energy expenditure was 63.7 and 70.0 Cal/sq.metre/hr for operating the three cleaners at the speed of 1.16 and 1.75 ft/sec. respectively. The increase over resting metabolism was 93.9 and 113.2 per cent for operating them at two speeds, whereas it was 49.3 and 64.1 per cent over standing for both the rates respectively.

Datta et al(1973) studied the relationship between energy expenditure and pulse rate with body weight and load carried. The weight transported and energy expenditure as well as heart rate were found to be highly and positively correlated (r = 0.91 and r = 0.88 respectively).

5. Pulmonary Ventilation rate:

Pulmonary ventilation usually means the volume of air which is exhaled per minute. The amount of inhaled and exhaled air is usually not exactly equal, since the volumeof inspired air in most situations is larger than the volume of carbondioxide expired (Åstrand and Rodahl, 1970). The pulmonary ventilation volume of expired air in litres/min.depends upon the intensity of work. The response is brought about by increasing both the tidal air and the frequency of respiration.

Durnin and Edwards (1955) found that during light and moderate exercise, when pulmonary ventilation was normally less than 50 litres per minute, the oxygen consumption of an individual was directly proportional to the pulmonary ventilation. They also emphasised that there were fairly large individual variations in relationships between pulmonary ventilation rate and oxygen consumption. Therefore, a separate regression line was drawn for each individual using the variables, pulmonary ventilation rate and energy expenditure. The more the readings of pulmonary ventilation, the greater the accuracy of measurement of energy expenditure by this method.

Karpovich (1966) reported that there was an approximately a linear relationship between pulmonary ventilation rate and oxygen consumption. It was also emphasised that this relationship was not only true during work but in the recovery period also. With an overload, however, this proportionality was disrupted and ventilation increased for excess of oxygen consumption.

Saltin and Astrand (1967) also reported that positive correlation existed between maximum pulmonary ventilation rate and oxygen consumed, but they also emphasised that maximum pulmonary ventilation could not be used for prediction of maximal oxygen uptake, as during heavy exercise pulmonary ventilation rate markedly increased without any further increase in oxygen uptake.

6. Methods of Approach

Scientific management had been considered in the measurement of energy. In this method, the motion of the workers were carefully surveyed, then recognised to eliminate as many motions as possible, thereby theoretically reducing the amount of energy required. Taylor (1911) and Gilbreth and Gilbreth (1917) reported that the correlation existed between the reduction of time and motion and the amount of energy expended. However, later experiments (Mahadeva et al, 1953; Keiser and Weaver, 1962; Rajgopal and Ray, 1977) showed that factors such as body weight, age, sex and posture tended to invalidate these theories.

It became necessary to use more exact means of measuring the energy of man. This was done by measuring the amount of heat produced by the body. In direct method, actual measurements of the heat given off by the body were made. In indirect ones; the oxygen consumption in a given interval was measured and converted to calories. In this case, either a closed or open circuit apparatus was used. The closed circuit type required the subjects to inhale oxygen-rich air from a spirometer. The exhaled air passed from a carbon dioxide absorbant as it returned to the spirometer. This reduction in oxygen in the spirometer was recorded on a kemograph. The open circuit type allowed the person to breath atmospheric air, the exhaled air was collected, measured and samples analysed for oxygen and carbon dioxide content. Early studies were conducted in the United States using a direct method of measurement, a calorimeter chamber. These experiments were costly and slow in obtaining results. So the analysis of the gas sample has continued to be the predominant method of determining energy expenditure. Either a spirometer for stationary activity or a Douglas bag where movements are required, has been used for determining the amount of oxygen required, and gas analysis made by Haldane Method.

It can be concluded from the briefing of the historical retrospect, that among the anthropometric measurements, body weight is the most important factor affecting the energy expenditure during work. Sitting-to-work was less favourable as compared to standing-to-work because, the energy expenditure was more while working in sitting position than in the standing position, in spite of the fact that body uses less energy for sitting quietly than for standing at rest.

Oxygen consumption was found to be linearly correlated with pulmonary ventilation for light and moderate work whereas for heavy work, pulmonary ventilation markedly increased without any further increase in oxygen uptake.

CHAPTER III

EXPERIMENTAL PROCEDURE

The experimental procedure of the study on physiological cost of chapati making in squatting and standing positions consisted of following steps:

1. Selection of subjects
2. Equipment used
3. Standardisation of the activities
4. Conducting the experiment
5. Statistical analysis

1. Selection of Subjects

Six female students of approximately same age, weight and height were selected randomly and the three parameters were recorded. The weight of the subjects was taken for three consecutive days and average was calculated. From the height and weight, the subject's body surface area was determined using the line chart. This nomograph has been computed from the DuBois and DuBois (1916) formula ($M^2 = W^{0.425} \times H^{0.725} \times 71.84$) for surface area.

2. Equipment used

The major equipment used for the study were:

a. Douglas bag with various attachments for the collection of exhaled air.

b. Water sealed (wet type) Gas Flow Meter (Toshniwal) for measuring the volume of exhaled air.

c. Rubber bellows for the collection of the sample of exhaled air.

d. Haldane gas analyser for analysing the oxygen and carbon dioxide in the exhaled air.

3. Standardisation of the activity

The study was conducted in the Department of Home Management. For standardisation of activity, the kitchen units were set up both for squatting (Goel, 1974) and standing (Chahel, 1972) working postures. The optimum-working areas were adequately equipped with items needed to conduct the experiment. For squatting posture, a piri of 5.2" height was provided, whereas, for standing posture the working counter height was 32". The rolling board and pin was placed between subject and gas burner. The dough plate was placed to the right and chapati box to the left side.

College students participated in a number of preliminary laboratory visits which were held in order to standardise the task. Instructions were given so as to keep the utensils, supplies and gas burner at a distance convenient to them. The picking up of ingredients was included within the time recorded for the performance of the activity. The subjects performed the activity at their normal speed and were asked to work in a relaxed mood to avoid mental as well as physical stress owing to the performance of the experiment. On the basis of this, procedures for kneading the dough and *chapati* making were standardised. 140 ml of water was used in 170 gms (Dhesi, 1970) of flour for making the dough. Procedure for *chapati* making included three steps, viz, making ball (weighing 30 gms), rolling the ball and roasting the *chapati* on griddle and puffing it (Appendix I).

Before starting the actual experiment all the subjects were acclimatised to the standardised procedure.

4. Conducting the experiment:

The standardised procedure was followed by all the subjects. The experiment was performed 1½ to 2 hours after taking meals in order to avoid the effects of specific dynamic action of food. No attempt was made to modify the eating pattern of the subjects since Weir (1949) observed that calorific value of one litre of oxygen was practically independent of the total respiratory quotient and that variations in respiratory quotient from day to day, of diet changes did not introduce appreciable error. Room temperature was recorded daily before the start of the activity. The subjects were clothed comfortably and were bare footed while conducting the experiment.

An open circuit metabolic apparatus was used for measuring the exhaled respiratory gases. This apparatus consisted of a mouth piece (containing one way valve) which was connected to two way aluminium stop cock through corrigated rubber tubing. The other end of the stop cock was tightly fitted into the mouth of Douglas bag of 60 litres capacity. The subject was asked to attach the mouth piece and nose clip. As soon as subject became comfortable, the activity was started. The subject inspired through the inlet valve of the mouth-piece. As she exhaled, the inlet valve was closed automatically and outlet valve was opened and gases were allowed to escape in the atmosphere. The expired air was collected in the Douglas bag for fixed time. For kneading the dough, the exhaled air was collected from 2nd to 5th minute whereas for <u>chapati</u> making from 4th to 9th minute. Expired air was also collected for 5 minutes when the subjects were not performing the activity (at rest) in both the body positions. Fig.1 and 2 depict the activity of <u>chapati</u> making in squatting and standing positions.

<u>Volume measurement and gas sampling of the expired air</u>

The volume of the exhaled gases was measured by using the water sealed gas flow meter. The Douglas bag containing the gases was connected to the glas flow meter through polyethylene tubing. The bag was

FIG. 1. Chapati making in squatting position.

FIG. 2. Chapati making in standing position.

evacuated by compressing it manually. In between the evacuation, gas sample was taken in small rubber bellow connected to the Douglas bag through a glass adapter (Fig.3).

Analysis of the expired air

The gases were analysed by using the Haldane gas analyser. Standard procedure with slight modifications was followed.

a) Setting the apparatus for analysis:

The mercury was filled in the mercury reservoir so that it reached the bulb of burette and 1/3rd of the reservoir was also filled with it. It was greased and stop cocks were inserted.

Stop cocks 1,2 and 3 (Fig.4) were turned such that only KOH pipette was opened to the atmosphere. Then half saturated KOH was added in the KOH pipette until it reached A and B and bulb was about one quarter full.

Stop cocks 1, 2 and 4 were turned so that only pyrogallol pipette was opened to the atmosphere. Liquid parafin was then added to the far right hand glass tube until its left hand bulb was full, so as to avoid the direct contact of air with oxygen absorbant.

Then the pinch cock was opened and alkaline pyrogallol was added until it was filled upto C. Finally the stop cocks 1,2 and 4 were turned to off

FIG. 3. Volume measurement of exhaled air and gas sampling

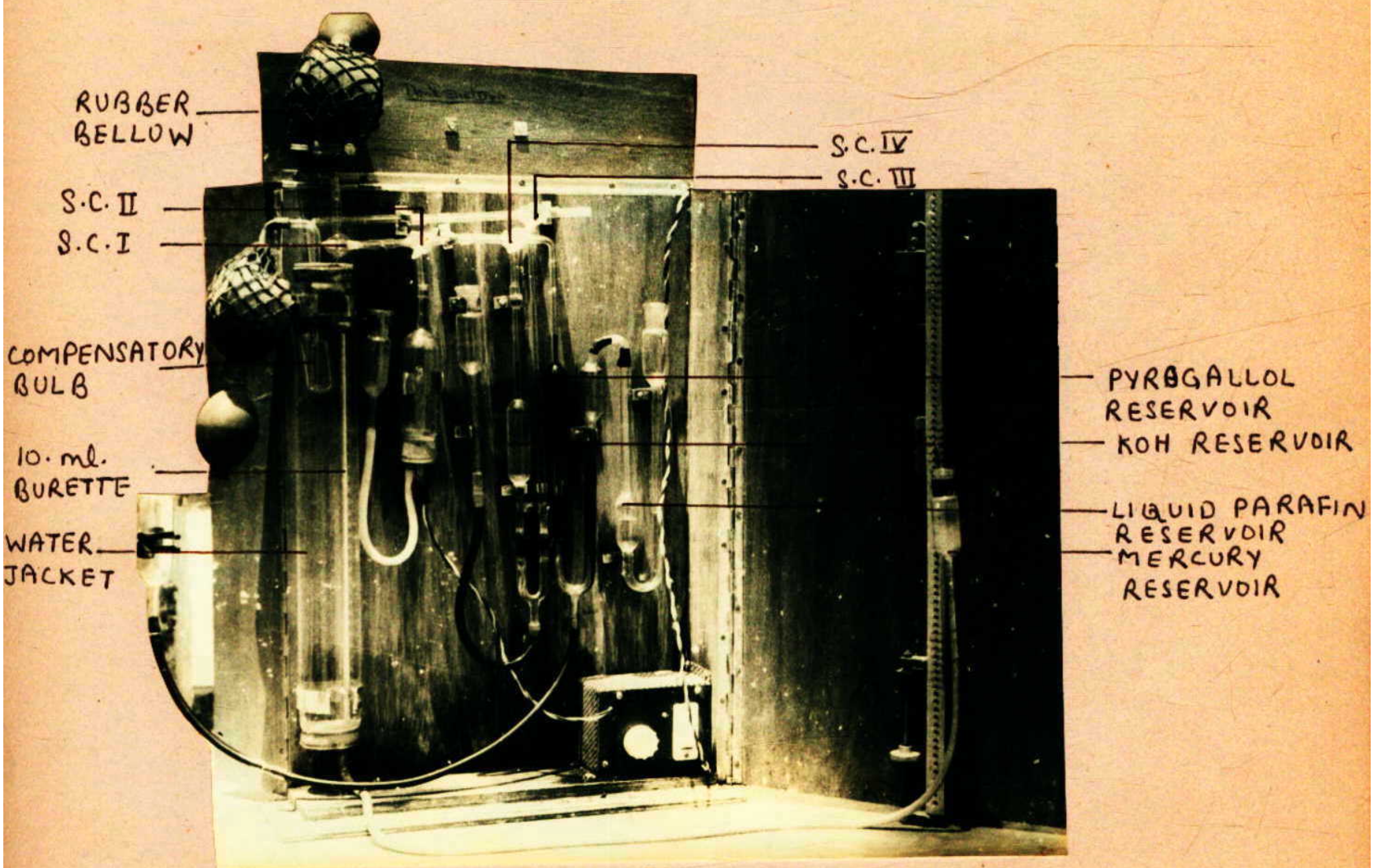

FIG. 4. Haldane gas analyser.

position.

b) <u>Procedure for analysis of gases:</u>

i) Rubber bellow was used to transfer the gas sample to the analyser instead of sampling tubes containing mercury. Stop cock (S.C.) 1 was opened to the atmosphere and mercury reservoir was raised so that the mercury reached at the top of glass adapter. S.C.1 was then turned off and the mercury reservoir placed on the rack.

ii) The outlet of the rubber bellow was connected with the adapter and the pinch cock opened. The S.C.1 was turned so that it was opened to burette and bellow. The mercury reservoir was lowered to such an extent that the mercury touched 10 ml mark in the burette. Then the stop cock 1 was turned to off position.

iii) S.C.3 was turned so that it was opened to compensatory bulb and KOH pipette.

iv) S.C.1 and 2 were turned so that burette was connected only with KOH pipette.

v) The mercury reservoir was adjusted so that KOH was at A and B. Then air was bubbled in water jacket.

vi) Total volume (V_1) reading at the top of mercury miniscus was recorded after readjusting KOH at A and B.

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v) The mercury reservoir was adjusted so that KOH was at A and B. Then air was bubbled in water jacket.

vi) Total volume (V_1) reading at the top of mercury miniscus was recorded after readjusting KOH at A and B.

vii) In order to absorb CO_2, the mercury reservoir was raised until the mercury reached the bulb of the burette and then it was lowered. The process was repeated 6-8 times. After placing the reservoir on the rack, the mercury level was readjusted so that KOH reached A. The burette reading was then recorded (V_2).

viii) Step vii was repeated until the difference in the burette reading (V_2) did not exceed 0.001 ml.

ix) To absorb O_2, the stop cock 2 and 4 were turned in such a way that the burette was connected only with Pyrogallol pipette. The procedures as in vii and viii were repeated. When Pyrogallol reached C, noted the reading in the burette(V_3), the S.C. was turned off.

x) The volume of O_2 and CO_2 were obtained as follows:

$$\text{Ml } CO_2/\ 100 \text{ ml exhaled air} = \frac{V_1 - V_2}{V_1} \times 100 \qquad - \text{ I}$$

$$\text{Ml } O_2/\ 100 \text{ ml exhaled air} = \frac{V_2 - V_3}{V_1} \times 100 \qquad - \text{ II}$$

Note: Before starting the analysis of gases, the apparatus was set free of any CO_2 and O_2 so as to make sure that capillaries contained only N_2.

C) Precautions taken

i) Stop cocks were greased properly.

ii) The entry of grease in the capillaries was prevented.

iii) None of the solutions were allowed to pass A, B or C.

iv) Water in the water jacket was constantly stirred.

v) The burette was kept moistened by a thin layer of acidulated water at the top of mercury surface.

vi) The apparatus was thoroughly checked for any leakage.

Calculations:

Following calculations were made:

1. Volume of expired air per minute.

2. Percentage of O_2 consumed as given below:
The inspired air at standard temperature and pressure has the following computations:

O_2 = 20.93 per cent

CO_2 = 0.03 per cent

N_2 = 79.04 per cent

Hence,

Percent drop in oxygen = 20.93 - II

3. Total volume of O_2 retained per minute = Volume of expired air per min. x $\frac{\%\text{ drop in } O_2}{100}$

4. Calorific value of oxygen taken up = X x 5.0 Calories/min.

The factor 5.0 was taken as it is an average value representing the caloric equivalent of 1 litre of oxygen consumed during moderate activity (Consolazio et al, 1963).

After the completion of the task, the subjects were asked to fill a questionnaire regarding their attitudes towards the task, equipment and supplies, bodily feelings, the social and psychological environment and the quality of the product.

Each experiment had three replications. Thereby, 108 sets of observations were recorded.

5. Statistical Analysis:

The data of various parameters was analysed statistically following the 2 x 3 x 6 factorial design (Snedecor and Cockran, 1968).

Linear regression equations were also derived. The equation for the linear regression is:

$$y = a + bx$$

where y is dependent variable

a is the intercept

b (slope) simple regression coefficient; and

x is independent variable.

CHAPTER IV

RESULTS AND DISCUSSION

The results and discussion have been compiled under the following heads:

1. General information
2. Carbon dioxide production
3. Oxygen consumption
4. Energy expenditure
5. Pulmonary ventilation rate
6. Attitude of the subjects towards the task.

1. General information

Six subjects (A, B, C, D, E and F) were selected for the study. Mean age of the subjects was 21.90 years, whereas height and weight were 158.66 cms and 48.83 kg respectively (Table 4.1). The average body surface area for six subjects was found to be 1.48 square metres. Body surface area was calculated in order to express the physiological cost on common surface area basis, since body heat is dissipated at the skin surface and total expenditures vary closely with surface area (Richardson, 1966).

Average time taken for the performance of kneading the dough and chapati making in squatting was 5.21 and 11.56 min. whereas it was 5.23 and 11.03 min. respectively

TABLE 4.1

Descriptive Information of Subjects

Subjects	Age(years)	Weight(Kg)	Height (Cms)	Body surface area (Sq.metres)
A	22.00	52.50	161.00	1.54
B	22.00	50.50	162.00	1.52
C	20.00	48.00	162.00	1.49
D	22.00	46.00	155.50	1.42
E	23.00	46.00	152.50	1.40
F	22.50	50.00	159.00	1.50
Mean	21.90	48.83	158.66	1.48
	± 0.41	± 1.07	± 1.59	± .02

in standing position. During the experimental period the ambient temperature varied between 21.9°C to 34.2°C. The temperature was recorded as it affects the physiological cost to a considerable extent. The metabolic rate increases at lower temperatures since the body produces an additional heat to maintain its temperature. Stanier (1975) also found that the oxygen consumption increase at lower temperature because of the same reason.

2. <u>Carbon dioxide production</u>

The average carbon dioxide production while at rest, kneading the dough and *chapati* making was 0.089, 0.182 and 0.148 l/sq.m./min. respectively in squatting and 0.09, 0.181 and 0.140 l/sq.m./min in standing position (Table 4.2 and Fig.5). The differences in CO_2 production at the two postures were statistically non-significant (Appendix II). This seems to be because the production of CO_2 depends upon the relative PCO_2 and its tension in the blood, which may not have been affected by the posture. The perusal of the Table 4.2 also indicates that the carbon dioxide production for kneading the dough was higher than that of chapati making in both the body positions.

The carbon dioxide production was 104.49 and 66.29 per cent to that of rest for kneading the dough and chapati making respectively in squatting which is

TABLE 4.2

Average Carbon Dioxide Production (1/sq.m/min.) during Rest, Kneading the dough and Chapati Making in Squatting and Standing Positions

Body position	Kind of activity	Mean CO_2 production (1/sq.m/min.)	Increase over base(rest) (1/sq.m/min.)	Percent increase over base
Squatting	a. At rest	0.089 ±0.003		
	b. Kneading the dough	0.182 ±0.015	0.093	104.49
	c. Chapati making	0.148 ±0.006	0.059	66.29
Standing	a. At rest	0.090 ±0.004		
	b. Kneading the dough	0.181 ±0.009	0.091	101.11
	c. Chapati making	0.140 ±0.006	0.050	55.55

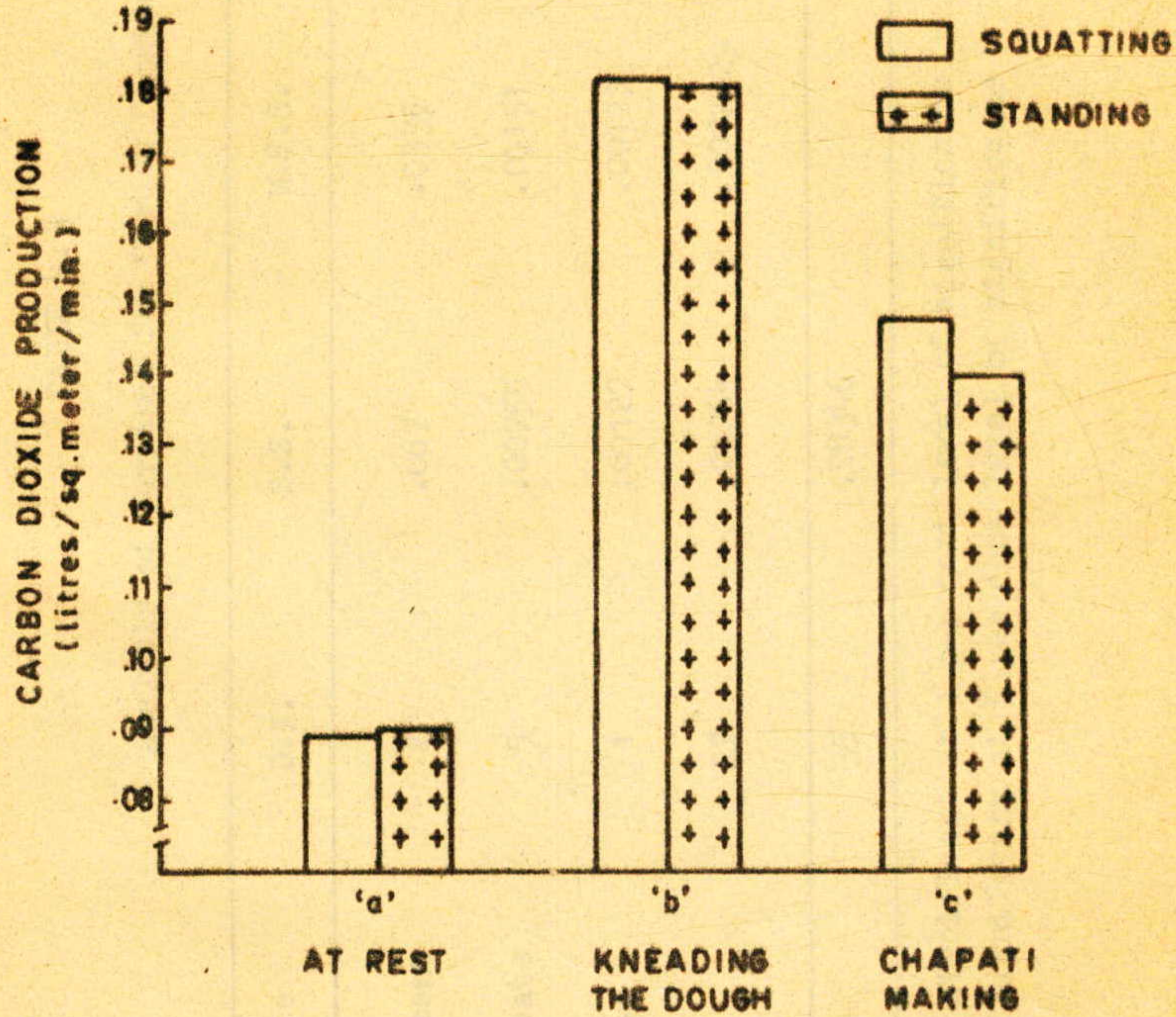

FIG. 5. AVERAGE CARBON DIOXIDE PRODUCTION DURING REST, KNEADING THE DOUGH AND CHAPATI MAKING SQUATTING AND STANDING POSITIONS.

TABLE 4.3

Analysis of Variance for Carbon Dioxide Production

Source	D.F.	S.S.	M.S.S.	F.Ratio
Treatment	2	.067	.0335	118.41**
Replicate	5	.00755	.00151	5.34**
Posture	1	.00127	.00127	4.49*
Error	27	.00764	.0002829	
Total	35	.08346		

** Significant at 1 per cent level of significance

* Significant at 5 per cent level of significance

TABLE 4.4

Average Carbon Dioxide Produced (l/sq.m/min) During Rest, Kneading the Dough and Chapati Making in Squatting and Standing Positions

Body position	Kind of activity	Subjects					
		A	B	C	D	E	F
Squatting	a. At rest	0.088	0.089	0.086	0.080	0.085	0.106
	b. Kneading the dough	0.203	0.176	0.174	0.214	0.268	0.242
	c. Chapati making	0.151	0.143	0.130	0.140	0.150	0.180
Standing	a. At rest	0.089	0.086	0.090	0.087	0.094	0.116
	b. Kneading the dough	0.172	0.180	0.176	0.160	0.174	0.226
	c. Chapati making	0.130	0.125	0.134	0.137	0.156	0.162

slightly higher than that of standing i.e. 101.11 and 55.55 per cent respectively.

The treatments had highly significant ($P < 0.01$) effect on carbon dioxide production (Table 4.3), which may be because of the higher metabolic activity while working as compared to rest.

Replicates also accounted for significant ($P < 0.01$) variation in CO_2 production. Carbon dioxide production was also significantly ($P < 0.05$) affected by the posture, which may be because the metabolic rate of rest and work is also affected by the posture.

Table 4.4 reveals that carbon dioxide production was more in case of standing at rest in all the subjects except 'B'. Similarly, subjects 'B' and 'C' exhaled lesser carbon dioxide, while kneading the dough at squatting position and subjects 'C' and 'E' while <u>chapati</u> making as compared to standing position. This seems to be because the individuals vary in their sensitiveness to the elevation of PCO_2 and the ability of the body to produce alveolar CO_2 depends upon this PCO_2 (Lambertsen , 1960).

3. Oxygen Consumption

The data on oxygen consumption during the performance of the activity has been presented in

Table 4.5 and Fig.6. The average oxygen consumption at rest was 0.131 l/sq.m/min in standing which is higher than that of squatting (0.127 l/sq.m./min.). The increased oxygen consumption while standing may be because the activity of standing requires full participation of the lower extremities along with head and trunk which involves some extra work. This leads to the increased O_2 consumption (Ganguli et al, 1973). Though the difference was found to be statistically not significant (Appendix II).

The oxygen consumption for kneading the dough was found to be 0.300 and 0.253 l/sq.m./min. for squatting and standing respectively and the difference was also statistically significant ($P < 0.05$, Appendix - II). However, the oxygen consumption for chapati making was 0.215 and 0.195 l/sq.m./min respectively for squatting and standing. The difference in O_2 consumption for chapati making was also statistically significant ($P < 0.05$, Appendix II). This may be due to the reason that the body consumes extra amount of oxygen while working in squatting position, which leads to the increased metabolic rate. The data revealed that oxygen consumption was higher for kneading the dough as compared to chapati making in both the body positions.

The oxygen consumption for kneading the dough

TABLE 4.5

Average Oxygen Consumption (l/sq.m./min.) During Rest, Kneading the Dough and Chapati Making in Squatting and Standing Positions

Body position	Kind of activity	Mean oxygen consumption (l/sq.m./min)	Increase over base (rest) (l/sq.m./min)	Per cent increase over base
Squatting	a. At rest	0.127 $\pm$0.003		
	b. Kneading the dough	0.300 $\pm$0.011	0.173	136.22
	c. Chapati making	0.215 $\pm$0.008	0.088	69.29
Standing	a. At rest	0.131 $\pm$0.002		
	b. Kneading the dough	0.253 $\pm$0.008	0.122	93.12
	c. Chapati making	0.195 $\pm$0.006	0.064	48.85

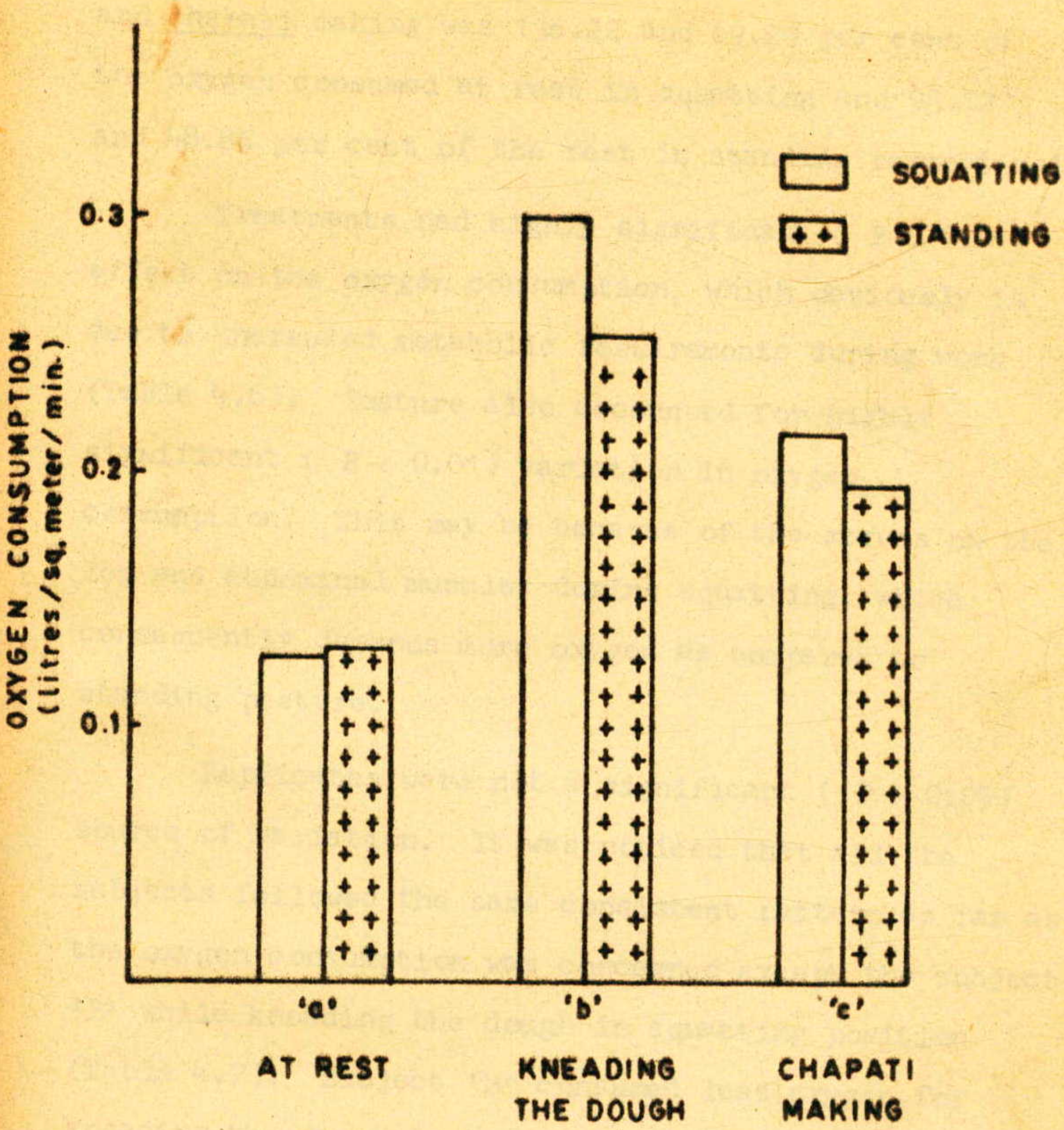

FIG. 6. AVERAGE OXYGEN CONSUMPTION AT REST, KNEADING THE DOUGH AND CHAPATI MAKING IN SOUATTING AND STANDING POSITIONS.

and *chapati* making was 136.22 and 69.29 per cent of the oxygen consumed at rest in squatting and 93.12 and 48.85 per cent of the rest in standing respectively.

Treatments had highly significant ($P < 0.01$) effect on the oxygen consumption, which obviously is due to increased metabolic requirements during work (Table 4.6). Posture also accounted for highly significant ($P < 0.01$) variation in oxygen consumption. This may be because of the stress on the leg and abdominal muscles during squatting, which consequently demands more oxygen as compared to standing posture.

Replicates were not a significant ($P > 0.05$) source of variation. It was noticed that all the subjects followed the same consistent pattern as far as the oxygen consumption was concerned except the subject 'B' while kneading the dough in squatting position (Table 4.7). Subject 'B' consumed less oxygen for kneading the dough in this posture. This is due to the physiological phenomenon of idiosyncrasy.

The data revealed that O_2 consumed was much less as compared to CO_2 produced. This seems to be because the oxygen is easily taken up by the red cells

TABLE 4.6

Analysis of Variance for Oxygen Consumption

Source	D.F.	S.S.	M.S.S.	F-ratio
Treatment	2	0.1300	0.065	168.83**
Replicate	5	0.0043	0.00086	2.23
Posture	1	0.0039	0.0039	10.12**
Error	27	0.0104	0.000385	
Total	35	0.1486	-	

** Significant at 1 per cent level of significance.

TABLE 4.7

Average Oxygen Consumption (l/sq.m./min) During Rest, Kneading the Dough and Chapati Making in Squatting and Standing Positions

Body position	Kind of activity	Subjects					
		A	B	C	D	E	F
Squatting	a. At rest	0.14	0.12	0.12	0.12	0.12	0.14
	b. Kneading the dough	0.29	0.26	0.29	0.30	0.34	0.32
	c. Chapati making	0.20	0.21	0.20	0.20	0.24	0.24
Standing	a. At rest	0.14	0.13	0.12	0.13	0.13	0.14
	b. Kneading the dough	0.24	0.27	0.25	0.23	0.24	0.29
	c. Chapati making	0.19	0.17	0.19	0.19	0.21	0.22

as a result of oxygenation of hemoglobin. This oxygenation leads to the liberation of H^+ ions which in turn react with HCO_3^- and lead to the formation of H_2CO_3 and ultimately H_2O and CO_2. The CO_2 then diffuses out through the plasma into the alveoli. Of the total CO_2 produced about 2/3 is present in plasma which is evolved and the rest 1/3 remains inside the red cells (Wagner, 1977).

4. Energy Expenditure

The average values of energy expenditure at rest, kneading the dough and chapati making are presented in Table 4.8 and Fig.7. The energy expenditure at rest in standing position (0.666 Cal/sq.m / min) was found to be higher than that at rest in squatting position (0.636 Cal/sq.m/min). But this difference was not statistically significant (Appendix II). Steidl and Bratton (1968) also pointed out that body uses less energy for sitting quietly than standing at rest.

The posture accounted for highly significant ($P < 0.01$) variation in energy expenditure (Table 4.9). The energy expenditure respectively for kneading the dough and chapati making was found to be 1.500 and 1.074 Cal/sq. m./min in squatting position and it was significantly ($P < 0.05$, Appendix II) higher than that of standing (1.268and 0.980Cal/sq.m./min). It may

TABLE 4.8

Average Energy Expenditure (Cal/sq. m/min) During Rest, Kneading the Dough and Chapati Making in Squatting and Standing Positions

Body position	Kind of activity	Mean energy expenditure (Cal/sq.m./min)	Increase over base(rest) (Cal/sq.m/min)	Percent increase over base(rest)
Squatting	a. At rest	0.636 $\pm$0.022		
	b. Kneading the dough	1.500 $\pm$0.055	0.864	135.84
	c. Chapati making	1.074 $\pm$0.041	0.438	68.86
Standing	a. At rest	0.666 $\pm$0.014		
	b. Kneading the dough	1.268 $\pm$0.047	0.602	90.39
	c. Chapati making	0.980 $\pm$0.033	0.314	47.15

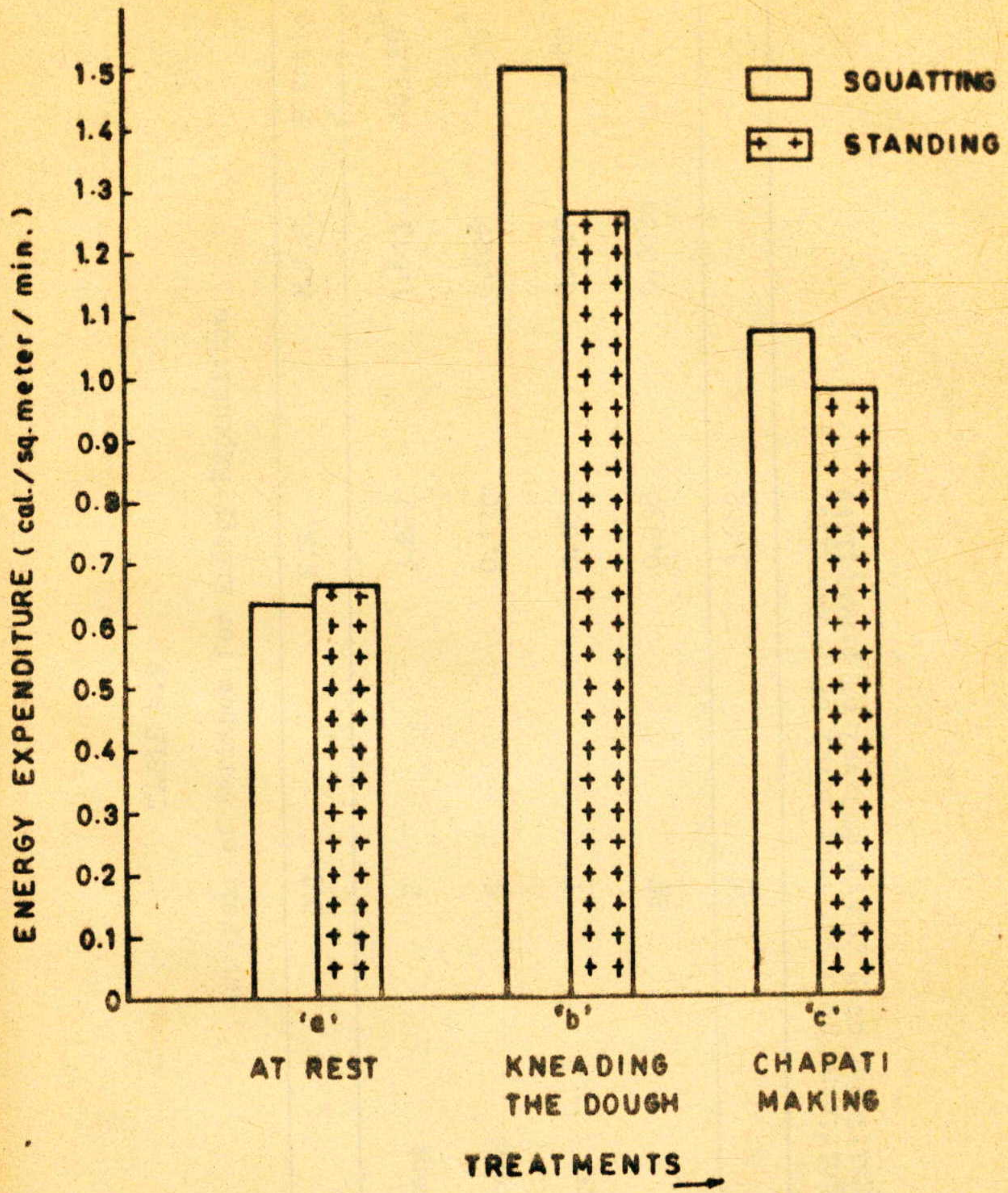

FIG.7. AVERAGE ENERGY EXPENDITURE DURING REST, KNEADING THE DOUGH AND CHAPATI MAKING IN SQUATTING AND STANDING POSITIONS.

TABLE 4.9

Analysis of Variance for Energy Expenditure

Source	D.l.	S.S.	M.S.S.	F-Ratio
Treatment	2	3.227	1.613	183.29**
Replicate	5	0.130	0.026	2.95*
Posture	1	0.087	0.087	9.89**
Error	27	0.238	0.0088	
Total	35	3.682		

** Significant at 1 per cent level of probability
* Significant at 5 per cent level of probability

be because of the fact that working in squatting position requires the head and trunk to bend forward, as a result of which ligaments and tendons undergo strain. The natural balance of the body is disturbed and localised group of muscles may have to maintain the contractions for long. The findings of the present investigation are in agreement with the study by Bratton (1958) who reported that energy expenditure while seated to work with knee forced to one side (1.5 Cal/min) was slightly higher than that for standing to work (1.4 cal/min). It was evident that energy expenditure for kneading the dough was higher as compared to <u>chapati</u> making in both the body positions.

The energy expenditure for kneading the dough and <u>chapati</u> making was 135.84 and 68.86 per cent respectively the energy spent at rest in squatting, and 90.39 and 47.15 per cent that of rest in standing position. The percentage increase in energy expenditure for kneading the dough and <u>chapati</u> making observed in the present investigation was much higher as compared to that of ironing determined by Richardson (1960). He found that energy expenditure for ironing in squatting and standing position was 31 and 28 per cent respectively of energy consumed at rest.

The differences in energy expenditure (Table 4.9)

TABLE 4.10

Average Energy Expenditure (Cal/sq.m/min) During Rest, Kneading the Dough and Chapati Making in Squatting and Standing Positions

Body position	Kind of activity	Subjects A	B	C	D	E	F
Squatting	a. At rest	0.701	0.578	0.621	0.600	0.609	0.706
	b. Kneading the dough	1.450	1.309	1.435	1.504	1.699	1.606
	c. Chapati making	1.013	1.046	0.993	0.988	1.182	1.223
Standing	a. At rest	0.701	0.650	0.616	0.651	0.664	0.712
	b. Kneading the dough	1.200	1.362	1.244	1.131	1.220	1.450
	c. Chapati making	0.977	0.849	0.964	0.954	1.051	1.088

while at rest, kneading the dough and chapati making were highly significant ($P < 0.01$). This may be because kneading the dough and chapati making involve physical activity (work). As a result, the metabolic rate increases to provide energy for the same.

Replicates also affected the energy expenditure significantly ($P < 0.05$, Table 4.9). It was observed (Table 4.10) that all the subjects except 'C' spent more energy while resting in standing position than squatting. And all the subjects except 'B' spent more energy for kneading the dough in squatting position than that of standing. These differences may be due to idiosyncrasy as explained earlier.

5. Pulmonary Ventilation Rate

The pulmonary ventilation rate followed the similar trend as that of oxygen consumption and energy expenditure. The average volume of exhaled air at rest, kneading the dough and chapati making respectively, was 2.93, 5.16 and 4.04 l/sq.m/min. in squatting and 3.04, 4.75 and 3.97 l/sq.m/min. in standing position (Table 4.11, Fig.8). The differences in pulmonary ventilation rate at two body positions (Appendix II) were statistically non-significant ($P > 0.05$). So it can be said that the increased energy demand was met by

TABLE 4.11

Average Pulmonary Ventilation Rate (l/sq.m/min) During Rest, Kneading the Dough and Chapati Making in Squatting and Standing Positions

Body position	Kind of activity	Mean PVR (l/sq.m/min.)	Increase over base(rest) (l/sq.m./min)	Percent increase over base(rest)
Squatting	a. At rest	2.93 ± 0.095		
	b. Kneading the dough	5.16 ± 0.352	2.23	76.10
	c. Chapati making	4.04 ± 0.19	1.11	37.88
Standing	a. At rest	3.04 ± 0.073		
	b. Kneading the dough	4.75 ± 0.13	1.71	56.32
	c. Chapati	3.97 ± 0.122	0.93	30.69

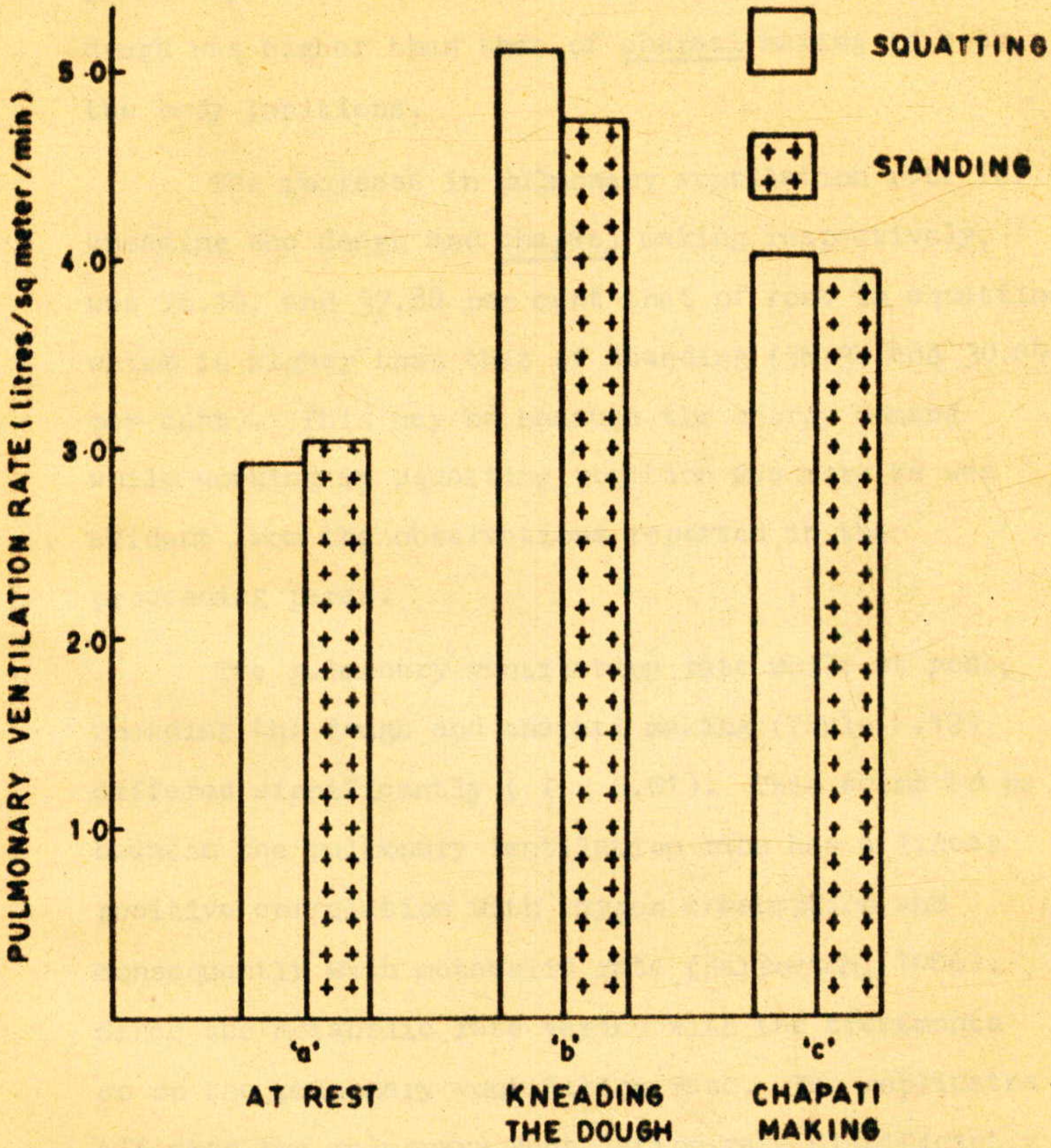

FIG. 8. AVERAGE PULMONARY VENTILATION RATE DURING REST, KNEADING THE DOUGH AND CHAPATI MAKING IN SQUATTING & STANDING POSITIONS.

increased oxygen uptake from almost same volume of pulmonary ventilation air. PVR for kneading the dough was higher than that of chapati making in both the body positions.

The increase in pulmonary ventilation rate for kneading the dough and chapati making respectively, was 76.10, and 37.88 per cent that of rest in squatting; which is higher than that of standing (56.32 and 30.69 per cent). This may be because the energy demand while working in squatting position was more as was evident from the observations reported in the proceeding paras.

The pulmonary ventilation rate while at rest, kneading the dough and chapati making (Table 1.12) differed significantly ($P < 0.01$). This seems to be because the pulmonary ventilation rate has a linear positive correlation with oxygen consumption and consequently with metabolic rate (Karpovich, 1966). Since the metabolic rate varied with the treatments so do the pulmonary ventilation rate. The replicates affected the pulmonary ventilation rate significantly ($P < 0.05$). This may be because of individual variations.

Although the average pulmonary ventilation rate value pattern was consistent with that of energy

TABLE 4.12

Analysis of Variance for Pulmonary Ventilation Rate

Source	D.F.	S.S.	M.S.S.	F-ratio
Treatment	2	23.26	11.63	77.53**
Replicate	5	2.49	0.50	3.33*
Posture	1	0.15	0.15	1.00
Error	27	4.13	0.15	
Total	35	30.03		

** Significant at 1 per cent level of significance
* Significant at 5 per cent level of significance

expenditure and oxygen consumption, but individual variation was also noted. From Table 4.13 it was observed that two subjects 'A' and 'B' exhaled more air while at rest in squatting position as compared to that of standing. For kneading the dough, two subjects 'B' and 'C' exhaled more volume of air in standing position.

In order to see the effect of oxygen consumption on pulmonary ventilation rate, pulmonary ventilation rate (l/sq.m/min) was plotted against oxygen consumption (l/sq.m./min.) separately for squatting and standing positions (Fig.9). The two variables were found to be highly, positively and significantly ($P < 0.01$, Appendix II) correlated in both the body postures i.e. squatting ($r = 0.906$) and standing ($r = 0.949$). Keeping in view the above correlation, the linear regression equations were derived.

(i) $y = 1.23 + 13.05\ x$ (for squatting)

(ii) $y = 1.31 + 13.53\ x$ (for standing)

where x is oxygen consumption and

y is pulmonary ventilation rate

Karpovich (1966), Saltin and Astrand (1967) also pointed out that there was a linear relationship between oxygen consumption and pulmonary ventilation rate. They further emphasised that this relationship was true only

TABLE 4.13

Average Pulmonary Ventilation Rate (l/sq.m/min) During Rest, Kneading the Dough and Chapati Making in Squatting and Standing Positions

Body position	Kind or activity	Subjects					
		A	B	C	D	E	F
Squatting	a. At rest	3.14	3.26	2.87	2.61	2.81	2.91
	b. Kneading the dough	5.68	4.75	3.93	5.20	6.47	4.93
	c. Chapati making	4.41	4.09	3.33	3.71	4.63	4.09
Standing	a. At rest	3.03	3.23	2.94	2.73	3.15	3.14
	b. Kneading the dough	4.87	5.16	4.73	4.18	4.72	4.82
	c. Chapati making	3.99	3.75	3.99	3.71	4.53	3.84

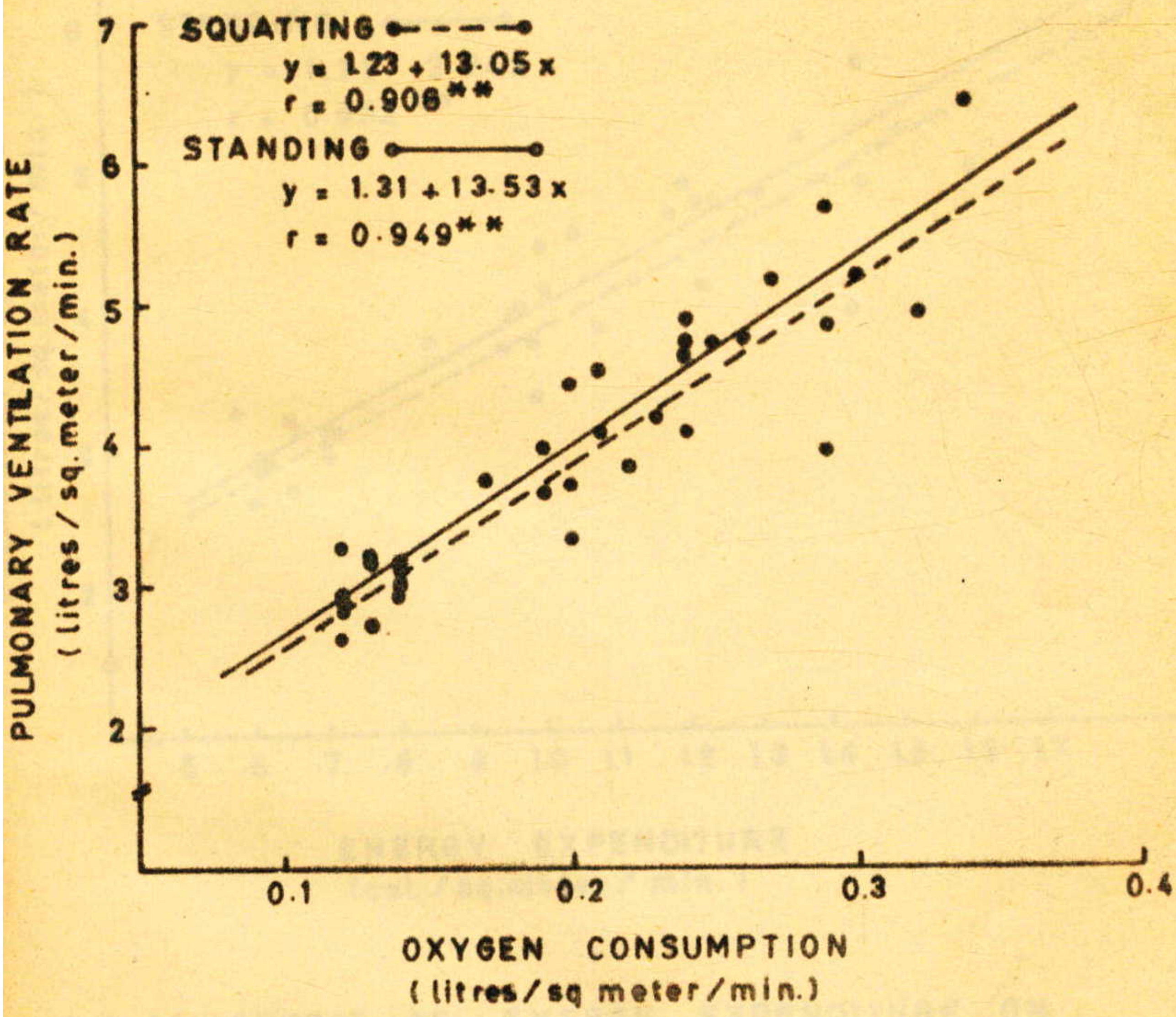

FIG. 9. EFFECT OF OXYGEN CONSUMPTION ON PULMONARY VENTILATION RATE.

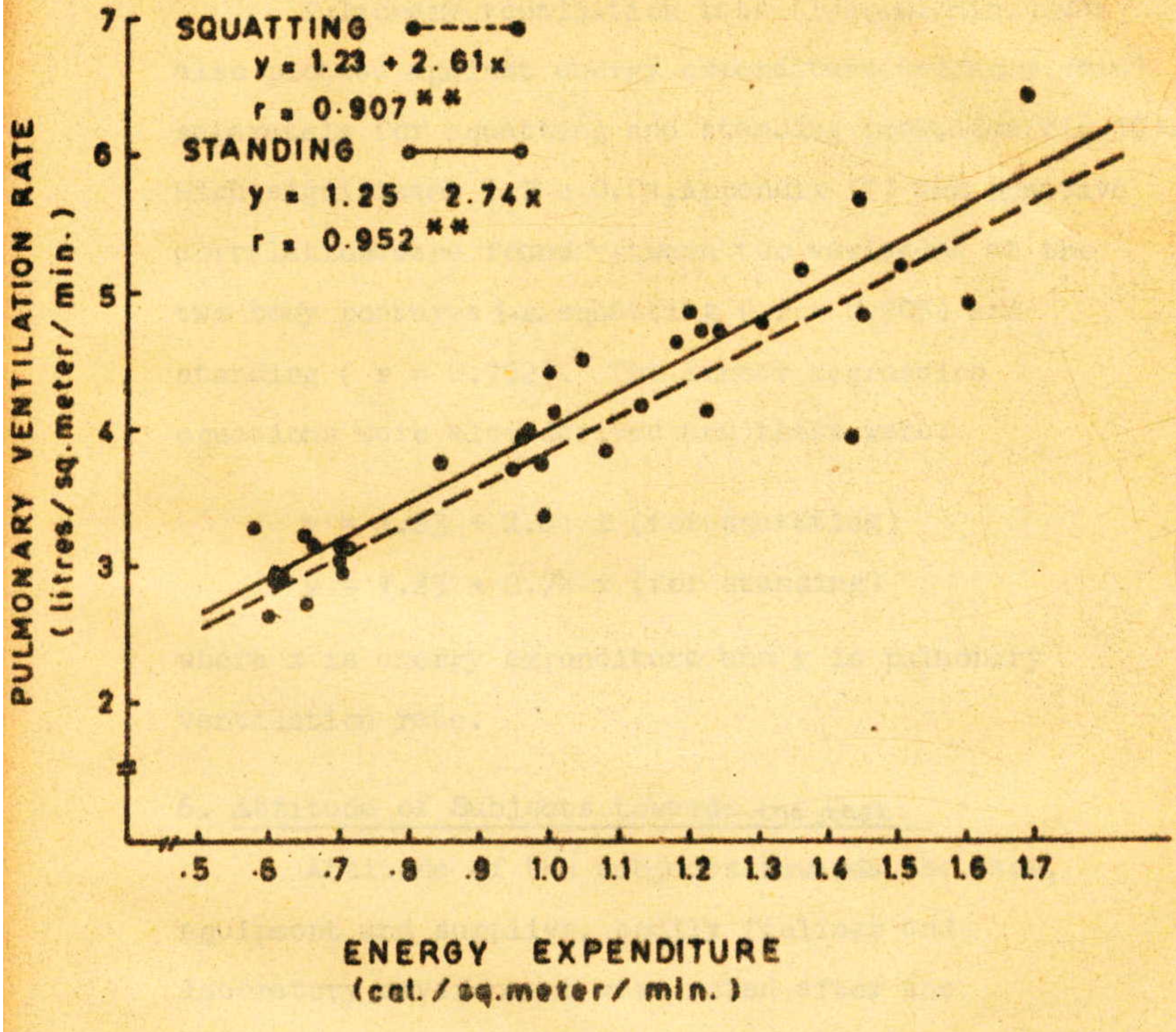

FIG. 10. EFFECT OF ENERGY EXPENDITURE ON PULMONARY VENTILATION RATE.

for light and moderate activities, whereas for heavy activities this proportionality was disrupted.

Pulmonary ventilation rate (l/sq.m./min.) was also plotted against energy expenditure(Cal/sq.m./min) separately for squatting and standing positions(Fig.10). High, significant ($P < 0.01$, Appendix II) and positive correlations were found between two variables at the two body postures i.e. squatting ($r = 0.907$) and standing ($r = 0.952$). The linear regression equations were also derived and these were:

$$y = 1.23 + 2.61\ x \text{ (for squatting)}$$

$$y = 1.25 + 2.74\ x \text{ (for standing)}$$

where x is energy expenditure and y is pulmonary ventilation rate.

6. Attitude of Subjects towards the task:

Attitude of the subjects towards the task, equipment and supplies, bodily feelings and laboratory environment were noted after the completion of the task. Mean scores were calculated to find out their responses (Appendix IV).

i) Feeling towards the Equipment and Supplies: The mean score of the attitude towards the equipment and supplies was 4.8 which reveals that equipment and supplies for the performance of the activity were liked by all the subjects. It seems to be because of the fact that all the equipment and supplies were kept at the convenient distance from the subjects.

ii) Feelings during the Task in Both the Positions: In standing posture, mean score of the bodily feeling during the task was 5 which shows that no pain was felt in any part of the body by any of the subject while performing the task. However for squatting posture, the mean score was 4.4. A little pain was felt by subject 'A' in neck and back, and by subject 'F' in neck, Back and upper legs while working in squatting posture. This can be because the head and trunk had to bend forward while working in squatting as a result of which the neck and back muscles were pulled, thereby causing the arrest of blood supply to the stretched muscles, leading to a diminished supply of oxygen and a build up of waste products. These waste products become the main cause of pain. The pain in the upper leg may also be due to the contraction of localised muscles for the longer period of time.

iii) Feelings about the Laboratory Environment: Mean score for the attitudes about the laboratory environment was 4.7 which shows that subjects were quite satisfied with the laboratory environment.

iv) Feelings about the Task: It was seen that the liking towards the task of kneading the dough was neutral with the mean score of 3. The task of chapati making was liked by all the subjects and the mean score for this was 4.8.

CHAPTER V

SUMMARY AND CONCLUSIONS

The present investigation was undertaken to compare the physiological cost of *chapati* making in squatting and standing positions.

Six female college students were selected. Their average height and weight were found to be 158.66 cms and 48.83 Kg respectively. The average body surface area was 1.478 sq.m.

Physiological parameters viz. carbon dioxide production, oxygen consumption, energy expenditure and pulmonary ventilation rate were worked out by indirect calorimetry. The gases in exhaled air were analysed by using Haldane gas analyser. All the subjects were well acclimatised with the various equipments and procedures before starting the actual experiment. They were also instructed to clothe themselves comfortably and take their meals 1½ to 2 hours before starting the experiment.

The average values of carbon dioxide production during rest, kneading the dough and *chapati* making were found to be 0.089, 0.182 and 0.148 l/sq.m./min for squatting and 0.090, 0.181 and 0.140 l/sq.m./min respectively for standing. Oxygen consumption was found to be 0.127, 0.300 and 0.215 l/sq.m./min respectively at rest, kneading the dough and chapati making whereas 0.131, 0.253 and 0.195 l/sq.m/min in standing. The energy expenditure values were 0.636, 1.500 and 1.074 Cal/sq.m/min in squatting and 0.666, 1.268 and 0.980 Cal/sq.m/min. in standing. The average pulmonary ventilation rate was 2.93, 5.16 and 4.04 l/sq.m/min respectively for the subjects while at rest kneading the dough and chapati making in squatting and 3.04, 4.75 and 3.97 l/sq.m/min in standing.

It was found that energy expenditure was more while at rest in standing as compared to that of squatting. Whereas, the energy expenditure for kneading the dough and chapati making was more while squatting than that of standing. It was found that the energy expenditure was least while at rest and maximum for kneading the dough both in squatting and standing positions.

The other parameters like carbon dioxide production, oxygen consumption and pulmonary ventilation rate also followed the similar pattern for the treatments and postures, which may be because they are interrelated.

A high and positive correlation was found between energy expenditure and pulmonary ventilation rate, oxygen consumption and pulmonary ventilation rate.

From the present investigation, following conclusions were drawn:

1. The energy expenditure was higher while resting in standing as compared to that of squatting position.

2. The energy expenditure was more for kneading the dough and chapati making in squatting position than that of standing.

3. Maximum energy was required for kneading the dough and minimum for rest.

4. The other parameters viz. oxygen consumption and pulmonary ventilation rate responded in a similar manner as that of energy expenditure for all the treatments and postures.

5. High and positive correlations were found between oxygen consumption and pulmonary ventilation rate, energy expenditure and pulmonary ventilation rate.

Suggestions for further Research

1. Since results of the present investigation are restricted to one season i.e. summer, investigations should be carried out all the year around in order to find the impact of

different seasons on the energy requirements.

2. Similar studies should be carried out for other important household activities.

BIBLIOGRAPHY

1. Astrand, I.(1960) Aerobic work capacity in men and women with special reference to age. Cited by Mountcastle, V.B.(1968) Medical Physiology. The C.V.Mosby Company: p.551.

2. Astrand, Per-Olof., and Rodahl, K.(1970) Textbook of Work Physiology. New York. McGraw-Hill Book Company: p.206.

3. Bratton, E.C.(1958) Some factors of cost to the body in standing or sitting to work under different postural conditions. J.Home.Econ. 51:102.

4. Broer, M.R.(1966) Efficiency of Human Movement. Philadelphia.W.B.Sanders Co.

5. Brown, J.R.(1961) The metabolic cost of industrial activity in relation to weight . Med.Servs. J.Can.17:262.

6. Carlsoo, S.(1961) The static muscle load in different work positions. Ergonomics.4:193.

7. Chahel, H.K.(1972) Relationship of heart rate and angles of the body bend during chapati making at standing level kitchens. M.Sc.thesis. P.A.U.Ludhiana.

8. Consolazio, C.F., Johnson, R.E. and Pecora, L.J. (1963) Physiological Measurements of Metabolic Functions in Man. New York. McGraw-Hill Book Company: p.9.

9. Datta, S.R., Chatterjee, B.B. and Roy, B.N.(1973) The relationship between energy expenditure and pulse rates with body weight and the load carried, during load carrying on the level. Ergonomics.16:507.

10. Dhesi, J.K.(1970) Relationship of body positions and heart rate during chapati making at ground level. Ph.D. thesis. The Ohio State University.

11. Dhesi, J.K. and Chahal, H.K.(1975) Effect of stages of chapati making and body bend on heart rate during sitting and standing postures. Indian J.Home Sci.9:7.

12. DuBois, D. and Du Bois, E.F.(1916) A formula to estimate the approximate surface area if height and weight be known. Arch. Int.Med. 17:863.

13. Durnin, J.V.G.A. and Edwards, R.G.(1955) Pulmonary ventilation as an index of energy expenditure. Q.jl.exp.Physio.40:370.

14. Fahrni, H.W.(1966) Backache Relieved Through New Concepts and Posture. Springfield. Illinois Charles C.Thomas.

15. Ganguli, S., Datta, S.R., Chatterjee, B.B. and Roy, B.N.(1973) Performance evaluation of an amputee - prosthesis system in below-knee amputees. Ergonomics.16:797.

16. Gilbreth, F.B. and Gilbreth, L.M.(1917) Applied Motion Study. New York. Sturgis and Walton Company.

17. Goel, M(1974) Space requirements for some selected activities carried out in the kitchen in the sitting position. M.Sc.Thesis. P.A.U.Ludhiana.

18. Grieve, (1972) Heart rate and daily activities of Housewives with young children. Ergonomics.15: 139.

19. Karpovich, P.V.(1966) Physiology of Muscular Activity. Philadelphia. W.B.Saunders Company. 6th Ed.

20. Keiser, M.B. and Weaver, E.K.(1962) Body movements related to energy used. J.Home.Econ.54:479.

21. Lambertsen, C.J.(1960) Carbon dioxide and respiration in acid base homeostasis. Anesthesiology 21:642; Cited by Mountcastle,V.B.(1968) Medical Physiology. The C.V.Mosby Company: p 717.

22. Mahadeva, K., Passmore, R. and Woolf, B.(1953) Individual variations in the metabolic cost of standardised exercise: The effect of food, age, sex and race. J.Physiol.121:225.

23. Malhotra, M.S., Ramaswamy, S.S. and Ray, S.N.(1962) Influence of body weight on energy expenditure. J.appl.Physiol.17:434.

24. Margaria, R., Cerretelli, P., Aghemo, P. and Sassi, G.(1963) Energy cost of running. J. appl.Physiol.18:367.

25. McCracken, C.E. and Richardson, M.(1959) Human energy expenditure as criteria for the design of household storage facilities. J.Home.Econ.51:198.

26. Mitchell, J.H., Sproule, B.J. and Chapman, C.B. (1958) The physiological meaning of the maximal oxygen intake test. J.Clin.Invest. 37:538.

27. Orsini, D. and Passmore, R.(1951) The energy expenditure in carrying loads up and down stairs.J.Physiol.115:95.

28. Passmore, R. and Durnin, J.V.G.A.(1955) Human energy expenditure. Physiol.Rev.35:801.

29. Rajagopal, L.S. and Ray, S.(1977) Energy cost of selected activities. Indian.J.Home.Sci.11:62.

30. Richardson, M. (1960) Energy expenditure of women performing selected activities. Cited by Nickell, P.N. and Dorsey, J.M.(1976) Management in family living. New York. John Wiley & Sons, Inc.

31. Richardson, M.(1966) Energy expenditure of women for cleaning carpets with three types of vacuum cleaners. J.Home.Econ.58:182.

32. Robinson, S.(1938) Experimental studies of physiological fitness in relation to age. Arbeitsphysiol. 10:251.

33. Royce, J.(1962) Oxygen intake curves reflecting circulatory factors in static work. Internationale Zeitschrift Fucr Angewandte Physiologie Einschliesslich Arbeitsphysiologie.18:123. Cited in Ergonomics.18:299.

34. Saltin, B. and Astrand, P.O.(1967) Maximal oxygen uptake in athletes. J.appl.Physiol.23:353.

35. Sanchez, J., Manod, H. and Chabaud, F.(1979) Effect of dynamic, static and combined work on heart rate and oxygen consumption. Ergonomics.22:935.

36. Sato, M. and Tanaka, S.(1973) Postural effect on the relation between O_2 consumption and heart rate. Ergonomics.17:693.

37. Schnauber, and Miiller, (1970) Working efficiency of hands working in different heights above heart level. Ergonomics.14:431.

38. Snedecor, G.W. and Cockran, W.G.(1968) Statistical Methods.Calcutta• Oxford and IBS Pub.Co.

39. Snorrason, E.(1955) Work chairs and work tables. Cited by Bratton, E.C.(1963) College of Home Economics at Cornell University, New York. Research report (4).

40. Stanier, M.W.(1975) Effect of body weight, ambient temperature and hudding on oxygen consumption and body temperature of young mice. Comp. Biochem.Physiol.51:79.

41. Steidle, R.E. and Bratton, E.C.(1968) The Physical component: Working position and Movement. Work in the Home. New York. John Wiley & Sons:p.138.

42. Swartz, V.W.(1933) The human energy cost of certain household tasks. Washington Agricultural Experimental stations Bulletin 282. Pullman Washington.

43. Tarriere, C. and Andre, A.(1970) Evaluation of the energy expenditure for various work postures and their effect on total energy expenditure. Ergonomics. 15:461.

44. Taylor, F.W.(1911) The Principles of Scientific Management. New York. Harper Bros.

45. Taylor, H.L., Buskirk, E. and Henschel, A.(1955) Maximal oxygen intake as an objective measure of cardio-respiratory performance. J.appl. Physiol.8:75.

46. Vokac, Z., Bell, H., Bautz-Holter, E. and Rodahl,K. (1975) Oxygen uptake/heart rate relationship in leg and arm exercise, sitting and standing. J.appl.Physiol.39:54.

47. Vos, (1973) Physical work load in different body postures, while working near to, or below ground level. Ergonomics.16:817.

48. Wagner, P.D.(1977) Diffusion and chemical reaction in pulmonary gas exchange. Physiol.Rev.57:302.

49. Wald, A. and Harrison, L.B.(1975) Oxygen consumption and heart rate: changes and relationships in static work. Ergonomics.18:299.

50. Weir, T.B. DE.V.(1949) New methods for calculating metabolic rate with special reference to protein metabolism. J.Physiol.109:1.

APPENDIX I

Procedure and Recipe for Kneading the Dough and Chapati Making

Kneading the dough

Recipe:

Wheat flour - 170 gms

Water - 140 ml

Knead it to a stiff dough by adding water gradually. Let the dough sit for about an hour.

Chapati Making

Procedure:

1. Make a ball weighing 30 gms and wrap it in a dry whole wheat flour.
2. Flatten the ball with hands
3. Roll the chapati
4. Pat the chapati
5. Roast the chapati on an iron plate and puff it.
6. Remove the chapati when it is done.

Instructions to the subjects for the task

1. Be in a comfortable dress while working.
2. Remove your shoes before the start of the task
3. Keep the equipment and supplies at your convenient distance.
4. Keep the knees in the standing position during the task.

5. Make one ball at a time

6. Make <u>chapaties</u> at your normal speed

7. Please do not try to talk during the task unless there is some emergency.

APPENDIX II

t-test for the different parameters during rest, kneading the dough and chapati making in squatting and standing positions

Physiological parameter	Rest or kind of activity (squatting/ standing)	t-value (n-1)
Carbon dioxide production		
	a. at rest	2.302
	b. kneading the dough	1.372
	c. chapati making	1.662
Oxygen consumption		
	a. at rest	2.05
	b. kneading the dough	3.055*
	c. chapati making	3.01*
Energy expenditure		
	a. at rest	2.02
	b. kneading the dough	3.101*
	c. chapati making	2.989*
Pulmonary ventilation rate		
	a. at rest	1.347
	b. kneading the dough	1.408
	c. chapati making	.469

* Significant at 5 per cent level of significance
** Significant at 1 per cent level of significance

t-test for coefficient of correlation

Physiological parameters	Body position	Co-efficient of correlation	$t_{(n-2)}$ values
1. Oxygen consumption and FVR	Squatting	0.906	8.59**
2. Oxygen consumption and FVR	Standing	0.949	12.04**
3. Energy expenditure and FVR	Squatting	0.907	8.61**
4. Energy expenditure and FVR	Standing	0.952	12.44**

APPENDIX III

Attitude Questionnaire

Date ______

Time ______

Name ______

Please give your attitude about how did you like the task of Kneading the dough and making chapaties. Also how did you feel about the environment in the Laboratory, and the factors which have contributed towards that feeling.

Important

(i) Be sure you check every set of words.

(ii) Do not put more than one check mark on one set of words.

(iii) Please see carefully the manner in which five point Likert's scale is to be applied.

(a) How did you feel about equipment and supplies in the laboratory?

(1) Arrangement of equipment and supplies.

V.Good   Good   Neutral   Poor   V.Poor

2. Ht.of piri/working counter.

V.Good ____ ______ ____ V.Poor

3. Size of Parat

V.Good ____ ______ ____ V.Poor

4. Amount of flour and water provided:

V.Good ____ ______ ____ V.Poor

5. Quality of dough

V.Good ____ ______ ____ V.Poor

6. Size of balls:

V.Good ____ ______ ____ V.Poor

7. Size of rolling pin

V.Good ____ ____ ____ V.Poor

8. Height of rolling board:

V.Good ____ ____ ____ V.Poor

9. Height of gas burner .

V.Good ____ ____ ____ V.Poor

10. Flame of the gas burner

V.Good ____ ____ ____ V.Poor

11. Distance of the rolling board from you

V.Good ____ ____ ____ V.Poor

12. Distance of the Gas burner from you:

V.Good ____ ____ ____ V.Poor

13. Distance of dough plate from you

V.Good ____ ____ ____ V.Poor

14. Distance of the Griddle from you

V.Good ____ ____ ____ V.Poor

15. Distance of the chapati box from you

V.Good ____ ____ ____ V.Poor

(b) How did you feel during the task?

1. Neck

No pain ____ ____ ____ Pain

2. Back

No pain ____ ____ ____ Pain

3. Arms

No Pain ____ ____ ____ Pain

4. Hands

No Pain	______	______	______	Pain

5. Upper legs

No pain	______	______	______	Pain

6. Lower legs

No pain	______	______	______	Pain

7. Feet

No pain	______	______	______	Pain

(c) How did you feel about the psychological environment in the laboratory?

1. Free	______	______	______	entrapped
2. At ease	______	______	______	Uneasy
3. Interesting	______	______	______	Not interesting
4. Not tiring	______	______	______	Tiring
5. Satisfying task	______	______	______	Not satisfying

(d) Feelings towards the tasks

1. Kneading the dough

Liked very much	Liked	Neutral	Disliked	V.disliked

2. Chapati making

Liked very much	______	______	______	Disliked very much

APPENDIX IV

Mean Score Values of Attitudes towards kneading the dough and chapati making

Questions	Mean score	Total	Average
(a) Feelings about equipment and supplies			
1. Arrangement of equipment and supplies	4.4		
2. Ht.of piri /working counter	4.4		
3. Size of parat	4.8		
4. Amount of flour and water provided	5.0		
5. Quality of dough	5.0		
6. Size of balls	5.0		
7. Size of rolling pin	4.8		
8. Height of rolling board	4.8		
9. Height of gas burner	5.0		
10. Flame of gas burner	5.0		
11. Distance of rolling board from subject	4.8		
12. Distance of gas burner from subject	4.8		
13. Distance of dough plate from subject	5.0		
14. Distance of griddle from the subject	5.0		
15. Distance of chapati box from subject	5.0	72.8	4.8
(b) Feelings regarding pain in the body			
1. Neck	3.5		

2. Back	3.5		
3. Arms	5.0		
4. Hands	5.0		
5. Upper legs	5.0		
6. Lower legs	4.25		
7. Feet	5.0	31.25	4.4

(c) Psychological environment in the laboratory

1. Free	4.6		
2. At ease	4.6		
3. Interesting	4.8		
4. Not tiring	4.6		
5. Satisfying task	4.8	23.4	4.7

(d) Liking toward the tasks

1. Kneading the dough	3.0	3.0	3.0
2. Chapati making	4.8	4.8	4.8

* The mean score values of attitude towards the task were same for squatting and standing except the feelings regarding the pain in the body. The mean score of feelings regarding the pain in the body was 5 for standing posture and 4.4 for squatting.